SPACE WEAPONS

Are They Needed?

John M. Logsdon
Gordon Adams
Editors

Space Policy Institute
Security Policy Studies Program
Elliott School of International Affairs
The George Washington University
Washington, DC

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Foreword

On January 11, 2001, the report of the Commission to Assess National Security Space Management and Organization was released. Among the many observations and recommendations contained in what has come to be known as the Space Commission report was the comment that “The Commissioners believe the U.S. government should vigorously pursue the capabilities called for in the National Space Policy to ensure that the president will have the option to deploy weapons in space to deter threats to, and if necessary, defend against attacks on U.S. interests.” The Commission was chaired by Donald Rumsfeld until he was named as the incoming Bush administration’s choice as Secretary of Defense.

The combination of the report’s recommendations, which called for more effective use of space capabilities as an instrument of U.S. national security, the choice of Rumsfeld as Secretary of Defense, and the appointment to high Pentagon positions of other individuals thought to be supportive of objectives such as U.S. control of space and use of space capabilities for force projection was troubling to those who held to the tradition that space was a global commons, open to all for peaceful use. In reaction, the past several years have seen the beginning of a broadly based discussion of the appropriate uses of outer space in pursuit of national and international security.
One venue for such discussions has been the Security Space Forum, created in Fall 2001 by the Space Policy Institute and the Security Policy Studies Program of George Washington University’s Elliott School of International Affairs. The work of the Forum is supported by a grant from the John D. and Catherine T. MacArthur Foundation. The Forum is to be the one place in Washington where specialists in military space policy, national security analysts, policy-makers, researchers, and the media can come together to confront differing viewpoints in this critical emerging arena of national security policy. The goal of the Security Space Forum is straightforward: to bring together both space specialists and national security generalists in order to educate each other on military space issues, with an eye to expanding the policy debate and adding to the expertise of the broader national security community. A fundamental purpose of the Forum is thus consciousness raising, and then issue definition and clarification, for the many elements of the Washington policy community interested in emerging national security issues.

As one of its activities, the Security Space Forum has since October 2001 organized a series of luncheons at which a core group of attendees gather to discuss a commissioned paper on some aspect of national security space policy. This volume brings together most of those papers so that they can be available to a broader audience.

In the first paper in this volume, Karl Mueller of the Rand Corporation provides some
extremely useful categories for thinking about the space weaponization debate. Then Everett Carl Dolman of the School of Advanced Airpower Studies at the Air War College puts forth a deliberately provocative argument in support of the use of space capabilities to create and maintain a “liberal world order.” From a quite different viewpoint, Theresa Hitchens of the Center for Defense Information assesses the issues associated with the development and deployment of space weapons. Air Force officer William Spacy provides, updated from his 1999 paper, a comprehensive technical and policy assessment that examines whether space weapons are needed to accomplish various national security objectives ranging from force projection to ballistic missile defense and space control. Michael O’Hanlon of the Brookings Institution argues from a pragmatic perspective that it is in the interest of the United States to take all possible measures to delay the development of space weapons. Richard DalBello of the Satellite Industry Association reflects on the impacts on private sector interests of increased military activity in space. Finally, another senior Air Force officer, John Hyten, in an article originally published in *Air & Space Power Journal* and reprinted here with permission, provides a thoughtful set of recommendations on how to develop an integrated national strategy for deriving security benefits from U.S. space capabilities.

The Forum will continue its luncheon discussions at least through the end of 2004, and hopefully beyond. As they are presented,
commissioned papers will be posted on the Forum’s web site at www.gwu.edu/~spi/spaceforum.

We wish to acknowledge the assistance of a number of individuals who have supported the Forum’s efforts. They include Rebekah Robinson and Todd Robinson of the Security Policy Studies Program and Madeline LePage and Ryan Carter of the Space Policy Institute. Graduate student Mark Avnet made a major contribution to the preparation of this publication. We are particularly grateful to Kenette Benedict and Lukas Hayes of the MacArthur Foundation for their support of the Security Space Forum.

The United States currently is the dominant space power. Whether it chooses to maintain that dominant position, and the uses to which it puts its current and emerging space capabilities, will be an important determinant of global security in the 21st century.

John M. Logsdon  
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Chapter 1

Totem and Taboo: Depolarizing the Space Weaponization Debate

Karl P. Mueller

Introduction

Should the United States place weapons in space? This question, long neglected in most discussions about U.S. defense policy except where it was touched upon by arguments about ballistic missile defenses and cold war nuclear stability, is now at last becoming the subject of active and serious debate in the United States and abroad. Many factors are contributing to this trend, including the growing economic and military importance of satellites, renewed U.S. interest in national missile defense, and the work of the Space Commission chaired by Donald Rumsfeld prior to his appointment as Secretary of Defense.¹

The U.S. policy debate about space weaponization is often portrayed as a fight pitting

¹ This paper, which to the best of the author’s conscious knowledge has no substantive connection to Sigmund Freud’s classic 1913 psychoanalytical work Totem and Taboo: Some Points of Agreement Between the Mental Lives of Savages and Neurotics, is based on a presentation at the Security Space Forum of the Elliott School of International Affairs Space Policy Institute and Security Policy Studies Program, George Washington University on December 3, 2001. The author is an associate political scientist at RAND in Arlington, Virginia (e-mail: mueller@rand.org). The opinions expressed here are his alone and do not reflect the views of RAND or any agency of the United States Government. A revised version of this paper appeared in the new journal Astropolitics, Vol. 1, No. 1 (2003)
Karl P. Mueller

idealistic, liberal arms control enthusiasts who oppose
all weapons against warmongering militarists who never
saw a weapon they didn’t like. Although there are
people who do fit one or the other of these stereotypes,
most serious opponents and advocates of space
weaponization do not. Moreover, positions on this
question do not always fall along a simple left-to-right
or liberal-to-realist continuum, so these caricatures fail
to capture the key elements of the debate even when
treated as polar extremes between which more moderate
opinions are possible.

This paper seeks to describe the principal schools
of thought regarding space weapons in a way that better
corresponds to reality, by suggesting a roadmap to the
debate that distinguishes among six different positions
regarding the question of whether and when the United
States ought to build space weapons. In order to do this,
I first address the preliminary problem of defining and
characterizing what space weapons and space
weaponization are. Following the main discussion, I
briefly examine the questions of whether space
weaponization is inevitable, and whether this matters,
and then return to the subject of all how the participants
in the weaponization debate might move beyond their
current polarization to make greater progress towards
developing sound policy in this increasingly important
arena.

What Is Space Weaponization?

Space weaponization is a subset of space
militarization. If one envisions a continuum running
from space systems not being used for any militarily
useful purposes to satellites providing services to support terrestrial military operations (from the late 1950s for the United States) to satellites being integral parts of terrestrial weapon systems (from the 1990s) to weapons themselves being deployed in space, weaponization occurs when the upper range of the spectrum is reached. At its most extreme, space weaponization would include the deployment in quantity of a full range of space weapons, including satellite-based systems for ballistic missile defense (BMD), ground- and space-based anti-satellite weapons (ASATs), and a variety of space-to-earth weapons (STEW), and these would play a central role in any type of military operations.

However, space militarization is not a simple linear path along which a phase change occurs at some point and space becomes weaponized. Instead, there are a number of intermediate steps along the way, and how politically significant each will be is not only unclear, but must necessarily be unclear prior to the event because it is a matter of social construction. For example, both the United States and the Soviet Union developed and tested rudimentary ASAT systems during the Cold War. Some insist that this means space has already been weaponized and we should stop talking about it, but this is clearly a fallacious argument: we have not yet crossed the principal space weaponization threshold precisely because almost everyone believes that we have not done so.

There are a number of dimensions of weaponization along which a given development may resemble more or less closely an idealized version of space weaponization. For each it is possible to identify
a number of steps on the ladder ranging from qualities that do not look very much like those of a “space weapon” to ones that seem quite extreme. However, in exactly what order the steps should be placed is not always apparent, as will be discussed below. At least six of these dimensions are worth considering in some detail, although others could certainly be identified as well.

**Basing**

The most basic dimensions are where the weapon is based and what sort of targets it can attack. The basing dimension ranges from purely terrestrial weapons, such as land-based ASAT lasers or terrestrial weapons for attacking space launch and support facilities, to true space-based weapons, satellite weapons platforms placed in orbit for the long term well before a conflict. Intermediate steps along this continuum include direct ascent ASATs (which are launched into space but not into orbit), suborbital weapons including ballistic missiles (which travel through space en route to their targets but do not linger there), and launch-on-demand orbital weapons (which are deployed into space only when needed, thus perhaps avoiding crossing the weaponization threshold during peacetime). Somewhere along this continuum fall weapons such as today’s satellite-guided bombs and cruise missiles, in which a terrestrial weapon depends completely upon space systems in order to operate; in some respects a JDAM is thus very much a space weapon, although policymakers and populations clearly do not consider the deployment of such weapons to constitute space weaponization.
Table 1: Dimensions of Space Weapon-ness

<table>
<thead>
<tr>
<th>Basing</th>
<th>(terrestrial, direct ascent, suborbital, launch on demand, long-term orbital)</th>
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<tbody>
<tr>
<td>Potential Targets</td>
<td>(location and type)</td>
</tr>
<tr>
<td>Attack Mechanism</td>
<td>(non-weapon, electronic, KE, conventional, DE, nuclear, . . .)</td>
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<tr>
<td>Weapon Effects</td>
<td>(nature, severity, duration)</td>
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<tr>
<td>Discrimination</td>
<td>(incl. collateral damage and orbital debris)</td>
</tr>
<tr>
<td>Potential Utility</td>
<td>(esp. in offensive and defensive scenarios)</td>
</tr>
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</table>

Potential Targets

Two features about the targets that candidate space weapons could attack are important: their location and their nature. Target locations include the land and sea surface, objects aloft in the atmosphere, and objects (satellites and suborbital projectiles) in orbital space, where it is important also to distinguish among different orbital altitudes, especially low-, medium- and geosynchronous earth orbit (LEO, MEO, and GEO respectively). Among space-based weapons, the ability to attack terrestrial targets (“space force application” in Air Force doctrine) is usually taken to be a more extreme form of weaponization that being able to attack other space vehicles, although a case could be made that the former actually represents far less of a departure from current military capabilities than does the latter, and this conventional intuition should be reversed. The
types of targets than can be attacked is a fairly straightforward matter, relating to how hard, how small, how fast, how agile, how distant, and how stealthy a target the weapon is capable of striking. (To this list could be added the question of how many targets could be attacked, either in total or during a particular window of opportunity, particularly for the rare weapon system that cannot simply be expanded to increase the number of targets it can strike.)

Together the basing and target location variables define the major categories of space (or not-quite-space) weapons. The hierarchy of “space weapon-ness” among them can be ambiguous—for example, is deploying a direct ascent ASAT a more limited or more extreme step towards weaponization than deploying a space-based laser for ballistic missile defense? In general, it can be said that space-to-space and space-to-earth weapons are generally considered to be space weapons, that terrestrial ASATs usually (but not always) are, and that terrestrial and purely suborbital systems (including ICBMs) for striking terrestrial targets usually are not.

Yet, muddled as this picture can be, it is further complicated by the fact that some weapons have the ability to attack secondary targets. For example, nuclear-tipped anti-ballistic missiles (and even short-range ballistic missiles) can potentially be employed as powerful ASAT weapons. This does not make a Scud a space weapon for most political purposes, but it would certainly have to be taken into account in any arms control effort to prohibit the possession of anti-satellite weapons. Much the same is true of the limited but potentially significant anti-satellite capabilities of the
U.S. Space Shuttle.

The remaining dimensions are less significant with respect to defining whether a system is a space weapon, and thus whether deploying it would constitute space weaponization. However, they might potentially be very important in determining how politically significant the deployment of such a weapon was.

**Attack Mechanism**

Space weapons (here and below in this section we will use this term in its widest possible sense for the sake of simplicity) can employ a wide range of mechanisms to affect their targets. The most obvious are conventional explosive, other kinetic energy, and directed energy (e.g. laser and radio frequency) weapons, which together occupy the middle range of this continuum, and seem clearly to qualify as weapons. Above these are nuclear weapons (and perhaps biological and chemical weapons, though the latter is especially unlikely for space weapons employment), the only category of weapon whose deployment in space is proscribed by international law or treaty.5

More interesting in political terms is the other end of the spectrum: devices or techniques that could have weapon-like effects but whose status as weapons is ambiguous. These include such things as electronic jamming of communications and telemetry, barriers with which to shade satellite solar panels or obstruct the view of space-based sensors, and space “special forces” capabilities, including direct human or mechanical interference with or sabotage of satellites in orbit.6
Weapon Effects

Weapon effects are an obvious and a relatively simple matter: does the weapon destroy, damage, or merely disrupt the activities of the target, and to what degree of severity? If less than destruction, how long lasting are the effects, will they abate on their own, and/or how easily can they be repaired or circumvented? Finally, will the effects, whether directly or indirectly, cost lives, or only inflict property or other economic harm?

Discrimination

The extent to which the effects of a weapon can be confined to its intended target is also likely to play an important part in shaping perceptions of the system, with more discriminate weapons appearing on the whole to be less objectionable. This is most obvious, perhaps, with respect to the creation of orbital debris by kinetic energy ASATs and the widespread damage that would be produced by using exoatmospheric nuclear detonations for anti-satellite purposes or to inflict electromagnetic pulse damage against terrestrial targets. At the lower end of the damage scale, a device to deny Global Positioning System signals to a narrow area or certain categories of receivers would be more discriminate than one which produced a similar effect over a broad region. For space-to-earth weapons, traditional concerns about discrimination and collateral damage in weapons effects would apply.
Potential Utility

Finally, the scenarios in which a weapon would or would not be effective or useful would be likely to affect the political implications of developing it. A weapon which would be powerful if used in a first strike but highly vulnerable to an enemy who struck first would probably create more furor or discontent than one that would work well on the strategic defensive. Because of the relative visibility of satellites and the predictability of their orbits, many space-based weapons would tend toward the offensive end of the scale than the defensive, but many factors would enter in to this equation. Similarly, weapons that could be deployed or employed without detection (or anonymously) would tend to offer more to an aggressor than ones whose use and ownership would be obvious. Clearly, if a weapons is effective only against a certain class of targets, say long-range ballistic missiles, this would have a considerable effect on how it was perceived, depending in large part upon what states possessed such targets. Similarly, whether a system would be capable of attacking many targets or only a few (a major consideration for missile defense systems in particular) would likely have considerable importance in determining the scenarios in which it would or would not be valuable.

Together, all of these factors would shape the political impact of any particular decision to develop or deploy space weapons, including in some cases whether the action in question would or would not be considered to constitute the profound violation of the current space sanctuary norm with which many space weaponization discussions are primarily concerned.
Six Perspectives on Space Weaponization

As the introduction to this paper suggested, the space weaponization debate often appears at first glance to be as a classical contest between hawks and doves. The former, now apparently in the ascendancy within the U.S. government under the George W. Bush administration, are said to believe that space weapons should and will be deployed more or less as soon as they can be, and that the United States must lead the way down this path lest another state do so in our place. Their other side of the debate is typically portrayed, at least by their opponents, as starry-eyed arms control enthusiasts who believe space should be preserved as a sanctuary free of weapons; in fact this was the preferred policy of the U.S. government during most of the space age, albeit usually for reasons that had little to do with idealism, although the Clinton administration was more conspicuous in its reluctance to develop space weapons than its predecessors.

Like any good cartoon, this image contains a considerable amount of truth. However, it is too simple a picture on which to base serious analysis of what is actually a far more complicated debate. There are in fact a variety of positions on both sides of the weaponization question, which the following discussion groups into a taxonomy of six basic perspectives, three of which favor a space sanctuary and three of which envision and advocate U.S.-led space weaponization, at least under certain circumstances. Each of these schools of thought is as least internally consistent, although I will argue that they are not all of equal
intellectual merit. However, it is important to note that these categories are ideal types, and are not mutually exclusive: it is entirely possible, and even commonplace, for individuals in the real world to hold beliefs that fall into more than one of these camps, which the reader should bear in mind throughout what follows.10

Table 2: Policy Perspectives on U.S. Space Weaponization

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<th>Pro-Weaponization Perspectives</th>
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<td>Space Racers</td>
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<tr>
<td>Internationalist</td>
<td>Space Controllers</td>
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<tr>
<td>Nationalist</td>
<td>Space Hegemonist</td>
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Sanctuary Idealists

The perspective most categorically opposed to space weaponization can aptly be labeled *sanctuary idealism*.11 Perhaps the most widely held of all the perspectives, especially outside of the United States, sanctuary idealists oppose the spread of weapons or warfare into any new realm (with outer space being the most prominent one not yet weaponized), and the deployment of new types of weapons; typically, they also at least nominally favor the elimination of some or all of the types of weapons that already exist, though this is of limited relevance to the space weaponization debate.

The reasons for this policy preference vary
among the idealists, but may range from aesthetic, moral, or philosophical distaste for contaminating unpolluted territory with engines of war, to more instrumental fears that opening new arenas to military competition will drain scarce resources from peaceful uses or will increase the level of animosity and distrust among nations. Most typically, sanctuary idealism is based on two central political premises. The first is that weapons are necessary for—and tend, through arms races, to be a cause of—war, so the absence of space weapons prevents space warfare, while their presence would not only make war in and from space possible, but would in fact encourage it. The second principle is that minimizing the amount and the extent of warfare is intrinsically desirable. Similar themes have underlain some earlier arms control advocacy, such as the effort before and after the First World War to prohibit the use of aircraft as instruments of war.

Thus, unlike the strands of space sanctuary theory discussed below, sanctuary idealist arguments are not for the most part related to the specific characteristics of space weapons, either individually or in general, or to the nature of orbital space. The logic of the idealist approach applies more or less similarly to other types of weapons that might be banned (such as chemical weapons or landmines) and to other places from which weapons might be prohibited (such as Antarctica, the deep seabed, or regional nuclear-free zones). However, space weapons are a natural focus for such arms limitation advocacy, since averting the development of new weapons appears far easier than does reversing the status quo after new weapons have been deployed and integrated into military operations.
Sanctuary idealists generally advocate some variation on the same policy theme as other sanctuary proponents: the United States should work to keep orbital space free of weapons. This might be pursued through negotiating an international agreement to ban space weapons, as China and Russia have occasionally proposed in the past. Even without such an agreement, most sanctuary idealists would argue that the United States should continue to exercise unilateral restraint in the development, or at least the deployment, of space weapons, in order to reduce the incentives for other states to build their own; some sanctuary idealists also contend that the example the United States would set by unilaterally eschewing space weaponization would give significant political and moral encouragement for other states to do the same. However, although space sanctuary proponents believe that the potential costs and risks of actually weaponizing space would be high, even sanctuary idealism is compatible with “space control” measures such as improving U.S. space tracking capabilities or hardening U.S. satellites to make them less vulnerable. None of the major schools of thought sees merit in American vulnerability to attack in space, though they may differ widely with regard to choosing the best ways to deal with it.

Sanctuary Internationalists

Where the idealists oppose new weapons, and weapons in new places, in general, sanctuary internationalists oppose space weapons in particular because of their potentially harmful effects on international stability. Drawing in part upon theories
about the effects of offensive advantage and the security dilemma, this perspective argues that the nature of space weapons makes them far better suited to offensive than to defensive warfare: weapons in orbit can strike quickly and with little warning, but are themselves vulnerable to attack because they move predictably, cannot remain over friendly territory, and are difficult to conceal. Thus, both the owners of space weapons and their enemies would have incentives to strike first in a crisis. In addition to encouraging preemptive attacks and preventive wars, if states were to shift their military investments from terrestrial to space weapons, these theories predict, the growing advantage of the offense would tend to produce other pathological political effects, heightening international tensions and further reducing stability.

Sanctuary internationalism also warns of potential coupling between space weaponization and nuclear instability, on several levels. First, and perhaps least seriously in the current global environment, opponents of space-based ballistic missile defense, like generations of BMD critics before them, fear that such systems would weaken the deterrent potency of major powers’ second-strike nuclear forces. Second, sanctuary advocates are concerned that anti-satellite warfare could contribute to nuclear instability by disabling space-based ballistic missile launch detection systems, reducing strategic warning and potentially allowing states to launch missile attacks anonymously, and thus with hope of avoiding retaliation. Third, they note that conventional space weapons, such as kinetic energy projectiles launched from orbit, might have considerable utility in their own right as part of a first strike against
an enemy’s nuclear capabilities. Finally, they argue that space weaponization might encourage nuclear proliferation, since states facing threats from space weapons but lacking the ability to respond in kind or to neutralize the danger would be likely to seek asymmetric means to shore up their security, among which the acquisition of nuclear weapons might be attractive.

For the sanctuary internationalist, the undesirability of space weaponization would depend on the particular shape it took. Some space weapons would tend to be more destabilizing than others: the more a specific set of technologies and deployment choices creates a situation in which space weapons are valuable to an aggressor but vulnerable to preemption, the more malignant the stability implications of space weaponization would be, and some space weapons might even enhance stability. However, since most possible space weapons would combine a high degree of first strike utility and vulnerability relative to most terrestrial weapons, and because space weapons without destabilizing characteristics might help pave the way for the weapons with them, sanctuary internationalists are inclined to oppose space weaponization in general, although they would tend strongly to embrace other, stabilizing means of reducing vulnerability to attack in or from space. Finally, they would not necessarily favor the United States responding to another state’s deployment of space weapons by doing the same: depending on the scenario, an American response in kind might either enhance or reduce overall stability.
Sanctuary Nationalists

The third sanctuary perspective is grounded in the tradition of classical realism. Sanctuary nationalists oppose space weaponization not because it would weaken global stability, but because they believe that although space weaponization might enhance American military capabilities in absolute terms, it would weaken the power and security of the United States relative to the rest of the world.¹⁴ Many of their arguments cluster around the theme that it is the United States, as both the dominant world power and the preeminent spacefaring state, which has the most to lose from space weaponization.

First, and most visibly, the United States takes the greatest advantage from the space sanctuary status quo. The U.S. military, government, and commercial sectors have led the world in exploiting the potential of satellites and space technology for a host of vital functions, with satellites being particularly indispensable for U.S. military operations. If satellites were subjected to substantial threat of attack or interference it would be a greater hardship for the United States than for any other major country.

Second, the United States enjoys an unrivaled ability to project military power around the world. Although space weapons would further increase its expeditionary military capabilities, their benefits would be only marginal in the vast majority of scenarios. On the other hand, effective space weapons might greatly enhance the military capabilities of other states, which currently have little capability to attack the United States and whose military inferiority is due in no small part to
the U.S. advantage in space capabilities. Moreover, while the United States would enjoy a large initial lead over its rivals in a space weapons competition, it already has a huge advantage in the other dimensions of military power, and there is little reason to believe that rivals would find it harder to challenge U.S. preeminence in space power than in sea or air power.

Third, sanctuary nationalists argue that the dynamics of alliance formation and maintenance imply that if the U.S. leads the way in space weaponization it would not only antagonize rivals and enemies, but would also tend to weaken the system of security ties between the United States and its large and powerful bloc of allies. The potentially oppressive proximity and omnipresence of American weapons in orbit might encourage other states to align against an apparent assertion of U.S. hegemony, and would at least make them less comfortable with American dominance in international politics. Even in the absence of such balancing behavior, a shift in U.S. military strategy toward greater autonomy from allies and coalition partners, which is one of the principal selling points of space-based weapons, would tend to weaken existing security relationships and increase the burden of defense on U.S. national resources.

Some sanctuary nationalists also contend that a shift to space weapons as the key currency of military power would weaken the global military dominance of the United States by making its currently overwhelming advantage in power projection through air and naval power obsolescent. Much as Britain’s naval superiority was undermined when steam replaced sail, and again when pre-Dreadnought battleships were replaced by
their steam turbine-driven, all-big-gun successors, the slate would be wiped clean and states that had previously lagged behind in the old technology would be able to compete in the new one from something much closer to a neutral start.16

Thus, sanctuary nationalists do not think that U.S. space weapons would be intrinsically bad, but instead that their eventual costs would greatly outweigh their benefits, particularly insofar as U.S. space weaponization would lead to other states building their own space weapons. Although sanctuary nationalists are likely to doubt that U.S. restraint in space weaponization would set a compelling moral example for other states to follow, or that arms control agreements would be a powerful barrier to weaponization, they maintain that other states’ would be more likely to embark on space weaponization if the United States does so first, for two reasons. The more obvious of these is that U.S. space weapons would give other countries more valuable and threatening targets to attack in and from space, creating greater incentives for ASAT and even STEW development.

The other reason is more subtle: a belief that by leading the way in space weaponization, the United States would not only encourage other states to follow suit, and save them from any political stigmatization that might be associated with being the first state to weaponize space, but would actually make it easier for them to do so. By serving as the technological trailblazer, and paying the costs of developing new technologies, the United States would reduce the technological and cost barriers for the states that followed. Such “advantages of backwardness,” well-
recognized in economists’ studies of the product cycle, are consistently visible in the development of military technologies, including aircraft, missiles, and nuclear weapons.17

The prescription that emerges from nationalist sanctuary theory is that the United States should avoid taking actions that will motivate or facilitate adversaries’ development of space weapons, or cause other effects that would tend to reduce U.S. military advantages over other states. In general, this would point towards avoiding space weaponization, whether through multilateral regimes or unilateral restraint—either one conditional on the actions of other countries—or other means. However, as for the internationalists, the specific features of potential space weapons would affect whether and to what extent the development in question would endanger U.S. security. To take one example, some but not all of the effects that nationalists seek to avoid would probably be less serious if the U.S. built suborbital rather than long-term orbital space weapons.

**Space Racers**

The pro-weaponization perspective that generally appears least extreme, though it is not necessarily the one that shares the most common ground with space sanctuary theory, is that of the *space racers*. These are more or less reluctant space weaponization advocates, who may accept that sanctuary is desirable in the abstract, but who believe that space weaponization is inevitable, and that this makes it imperative for the United States to lead the way in the development and
deployment of space weapons. The space racer perspective is shared by many, including both academic theorists who are attracted to restraint in armament but pessimistic about its prospects, and military leaders who are reluctant to see defense resources diverted from other areas into space weapons, but who are similarly skeptical about the chances of avoiding this. Because the thesis that space weaponization is inevitable is tied to many of the pro-weaponization perspectives, the next section of this paper will examine it in some detail, and the present discussion will focus simply on its implications.

For space racers, the most important consideration with respect to space weapons is that the United States should not allow other countries to surpass, or even to rival it, in this arena of military competition. Being the leading space power may offer significant military advantage, or it could simply be an important source of national prestige and international political influence. In either case, the United States must keep ahead of the pack, and in the end must be the first state to weaponize space, for even if that is unpleasant, it will surely be better than being the second state to do so. Moreover, if weaponization is inevitable and if leading the way is imperative, any political costs associated with being the first state to violate the sanctuary of space will have to be paid sooner or later, and delaying will not avert having to pay the price.

According to this perspective, the correct time for the United States to weaponize space will depend at least in part on the behavior, capabilities, and intentions of other countries. If the threat of a rival state weaponizing space were remote, the United States
would have the option of moving relatively slowly down this path, as long as it carried out sufficient research and development efforts to remain squarely in the forefront of this dormant arms competition. Many space racers are far from sanguine about the prospect of space weaponization by other states, especially in light of China’s rapidly advancing space program, and anticipate that it will not be very long before the United States is compelled to deploy weapons in space. Other see the threat of space weapons rivals as less imminent, but in either case the space racer perspective is essentially threat-based.

Although it can be described as the most “middle of the road” approach to space weaponization policy—or perhaps because of this—the space racer perspective is arguably also the least intellectually satisfying. Its central weakness, though it is not necessarily a fatal one, is the contention that space weapons will be so irresistible that states will not be able to refrain from building them, and above all so powerful that it would be catastrophic for another state to build them before we do, yet not so attractive that the United States should build them as fast as possible in the absence of a military space challenger. Most sanctuary theories reject the first or the second (or both) of these propositions; the other two pro-weaponization perspectives accept them but reject the third.

**Space Controllers**

Within the U.S. military space community, the dominant attitude regarding weaponization is probably what has become known as the *space control*
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perspective. Space controllers believe that space will necessarily be an important arena of future conflict due to the great military benefits that space weapons will provide to states that operate them. Some military missions, such as boost-phase intercontinental ballistic missile defense against large adversaries, can feasibly be conducted only from space, while the ever increasing importance of satellites for communications, targeting, and other essential military functions will make both attacking enemy satellites and defending one’s own satellites (for which space controllers believe that space weapons will be required) a matter of leading strategic priority. In addition, as the relevant technologies improve, space-to-earth weapons will become a potent military instrument.

Space controllers may accept the proposition that weaponizing space will be politically costly—though many in this camp tend to ignore such political variables in their enthusiasm for the development of American space power,21 not all do—but in addition to agreeing with the space racers that any such costs will have to borne sooner or later, they believe that these will be outweighed by the military benefits of any space weapons that are worth deploying. Moreover, they are highly skeptical of the suggestion that U.S. restraint in space weapons development would significantly reduce other states’ inclination to weaponize space as soon as doing so appears to be militarily advantageous to them, and of the prospects for negotiating feasible limitations on space weapons.

For space controllers, the right time for the United States to weaponize space will be as soon as doing so appears to be useful, whether or not other states
are moving in the direction of doing the same. The key criterion for such a decision will not be a comparison of potential U.S. space weapon capabilities with those of rival states, but a comparison of future U.S. military capabilities with and without the potential space weapons. From this perspective, space racers seem to lack the courage of their own convictions: if space weapons will enhance a nation’s power, the United States should not squander the opportunity to develop them while waiting for a challenger to appear on the horizon.

**Space Hegemonists**

Finally, at the most pro-weaponization end of the spectrum, are the *space hegemonists*. Where space controllers believe that space will be an important arena of conflict in the future, space hegemonists argue that space will be the critical battlefield, the “ultimate high ground.” In the tradition of Mahan and Douhet, space hegemonists believe that he who controls space will control the world. In the words of Sen. Bob Smith, the most prominent if not the most persuasive spokesman for this perspective, concerted American development of space weapons will buy generations of security that all the ships, tanks, and airplanes in the world will not provide. . . . With credible offensive and defensive space control, we will deter and dissuade our adversaries, reassure our allies, and guard our nation’s growing reliance on global commerce. Without it, we will become vulnerable beyond our wildest dreams.
With respect to the development of space weapons themselves, space hegemonists differ from space controllers only in matters of degree. Where the controllers favor deployment of weapons as soon as it is militarily advantageous, the hegemonists tend to advocate an even more aggressive weaponization program, with little consideration of the possibility that space weapons might not prove to be the optimal solution to most military problems. Space controllers tend to envision space weapons complementing terrestrial weapons, as well as offering unique capabilities that would be impossible or difficult to provide without them; space hegemonists are more inclined to envision space weapons as supplanting most terrestrial weapons, and becoming the queen of the traditional battlefields as well as the new ones in space, in a genuinely transformational revolution in military affairs. ²⁴

Where the space hegemonists stand out most fundamentally from other weaponization advocates is on the political dimension, where controlling space becomes controlling the world. One explanation for how this is to occur, as Smith has suggested, is that overwhelming U.S. space power will be unassailable, so that the rest of the world will not challenge American hegemony. Either they will perceive it to be benign, or they will be so intimidated by it that defiance of the United States will appear pointless. The weakness of this scenario lies in the tension between believing that there are rival states strong enough to become the space hegemon if the United States fails to do so, and believing that these rivals are too weak or too meek to develop dangerous space capabilities in the face of U.S.
space power.

The other scenario, couched in less optimistic realpolitik terms, is that space weapons will be so powerful that the United States must exploit its current lead in space technology to seize control of the high ground and actively deny its use by unfriendly states. According to this point of view, rival powers will indeed have incentives to challenge U.S. dominance of space, and since the United States will not be able to afford to have its control of space contested, it will need to quash any such challenges before military space races develop, including preemptively destroying any space launch vehicles attempting to enter space without U.S. authorization and any terrestrial ASAT weapons that unfriendly states might build. This vision of the future represents the core elements of the other pro-weaponization perspectives being carried to their logical extreme: if space weapons are too powerful not to build, they must also be too powerful to allow our potential enemies to possess.

Is Space Weaponization Inevitable?

As the preceding discussion described, the belief that space weaponization is, or is not, inevitable looms large for several of the major perspectives. It is most central for the space racers, for it is the expectation of inevitable weaponization that drives them into the pro-weaponization camp. The other pro-weaponization perspectives are not based on such an inevitability belief, but their adherents routinely invoke it as an argument against a sanctuary approach. For their part, all three of the sanctuary perspectives presume that
weaponization is avoidable, or at least that American actions can affect how soon and in what form it occurs. Therefore this section will briefly examine the four principal arguments for the thesis that space weaponization is inevitable.\textsuperscript{26}

Specifically, the question here is whether there is good reason to believe with certainty that space weapons will be built and deployed to a substantial degree in the near-to-medium term, say the next fifty years, regardless of the behavior of the United States.\textsuperscript{27} There are four prominent arguments which hold that this is true: that human nature predestines weaponization, that historical analogies with the sea and air prophesy it, that the growing economic importance of satellites mandates it, and that the military utility of space weapons will make not building them strategically irrational. This section will consider each of these propositions in turn, arguing that the first three are thought-provoking but ultimately weak, while the last is more powerful but less than conclusive.

**Human Nature**

The simplest inevitability argument is that warfare and armaments are intrinsically uncontrollable because people are warlike: weapons and warfare abhor a vacuum, and will spread wherever humanity goes.\textsuperscript{28} This assertion is often accompanied by arguments that arms control never works,\textsuperscript{29} although it is possible to argue more narrowly that only space arms control is infeasible.

This generalization is not far from the truth, yet it is far enough away that it should be considered
invalid. For example, although the longstanding success of the 1957 treaty prohibiting military bases in Antarctica, often cited as an example of an effective sanctuary regime, would be more impressive if the signatory powers actually had strong incentives to establish bases on that continent, it still flies in the face of the idea that weaponization must always follow wherever people go (the argument that space weapons in particular will have military utility too great to resist is a different proposition from the contention that weapons always spread everywhere). Similarly, some types of weapons have fallen into disrepute over the last century, while they have not yet disappeared, chemical and biological weapons have been shunned by all but renegade states, and anti-personnel land mines are following in their wake. Many states that could easily have developed nuclear weapons have opted not to do so, in some cases in spite of apparently very good military reasons to go nuclear. Perhaps most strikingly of all, even among space weapons advocates one does not find voices arguing that the placement of nuclear weapons in orbit is inevitable based on the rule that weapons always spread. The fact that this has not happened is due to many factors other than the Outer Space Treaty’s prohibition on such weaponization, but if some weapons do not necessarily follow wherever people go, the idea that a law of human nature requires that others will do so should not be seriously embraced as a basis for national policy.

Historical Analogies

The second argument that space must inevitable
be weaponized is that the evolution of sea and air power reveal a striking pattern leading inexorably in this direction, which the exploitation of space is also following. According to an influential recent commander of U.S. Space Command, for example,

If we examine the evolutionary development of the aircraft, we see uncanny parallels to the current evolution of spacecraft. . . The potential of aircraft was not recognized immediately. Their initial use was confined to observation . . . Until one day the full advantage of applying force from the air was realized and the rest is history. So too with the business of space. . . [Military] space operations, like the land, sea, and air operations that evolved before them, will expand [into] the budding new missions already included in the charter of U.S. Space Command of space control and force application as they become more and more critical to our national security interests.31

The parallels between the early days of space flight and, especially, the early development of aerial flight are indeed striking, at least at first glance. Yet upon closer examination, it is clear that the spread of weapons into the three previous environments into which human activity has so expanded—the seas, the air, and the undersea world—has been far from identical, raising serious doubts about the soundness of drawing strong analogies when predicting the future of military space exploitation.32

Sea Power. The first new realm into which human enterprise expanded was the surface of the oceans and other bodies of water, initially along the coasts and later onto the high seas. Maritime transport
offered many advantages over land-bound alternatives, especially prior to the invention of the railroad, and armed conflict followed commerce onto the seas. Navies soon developed to protect merchant vessels from pirates and other enemies, to prey on enemy shipping, and to attack or defend coastlines and sea lanes.

In spite of the intuitive similarities between seafaring and spacefaring, however, there is one fundamental difference between them which makes the sea-space analogy very weak: ships primarily transport goods and people, while spacecraft (with only minor exceptions) are built to collect, relay, or transmit information. This means that space piracy is not a problem, so space navies are not required to suppress it, while “commerce raiding” threats to space systems can be ameliorated by building redundant, distributed systems of satellites; for merchant shipping this is obviously not an option. It also means that whatever threats may be posed by enemy space systems, invasion is very low on the list. In short, satellites have more in common with lighthouses than with oceangoing ships, and space commerce resembles telegraphy or terrestrial radio more than it does maritime trade. This does not mean that nothing we know about sea power can be applied to space, or that space strategists should not study the works of Corbett and Mahan. However, there is little reason to conclude from the evolution of naval forces either that the weaponization of space is inevitable, or that it is not.

**Air Power.** The parallels between military use of the air and of space are far more impressive. Both balloons and airplanes were used for military observation soon after they were first invented, and
because aerial observation was so powerful in the First World War, armed aircraft were soon employed as interceptors and then as escorts. Airplanes and airships were also used for bombing even before the dawn of air-to-air combat, and by 1918 virtually every modern military air mission had been undertaken or proposed.\textsuperscript{34} Serious commercial exploitation of the air came only later. In space, strategic reconnaissance was the purpose of most early satellites, and intelligence collection remains the most visible military space application;\textsuperscript{35} it was the value of being able to destroy enemy surveillance satellites that drove ASAT programs in both the United States and the Soviet Union.\textsuperscript{36}

However, the evolution of air and space power has not been as similar as space weapons advocates’ analogies often suggest. For example, less than a decade elapsed between the Wright brothers’ first flight and the first aerial combat missions, while in the fifth decade after Sputnik space remains unweaponized. Of course, the occurrence of a major war in the 1910s had much to do with the rapid evolution of air power, and space power might look very different today if World War III had broken out in the 1960s, but with no major wars now on the horizon, this caveat hardly makes the parallel between the two cases look like a strong basis for space policy in the 21st century. In fact, both superpowers did develop anti-satellite interceptors, but then abandoned their ASAT programs,\textsuperscript{37} something utterly without precedent in the history of air power that casts further doubt on the soundness of the analogy. Naturally, it would be foolish to conclude from the history of the last fifty years that space will definitely not be weaponized during the next fifty, but it would
also be reckless to deduce the opposite from the history of flight between 1903 and 1915.

**Submarine Power.** Space weaponization advocates rarely mention the third new environment into which human activity has expanded: the undersea world. In this case, although there are many similarities between submarine and space operations, the two weaponization histories have little in common. Warfare was the sole purpose of the first generations of subsurface vessels, joined only much later and on a vastly more limited scale by scientific research, while submarines have so far been of virtually no commercial significance. This says little about what the future of space power will look like, but it provides one more reason to be skeptical about the proposition that weapons spread into new environments according to a consistent and deterministic pattern.

It is also worth noting that one of the most striking commonalities among the three historical precedents is rarely if ever predicted to hold true for space as well. Nuclear weapons were deployed in each of these environments by all the major nuclear powers more or less as soon as each was capable of doing so. Yet not only has this failed to happen in space, but those who make the analogical argument for the inevitability of space weaponization routinely fail to insist that the nuclearization of space will occur in the future, raising doubts about the extent to which even its supporters truly believe in this argument.

**Economic Vulnerability**

The third inevitability argument is that as space
systems become more and more economically important to the United States, these assets will naturally become attractive targets of attack for rival states, terrorists, and other enemies, and therefore it will be necessary to place weapons in space in order to protect them. American industry, commerce, and civil society do indeed depend heavily and increasingly on space systems for communications, navigation, weather prediction, and many other functions. However, it is far from clear that attacking U.S. commercial space assets would automatically appear worthwhile to an enemy seeking ways to hurt the United States, or that protecting them would necessarily require weapons in space.

In the abstract, it is apparent that an enemy seeking to harm or to intimidate the United States might want to attack important satellites, potentially causing disruption of the services they provide, destroying expensive pieces of American infrastructure, and possibly even causing significant damage to the U.S. economy. However, an enemy that wanted to achieve such a result against the United States could do so far more easily by attacking something other than satellites in orbit, and unlike satellites, most of these targets can be attacked without first developing or acquiring specialized weapons for one exotic target set. Attacking satellites is certainly possible, but crippling or destroying a small object hundreds of miles overhead moving at 17,000 miles per hour (to say nothing of satellites at higher altitudes) is considerably more challenging than doing comparable damage to targets such as ships, airliners, bridges, dams, pipelines, computer networks, office buildings—the list could go on almost indefinitely. That such targets are not
attacked on a regular basis is due mainly to the relatively small numbers and limited capabilities of serious terrorist enemies, not to any great degree of protection for these assets. Increased defensive measure since 11 September 2001 have done little to alter the relative difficulty of attacking space and terrestrial targets. Moreover, if an enemy did want to disrupt the use of American satellites, attacking their ground communications stations and launch facilities might well be more effective than striking satellites in orbit, as well as much easier.

If an adversary did wish to attack U.S. satellites rather than something else in order to hurt the United States, space-based lasers or kinetic energy weapons would be useful for defense against direct ascent ASATs or “space mines” that were detected before attacking, but they would provide no protection against attacks by ground-based lasers or covert mines already positioned near their targets, against electronic jamming, or against attacks on the infrastructure that supports satellites. Instead, the greatest improvements in the security of valuable U.S. space assets might be achieved by making satellites less vulnerable to attack and, especially, by making them individually less valuable through the construction of satellite systems that are more distributed and redundant, with more smaller satellites doing the same jobs as fewer large, expensive ones. The ultimate goal would be for the communications and other satellite infrastructures to become like the U.S. interstate highway system: economically vital, but not worth attacking because its resilience means that none of its individual components is critical.
Military Advantage

The best argument for the proposition that space weaponization is inevitable is that the military utility of space weapons will soon be so great that even if the United States chooses not to build space weapons, other countries will certainly do so, in large part because of the great and still growing degree to which U.S. military operations depend upon what has traditionally been known as “space force enhancement”: the use of satellites to provide a vast array of services including communications, reconnaissance, navigation, and missile launch warning, without which American military power would be crippled. This parallels the argument that the importance of satellites to the U.S. economy will make them an irresistible target, except that military satellites are far more indispensable, and successful attacks against a relatively small number of them could have a considerable military impact, for example by concealing preparations for an invasion or by disrupting U.S. operations at a critical juncture.45 Rivals of the United States might also find space-to-earth weapons to be a very attractive way to counter U.S. advantages in military power projection.

This is a reasonable argument, but to conclude for this reason that space weaponization is inevitable, rather than merely possible or likely, is unwarranted, for several reasons. There is no question that space systems are critical to U.S. military capabilities. An enemy that attacked them might be able to impair U.S. military operations very seriously, but while this ranks high among threats that concern U.S. strategists, it need not follow that enemies of the United States will do so, or will invest in the weapons required to do so. The U.S.
armed forces possess many important vulnerabilities that adversaries have opted not to attack in past conflicts, typically due to resource limitations, a desire to avoid escalation, or fear of the reaction of third party audiences. For example, during Operation Allied Force in 1999, Serbia apparently did not attempt to mount special forces attacks against key NATO airbases in Italy or to use manportable missiles to shoot down aircraft operating from them, although such an action could have profoundly disrupted the Alliance’s bombing campaign. Moreover, it is quite possible that if a potential enemy did want to develop the ability to attack U.S. space systems, it would choose to do so in ways that would not involve weaponizing space—such as investing in computer network attack capabilities, non-space weapons to attack the terrestrial elements of space systems, or ASAT capabilities that are not weapons in the conventional sense—and against which the logical defensive countermeasures would not involve deploying U.S. space weapons. For military as well as commercial satellites, a transition to redundant networks of satellites would do much to reduce their vulnerability, perhaps together with supplementing satellite platforms for some military functions with new types of terrestrial systems, such as high endurance unmanned aerial vehicles (UAVs).

In the end, most of the inevitability arguments are weak. Even the best one, that space weapons will provide irresistible military advantages for those who employ them, is plausible but not decisive, and many of those who assert it probably harbor exaggerated expectations about the capabilities that space weapons will offer. In spite of the large number of people who
apparently believe the inevitability thesis to be true, there is good reason for prudent policymakers to assume that the weaponization of space is not in fact predestined, and that U.S. military space policy is one of the factors, but not the only one, that will shape the likelihood of space weaponization of space by other countries.

**Inevitability versus Primacy and Urgency**

The prominence of the inevitability question within debates about space weaponization is not surprising, but all too often it distracts attention from two far more important issues: whether it is in fact desirable and important for the United States to be the first country to weaponize space and/or for weaponization to occur sooner rather than later. If so, an aggressive effort to develop space weapons may be called for even if weaponization is not strictly inevitable. If not, a space sanctuary strategy may be appropriate for the United States even if it is certain that space will eventually be weaponized.

For space racers, primacy is what matters most, because they believe that the first state to deploy space weapons will have a great, and perhaps insurmountable, advantage over its rivals, though they may not in fact be eager to see the disappearance of the existing space sanctuary. Knowing simply that weaponization is inevitable is of little value from this perspective, though having a reasonable idea of when it would occur would be important. For many more ardent weaponization advocates, in contrast, the right time to deploy space weapons is immediately, or at least as soon as possible,
regardless of what other countries may or may not be likely to do later on. Thus, although they often make inevitability arguments, these are essentially tangential to the real basis of their policy prescriptions. Finally, for space sanctuary advocates who fear that weaponization will cause international instability or will erode U.S. hegemony, and who doubt that a rival could establish a decisive lead over the United States by taking the first step in a space weapons race, averting the deployment of at least some types of space weapons as long as possible appears desirable even if they are only temporarily delayed.

**Conclusion: Beyond Totem and Taboo**

The polarization of the space weaponization debate—treating a complex, multidimensional policy question as a simple all-or-nothing choice in which weaponization advocacy and opposition take on extreme, almost theological qualities—produces several seriously malignant consequences. The most obvious of these is that it discourages real dialogue among those who favor different military space policies. Many of the debate participants appear to be interested only in preaching to their fellow believers, treating their adversaries’ arguments so dismissively that they cannot possibly change the minds of those who view the issues differently from themselves. The marketplace of ideas breaks down when contending camps turn inward from healthy competition to mercantilist isolationism.

But this extreme polarization also harms the interests of the individual camps themselves. Weaponization opponents who treat space weapons as
an absolute taboo risk squandering opportunities to establish useful restraints on space weapons development, deployment or use that fall short of complete prohibition. They also preclude supporting forms of weaponization that might enhance global stability or further their ultimate policy objectives in other ways. Of course, it can be argued that compromise will invite predation by one’s adversaries, so that supporting benign weaponization would backfire over the long run, but such a position should be based on open and rational debate of its merits, not on doctrinaire faith that more arms control is always better than less of it, or that armament and security are incompatible.

Conversely, by making space weapons their totem, spacepower advocates distract both themselves and others from the fact that many, even most, of the important space policy measures that are needed now and in the near future do not involve building space weapons per se. Better space tracking networks, systems to detect attacks against satellites, passive defenses, and more effective exploitation of space-dependent terrestrial weapons such as satellite-guided munitions all promise to dramatically enhance U.S. spacepower—and U.S. national security. Becoming “shooters” might make it easier for space operators to win full citizenship rights alongside pilots in officer’s club bars, but in the end, with or without space weapons, they will need to make the rest of the armed forces understand that today all United States airmen, sailors, soldiers and Marines are space warriors.

Beyond calling for moderation and for taking the views of others seriously, what can be done to make the space weaponization debate more intelligent and
productive? A good place to start would be for all sides in the debate to acknowledge four simple but important truths about space weaponization that are often overlooked in polemical arguments about the subject.

First, space weaponization is inherently political, a fact that space weapons advocates sometimes seek to ignore—though, happily, this is gradually becoming less common. This is not a question simply, or even primarily, of science and engineering. Whether space weapons will make the United States more powerful or secure, or less, depends on political variables: how other countries will react to them, what resources we will have to redirect to build them, and so on. Military capability can be measured in static, absolute terms, but power is relative and dynamic. Moreover, the effects that weaponization would have on international politics, and even what actions would be considered to constitute weaponization, depend upon subjective and perhaps malleable perceptions, both of space weapons and of American military power.

Second, however, the military and technical details of space weapons do matter a great deal, though weaponization opponents—and enthusiasts as well—often paint their arguments with too broad a brush. Although all satellites do share certain important properties, the specific features of particular space weapons must be taken into account when assessing their strategic, and even their broader political, implications. This became second nature during debates over nuclear weapons and strategic defenses, when the minutiae of warhead accuracy, basing modes, and command and control systems were in the forefront of most policy arguments, and even ardent doves could
couch their arguments in the language of throw weights, equivalent megatonnage, and CEPs.\textsuperscript{48} Space weapons (like conventional weapons more generally) are a far more complicated and diverse subject, and require at least as much effort and attention to debate satisfactorily, yet surprisingly little work has yet been done to describe and analyze them in satisfying detail.

Third, because of the previous point, many participants on both sides of the space weaponization debate appear to harbor what are likely to be quite unrealistic expectations about the capabilities of space weapons, and to a lesser extent about their costs.\textsuperscript{49} It is seductively easy to speak in general and often glib terms about global reach, the importance of holding the high ground, and revolutions in military affairs, but it is important to develop and debate a more nuanced understanding of the ways in which space weapons truly are and are not likely to alter the strategic landscape if they are built.

Finally, everyone involved in the debate should remain aware that their arguments are necessarily based on educated speculation, not certainty. This is particularly true with respect to the political implications of weaponization. Would U.S. space-to-earth weapons cause other states to be more or less friendly towards the United States, for example? Theorists on all sides of the debate offer answers to this question. These should be evaluated against relevant historical experience, for there is evidence than can shed light on the question, and some of these arguments appear better than others upon careful consideration. However, at the end of the day a considerable degree of intellectual modesty is in order: nobody actually knows with confidence what will
happen if and when space is weaponized—and what shape weaponization takes, and what happens between now and then, will certainly affect its consequences.

These are burdensome calls to action. It is more work to develop analyses and recommendations about policy that are well informed by the physical and social sciences than it is to offer ones that are not. However, as in the debates about nuclear weapons and strategy during the cold war, this is an area of policy that is too important to be guided by anything less.

Notes

2 To this list could be added potential systems for destroying or diverting interplanetary objects threatening to collide with the Earth, some of which might have secondary military capabilities.

4 See, for example, Karl P. Mueller, “Is the Weaponization of Space Inevitable?” paper prepared for presentation at the International Studies Association Annual Convention, New Orleans, La., 27 March 2002.

5 Under the terms of the 1967 Outer Space Treaty, which prohibits the placement of weapons of mass destruction in space. The 1972 ABM treaty also prohibited space-based weapons that could be used for ballistic missile defense, until the United States withdrew from the treaty in 2002.


7 This generalization might be offset in certain cases by more discriminate weapons appearing to be more useful for aggressive purposes.

8 For example, James Oberg, Space Power Theory, (Washington: Government Printing Office, 1999), 146-47.

9 The most widely used such typology at present is that provided in David E. Lupton, On Space Warfare: A Space Power Doctrine (Maxwell AFB, Ala.: Air University Press, June 1988), more recently summarized and updated in Hays et al., Spacepower for a New Millennium: 3-4. Lupton describes four categories of policy preferences, which he calls Sanctuary, Survivability, Control, and High Ground, but defines these primarily in terms of the relationship between space systems and the strategic nuclear balance, which limits the utility of his framework for understanding the current weaponization debate (for example, he characterizes his Sanctuary school as favoring vulnerable space systems, which makes it little more than a straw man). However, the discussion of pro-weaponization perspectives below does draw heavily upon the more useful parts of his framework.

10 This is equally true of many of the citations in the following discussion. The fact that an example is used below to illustrate an argument from one of these perspective should not be taken to imply that everything in the cited work, or in
other works by the same author, falls into the same category as they are defined here.

11 The “idealist” label is not intended to imply that this perspective is unrealistic, but rather that it is guided by larger normative principles, in keeping with the classical idealist tradition in international political theory.


15 The key presentation of these arguments is Stephen M. Walt, The Origins of Alliances (Ithaca: Cornell University Press, 1987); they are challenged in Randall L. Schweller, Deadly Imbalances: Tripolarity and Hitler’s Strategy of World Conquest (New York: Columbia University Press, 1998). For the proposition that the United States won the Cold War because it was a relatively unthreatening superpower, see John Lewis Gaddis, We Now Know: Rethinking Cold War History (New York: Oxford University Press, 1997).


19 “The logic essentially boils down to a belief that weapons in space are an inevitability. Since weaponization of space is inevitable, the United States, as the country with the historical opportunity to be the first to field them, would be foolish not to do so. And should it not afford itself the opportunity, it will likely find itself hostage to the state that does.” Oberg, Space Power Theory, 147.

20 This is analogous to arguments of reluctant nuclear arms racers in the 1970s and 1980s that having a large nuclear arsenal than one’s adversary might be militarily irrelevant in a world of mutual assured destruction, yet still be important because of the political effect of appearing to be the dominant nuclear power. See Charles L. Glaser, “Why Do Strategists Disagree about the Requirements of Strategic Nuclear Deterrence?” in Lynn Eden and Steven E. Miller, eds. Nuclear Arguments (Ithaca: Cornell University Press, 1989), pp. 109-171.

21 A prominent example is the strong and unconditional recommendation in the USAF Scientific Advisory Board’s New World Vistas study that “The Air Force should broaden the use of space to include direct force projection against surface, airborne, and space targets,” in spite of the fact that the study included no analysis at all of the potential consequences of pursuing such a policy. (New World Vistas, Space Applications Volume, 164.)

22 This geopolitical argument is made preeminently in Everett


24 For example, *New World Vistas*, Space Applications Volume, xviii: “In the next two decades, new technologies will allow the fielding of space-based weapons of devastating effectiveness to be used to deliver energy and mass as force projection in tactical and strategic conflict. This can be done rapidly, continuously, and with surgical precision, minimizing exposure of friendly forces.”

25 Dolman, *Astropolitik*.

26 For a more detailed examination of this issue, see Mueller, “Is the Weaponization of Space Inevitable?”

27 It is possible to argue that weaponization is inevitable because the United States will certainly build such weapons for reasons internal to itself, but this is not a useful meaning of “inevitability” when seeking to guide U.S. policy.


31 Gen. Howell M. Estes III, Commander, Air Force Space Command, speech to the Air Force Association Annual

32 Regarding the dangers of faulty analogical reasoning in general, see Richard E. Neustadt and Ernest R. May, *Thinking in Time* (New York: Free Press, 1986) and Yuen Foong Khong, *Analogies at War* (Princeton: Princeton University Press, 1992). One could potentially argue that cyberspace represents a fifth environment worth considering in this context. The shape of the weaponization story for this case would depend on exactly how one defined the arena in question, and what constitutes a weapon within it. Again, some interesting parallels with the development of space technology would appear, and the overall pattern would not correspond to that of any of the other four cases.

33 As space travel expands beyond earth orbit into interplanetary space, where the transportation of material goods may finally become one of its major functions, the parallels between sea and space power may become more pronounced.


Of course, there are important physical differences between air and space warfare, such as air being territorial while low earth orbital space is not, but these do not in themselves prevent drawing parallels between the evolution of air and space power. See Bruce DeBlois, “Ascendant Realms: Characteristics of Airpower and Space Power,” in Phillip S. Meilinger, ed., *Paths of Heaven: The Evolution of Airpower Theory* (Maxwell AFB, Ala.: Air University Press, 1997), 529-78; Smith, “Ten Propositions.”


Although this is true in the aggregate, it is less true than most analysts expected it to be a few years ago, and more true in some functional areas than others. Most notably, the satellite communications boom of the 1990s has substantially leveled off due to the growth of long distance fiber optic cable networks, and the anticipated rise of commercial satellite telephone networks has been overtaken by advances in terrestrial cellular telephony; see Barry D. Watts, *The Military Use Of Space: A Diagnostic Assessment* (Washington: Center for Strategic and Budgetary Assessments, February 2001): 49-56.

A partial exception to this generalization might be the possibility of detonating an exoatmospheric nuclear explosion, which would destroy nearby satellites but also energize the Van Allen radiation belts, drastically reducing the lifespan of all un-hardened satellites orbiting at the affected altitudes. Such an attack—which would be of dubious short-term military value—might appear to be a way to use a single
nuclear weapon to produce massive economic damage without causing many human casualties (at least directly). However, it presumably would not be a way to use a nuclear weapon free from fear of retaliation.

41 It is not particularly difficult compared to building, launching, and operating satellites, however. The relative difficulty of attacking satellites in orbit is even more pronounced for non-state terrorist organizations, which are unlikely to be even remotely as capable of conducting ASAT attacks satellites as they are of striking a wide range of terrestrial economic targets.

42 It remains difficult to envision a motive for such a course of action, however. Although attacking satellites might provide an opportunity to cause economic harm without directly injuring anyone, there are plenty of terrestrial targets where this would also be true. Satellites might be attacked more covertly than most terrestrial targets (though the opposite is more likely to be true), but terrorists or other coercers would have to reveal their actions in order to achieve their goals, and any concerted anti-satellite campaign for economic warfare purposes would quickly become visible to the victim.

43 Spacy, *Does the United States Need Space-Based Weapons?*, 25-26, 33-37. Terrestrial ASAT lasers could be counter-attacked by space-to-earth weapons, but would also be vulnerable to attack by other means.


45 The greatest damage might be achieved by disabling a large part of the Global Positioning System satellite network, which would have a wide array of devastating military (and also economic) effects, especially now that many U.S. weapons are guided to their targets by GPS signals, but this would be difficult to achieve since the GPS constellation is large, hardened, and operates in relatively high altitude orbits.
Many other examples will spring to mind upon contemplating the matter, but I am reluctant to compile target lists for potential enemies.


One might also suspect that the expectations are overly shaped by the portrayals of space warfare in movies and television. This is by no means a new or surprising pattern: expectations about air warfare both before and after the First World War had much to do with the works of H. G. Wells and other authors of speculative fiction.
Chapter 2

Space Power and US Hegemony: Maintaining a Liberal World Order in the 21st Century
Everett Carl Dolman

The point of this essay is unequivocal. The question is not how to dominate space, or whether a single member of the extant state system ought dominate it, or whether the domination of outer space is even possible – these concerns have all been discussed in detail, though consensus has hardly been achieved. If one accepts for the moment, however, that space can be dominated, and that the state or entity that does so will have an enormous advantage in the extension of military power on the terrestrial battlefield, among the obvious questions to emerge are; who could, who would, and who should dominate it? Here a case is made that the United States is the morally superior choice to seize and control space, and that it should endeavor to do so as soon as possible.

The Argument

Several assumptions animate this essay, both technical and moral, and they shall be dealt with briefly. Technical assumptions are relatively clear-cut, and were introduced above. If space, or at least low-Earth orbit, can be controlled, then the state that does so will be able
to prevent others from gaining a foothold there. Also, domination of low-Earth orbit already does – and will continue to give – a tremendous advantage in terrestrial combat. Moral assumptions are more interesting, and controversial. First, the expansion of modern liberal democracy and free-trade capitalism throughout humanity is *A Good Thing*. Second, the Democratic Peace argument is valid and robust. Both will be discussed briefly, following which a case will be made that *provision of a world order that promotes and secures both economic prosperity and political rights is a collective or social good*. Accepting the logic of collective action, such a good can only be provided by a global hegemon, one that is liberal in character and endowed with the necessary power and will to enforce the compliance necessary to achieve that social good. At this moment in history, the United States is in position to take the mantel of hegemony and provide that good for all humankind. As part of the strategy for such a collective good provision, the United States must seize physical control of low-Earth orbit and station weapons there with the capacity to engage and destroy targets in space, in the atmosphere, and on the surface of Earth.

**Moral Assumption One: Liberal Democracy**

When advocating participatory or democratic government, the political structure
intended is the modern model of the liberal democratic state. This form allows the majority to express its will while retaining a commitment to individual liberty, politically and economically, through limitations placed on the capacity of government to intervene in citizen’s daily lives. There is no single functional model that best describes this form of governing, though United States-style Presidential and British-influenced Parliamentary models dominate in modern practice. Ultimately, the criterion of liberal democratic government is simple: ‘People can choose and change their government.’ The ability to change government is indispensable, and ensures that the social contract is continually renewed. The selection procedure is not mandated, though it is usually recognized as some manner of casting ballots in free and fair elections.

Thus moral, legal, and institutional constraints upon the will of the majority are intrinsic to liberal definitions of democracy. Provision must be made to limit the capacity of the majority to do whatever it will with the minority. Basic individual rights must be recognized and established as beyond the purview of the majority – through the instrument of government – to diminish. Roy Macredis and Bernard Brown provide the best explanation of how this transforms liberal democracy from mob rule to enlightened authority in their description of the Lockean or consensual model of Government. The formation of the body politic
is an act of will, symbolizing the ‘cardinal rule that the majority of the people, through their representative institutions, govern.’\textsuperscript{5} But the majority is neither arbitrary nor omnipotent. It is bound and restrained by law. \textit{Property rights} and \textit{individual freedoms} are inviolable. A minority may be coerced only to the extent necessary to implement the basic constitutive agreement, but coercion cannot be used to silence or destroy the minority. Thus, the majority has the \textit{right to act} while the minority has the right to protest, and – most critically – the right to become the majority if it can persuade defections to its point of view (hence the critical importance of free speech and assembly). This model is so powerful because it incorporates both the obligation to obey and the rights to criticize, protest, and oppose:

It allows the \textit{force} of the state to be transformed into authority, deriving its legitimacy from the basic agreement. Individual dissent is expressed not in disobedience, but through organized opposition seeking to present alternative policies. Thus, opposition in the democratic scheme is harnessed to the total political system, which is strengthened, not weakened, by political dissent.\textsuperscript{6}

To expand this assumption dramatically, liberal democracy as defined here is assumed to be good for all peoples in all times, at any place they may
be or go. A process that effects a transition to
global liberalism is desirable. An obvious
inference of this discussion is that a liberal
democratic state is alternatively structured for
international relations. Like the voting members
of its society, the leaders of liberal democracies’
act with respect for other liberal state leaders,
and accept the basic rights of survival and self-
determination of those similarly constituted
states. Only a liberal world hegemon would be
able to practice the restraint necessary to
maintain its preponderant balance of hegemonic
power without resorting to an attempt at empire.
Only a liberal hegemon could prosecute a benign
and impartial foreign policy of the type
advocated here.

**Moral Assumption Two: The Democratic Peace**

Mounting empirical evidence points to
the proliferation of modern liberal democracy as
a pacifying force in international relations.
Liberal democratic states have not gone to war
with each other, and although they have had
considerable conflicts of interest, appear content
to resolve common disputes with rare resort even
to the threat of military violence. As more states
democratize, these observations lead to the
promise of an ever-widening democratic zone of
peace, ultimately encompassing the globe and
presaging an era of international cooperation and

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stability. When all states are democratic, war will be a social relic.  
For many traditional peace theorists, who concentrate on eliminating war by reducing and eliminating the military capacity to engage in combat, democratic peace theory appears fully complementary. Since war is the problem democracy corrects, they presume the tools of war are by association anti-democratic. Reducing or eliminating arms promotes peace and decreases external threats, which in turn fosters domestic development of individual liberty. William Thompson makes precisely this point as he argues peace causes democracy, not the reverse. Moreover, when all states are democratic there will be no need to maintain the military forces necessary to prosecute war, and all states will be able, if not compelled by socio-economic necessity, to complete any remaining process of disarmament.

Most international realists instead contend that the democratic peace is a coincidental facade. They argue it is not armed force that destabilizes; it is the attitudes and perceptions of the potential wielders of weapons that matter. Stable peace, wholly desirable but fragile, can be obtained only via balancing strategies based on mutual positions of strength. Democratic states may be especially vulnerable in a less militarized world, since their societies tend to be more open, mobilization is public and difficult, and they are thus susceptible to first strike attacks. Under these conditions, all states
should avoid eliminating or unduly weakening their armed forces. To do so would be an invitation to war.

The concerns of the realists are well argued, and cast a wary doubt on the abundance of empirical evidence cited by the democratic peace proponents. Nonetheless, I accept as an analytical assumption the proposition that liberal democratic states do not go to war with each other. In this manner one can make the argument that a powerful United States, in control of outer space, should not be a traditional threat to liberal great powers. Only non-democratic states should be apprehensive or wary of American control of low-Earth orbit. The natural inhibitions of stable democratic states to mutual armed conflict will ensure these forces are used only for defense. Realists should find this assumption fully compatible with their wary views because if the democratic peace should break down, the United States will not have sacrificed military readiness to an ideal.

Technical Assumption One: Space as a Force Multiplier

Arthur C. Clarke called the 1991 Persian Gulf War ‘the world’s first satellite war.’ The critical roles of outer space assets were featured throughout that conflict, and with its successful performance, space warfare has emerged from its embryonic stage and is now fully in its infancy. From early warning and detection of missile and
force movements to target planning and battle
damage assessment, space-based intelligence
gathering assets proved themselves to be
legitimate combat force multipliers. The most
surprising and enduring contributions evident in
the expanded military role of outer space
technology, however, may have come from the
previously under-appreciated value of
navigation, communications, and weather
prediction satellites. In the post-Cold War era,
downsizing of traditional military forces
continues, access to customary forward basing is
increasingly withdrawn, high-technology
Command, Control, Communications, and
Intelligence (C3I) and mission support is
integrated into routine operating procedures, and
reliance on intelligence forecasting for optimal
troop deployments is emphasized. In this
transitional environment, employment of space
systems for all levels of inter-state conflict is
likely to increase significantly.11

The United States’ reliance on military
space support is greater than that for any other
nation. Should it be denied access to space, the
United States would be unable to conduct
coordinated, large-scale offensive military
operations abroad, and the security and economic
well-being of the United States and its allies
would be directly threatened.12 And the United
States is vulnerable to a wide array of anti-space
hostilities. These include anti-satellite attack,
physical destruction of space support centers,
electromagnetic attack (jamming) and
information attack (hacking). So potentially vulnerable are its space systems that the authors of the Space Commission Report suggest a ‘Pearl Harbor’ in space scenario is possible in the near future.\textsuperscript{13} This vulnerability has prompted several analysts to decry any attempt at weaponizing space.\textsuperscript{14} Doing so would signal weakness to potential enemies, and would encourage them to build anti-space capabilities.\textsuperscript{15} Restraint, they assert, would signal that no need to build such capabilities exists.

Such arguments are stunningly feeble. They suggest that the best protection is no protection; the more damage that can be done by the loss of an asset, the more imperative it is not to protect it. This head-in-the-sand derivative of Cold War MAD (Mutual Assured Destruction) logic is misplaced in the Space Age. Indeed, an active attempt to physically defend space assets will be a signal to others of their value to the United States. It also ratchets up the difficulty for a state attempting to deny that capability. Today, a single nuclear detonation in low-Earth orbit could cause massive long-term damage to spacecraft (to name only one of the more ubiquitous possible threats), and dozens of countries have the missile capacity to place such a device into orbit. The Cold War assumption that the anti-weaponization advocates make is that putting a device into orbit that could shoot down an attempt to place a nuclear warhead there would force potential adversaries to take
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precisely that action before the defensive device became operational.

This is similar to the anti-Strategic Defense Initiative (SDI or ‘Star Wars’) logic that said development of an anti-missile shield would force the Soviet Union to attack the United States (with nuclear weapons) before it could be deployed. Of course, to do so would have been suicide. The American MAD policy guaranteed it. The balance of terror created by mutually defenseless nuclear powers was thought to deter the possibility of nuclear war. Thus a launch against the United States would have been by definition an irrational act. And there’s the rub. One cannot deter an irrational act. One can only defend against it.

Because of their value and importance, an attack on United States space assets will likely receive some retaliation whether there are weapons in space or not, and hence the deterrent – what there is – is already in place. But is it enough of a deterrent? We simply have no way of knowing for sure if deterrence works, or if it has ever worked. We can only know when it fails. If deterrence, no matter how credible or overawing it may seem, fails, then the deterrer must suffer the consequences or be prepared to defend against the transgression. This is precisely the point. It may be that no state would ever attempt to attack the United States’ space-based capabilities – but if some state (or non-state group) does attack, it is presently unobstructed.
Technical Assumption Two: Space as the “Unflankable” High Ground

Technology should not drive policy. The fact that it does is hereby overlooked. There is no attempt here to describe or advocate precisely what weapons systems will or can be placed into orbit. They must be able to strike targets in the air, at sea, and on the ground, however, because of the advantages endowed from that location. In a two-dimensional rendering, Earth is to low-Earth orbit what a deep pit is to a military planner. Armaments placed in orbit, at or near the top of the planet’s gravity well have obvious and enormous strategic advantage as the ultimate high ground.

In 1981, G.H. Stine wrote of the energy and maneuver advantages of high ground positions in outer space. The first, energy advantage, is a firepower benefit because weapons placed higher in the gravity well gain the downward momentum – velocity in the power equation velocity times mass – while kinetic energy weapons firing up the gravity well lose momentum, thus power. The maneuver advantage comes because spacecraft higher up in the gravity well have more time to observe and react to attacks than those at lower positions. Stine argued that true tactical and operational advantage in space would go to those who could dominate the top of the gravity wells, and the best positions were those that because of
counterbalancing gravitational forces had no
down well pull in any direction.

The important factor here is that once a
state has established weapons in space capable of
shooting down rockets and launch vehicles in
boost, no other state can put weapons there.
Total domination of space is effected. Fears of an
arms race in space are eliminated. Only in the
situation where more than one side can place
weapons into space is an arms race possible (e.g.
the Cold War). This is because both sides will be
attempting to fill and dominate the position
before the other, taking advantage of orbital
placement to acquire tactical superiority over the
process. Where such an indeterminate outcome is
possible, both sides have an incentive to create
legal and international restraints that make it
difficult for either side to engage in such an
activity. If, as is the case today (though for how
long is unknown), only the United States has the
capacity to place weapons into space quickly
enough to gain an insurmountable edge on its
potential rivals, then a window of opportunity
exists to seize this vital territory without
significantly countering space opposition or
competition. Once in place, the entry cost for an
opponent to attempt to vie for space dominance
is too high.

The analogy is to a blockade of a small
island, or perhaps a siege. The United States, due
to its fortunate geographic position, can re-
supply, replace, and reinforce its space assets
indefinitely. Moreover, and unlike a siege or
blockade, there is no force outside the boundary that can break the siege. The rear and flanks of space are not vulnerable. The only kinetic attack on space assets so deployed must come from Earth, up the viciously steep gravity well and vulnerable to the very weapons they wish to engage. Laser or other directed energy antisatellite weapons could be destroyed before they come on line, as manufacture and assembly of such weapons would be observable from the high perch of low-Earth orbit, but even should these manage to come on line, the optical targeting effects of Earth to space are vastly more difficult than from space to Earth.

Ultimately, the reliance that the United States has placed in space assets – a reliance that grows daily – is substantiation enough that physical protection of these assets is needed in addition to deterrent threats. The strategic advantage from occupying then denying access to potential threat use of space is so compelling, and today so tantalizingly possible, that to wait would be to irresponsibly cede the initiative. And perhaps today the United States is finally psychologically prepared to take on the responsibility of reluctant international sheriff. Isolationist from birth, this is a duty the United States has traditionally shirked, almost always to its detriment. Since the terrorist events of September 11, however, the United States has moved closer to its unwanted role of global policing. It is intent on ferreting out and destroying global terrorism networks. It has
declared and acted on the New World Order dictum that international disputes shall not be settled by violence. Like it or not, the time has come for the United States to accept its responsibility as steward of the world’s democratic movement, and to create the stability needed for global peace and prosperity. The world will be a better place for it.

**Weaponization of Space – Pro and Con:**

The *weaponization* of space is often depicted as a radical option in the pantheon of options in the debate over the *militarization* of space, but this is a naïve view. The fact is that the militarization of Space is a *fait accomplis*, and like Pandora’s box, there may be no going back. In the range of postures outlined at figure 1, the world is already well right of center on the weaponization scale (at surface and space to space antisatellite (ASAT) capability).

Still, compatible with the view that space is the province of all mankind, and that its riches belong to all of the peoples of Earth, demilitarization is seen as a viable strategy. This stance is centered in the notion that space is a sanctuary from the evils of this planet. Why spread the disease of war and violence to the cosmos? Indeed, from this perspective, space may be the only hope for the future of humanity. As we destroy our planet through nuclear or political abuse and environmental misuse, space as pristine frontier looms ever more valuable as
the last, best refuge of humanity. And it could work, say proponents. Antarctica has been collectively held as an international common for over forty years (though it’s resource potential has barely been tapped). The same model could and should apply to space, say the space sanctuary proponents. The argument is an old one. Alton Frye wrote in 1963:

There is a strong American consensus in support of the basic elements of national space policy. The world will be a much safer place if we can succeed in maintaining space as a sanctuary for purely peaceful activities. [But] how do we keep the arms race from spreading to this new arena? Presently the United States hopes to accomplish this noble purpose by a declared policy of abstaining from developing space weapons. While pressing for international agreement on the peaceful use of space, we promise the Soviets that we will refrain from orbiting weapons of mass destruction so long as they do not station such devices in space.¹⁸
Yet even 40 years ago, Frye recognized that despite the noble intentions of his argument, space had already been militarized, and weaponization of the realm was moving apace. David Zeigler provides a subtler and more powerful argument.\footnote{David Zeigler provides a subtler and more powerful argument.\footnote{David Zeigler provides a subtler and more powerful argument.}} His space as strategic sanctuary thesis argues that the militarization of space actually detracts from the security of states that pursue it. Whereas a space militarization policy may have been consistent with Cold War strategies, it may not be at all appropriate in a post-Cold War world. Although the sanctuary argument, ‘in the strictest sense, [claims] space is a sanctuary when it is completely unthreatened by terrestrial or space-based weapons,’ Zeigler, too, admits this is problematic.\footnote{David Zeigler provides a subtler and more powerful argument.\footnote{David Zeigler provides a subtler and more powerful argument.}} So Zeigler suggests a more flexible and useful point, that space is a sanctuary ‘so long as nations truly intended never to use space weapons,’ a condition he claims exists precariously today.\footnote{David Zeigler provides a subtler and more powerful argument.\footnote{David Zeigler provides a subtler and more powerful argument.}} Initially, America and the world embraced space as sanctuary policy because of the extraordinary vulnerability of their fragile but immensely useful on-orbit assets. Blatant arming of space or the creation of new and effective antisatellite capabilities would only serve to induce other states to match or surpass United States capability, and would threaten its most expensive and vital military support link. Additionally, the deterrent logic of MAD might be abrogated in the deployment of space-to-ground weapons in the future. The 30-35 minute warning of an
ICBM attack, and at least several minute warning of Medium and Short Range Ballistic Missile attack were deemed necessary for calculated national responses. Nuclear bombardment from space-based platforms would bypass satellite and ground radar monitoring systems thus providing no effective warning time, and the potential for surprise attack would have been increased. In practice, however, Zeigler must concede the fragile basis for his point. The world’s space faring nations had been publicly employing the sanctuary argument even as they cautiously and covertly developed space weaponization policies. The intent to use weapons was always publicly denied, but privately reserved as a viable option.

In the current post-Cold War environment, Zeigler maintains the need for space sanctuary is greater than ever before. First, states increasingly deploy and rely on space systems for battlefield support, so just the threat of losing those systems makes states less secure overall. If states were monitoring terrestrial crises with satellites, any attempt to deprive them of that information (through jamming, laser ‘blinding,’ or direct ASAT attack) could be interpreted as preparation for imminent hostilities. States so deprived might feel compelled to launch a first strike. Second, it is unwise and premature to invest heavily in space weapons when so many pressing battlefield hardware and personnel requirements go unfilled. All of the services have seen cuts in
budgets that effect readiness and morale. Space weapons are costly and, in Zeigler’s view, grossly overrated. In addition, space weapons are simply not as cost-effective as passive countermeasures against enemy space capabilities. Third, the United States’s ‘physical security, economic well-being, and democratic expansion depend on the quality of American international relations,’ and any attempt to weaponize space would be ‘unacceptably provocative,’ leading to ‘global instability.’ Ultimately, Zeigler’s argument rests on the conviction that military space power has been overstated, and that existing United States conventional capabilities are more than adequate for its security needs (if properly funded) even with the loss of space-based support. The claim is not convincing.

At the opposite side of the options spectrum is full armament of space. Space as the ultimate high ground is the prevalent view here, and as a counter to the space sanctuary argument it stems from the notion that the weaponization of space is inevitable. So long as the fight is surely coming, one ought stake out and maintain the best defensive positions and be prepared for any contingency. In 1997, then Commander-in-Chief of United States Space Command General Joseph Ashy declared that the United States was becoming so dependent on space systems for its armed forces that it had [perhaps unwittingly] created an enormous incentive for future enemies
to target them. The United States, Ashy said, “must be prepared to defend these systems.”

It’s politically sensitive, but it’s going to happen … we’re going to fight in space. We’re going to fight from space and we’re going to fight into space … That’s why the US has development programs in directed energy and hit-to-kill mechanisms. We’ll expand into these two missions – space control and space force application – because they will become increasingly important. We will engage terrestrial targets someday – ships, airplanes, land targets – from space. We will engage targets in space, from space.

All views depicted at Figure 1 have the same goal, limiting the likelihood (if not possibility) of space war. The radical armaments view has never been subtly portrayed, an omission I hope to address directly.

**Social Choice Theory**

This simple and astonishing observation is the crux of Mancur Olson’s work on collective, public, or social goods theory:

unless the number of individuals in a group is quite small, or unless there is coercion or some other special device to make individuals act in their common
interests, rational, self-interested individuals will not act to achieve their common or group interests. In other words, even if all the individuals in a group are rational and self-interested, and would gain if [as a group] they acted to achieve their common interest or objective, they will still not voluntarily act to achieve that common or group interest.27

The size of the group is important, and the failure of individuals to act in support of group welfare increases as the size of the group increases. Hence large groups are especially prone to this paradox (small groups may routinely overcome it), but ‘even when there is unanimous agreement in a group about [what] the common good [is] and the [best] methods of achieving it,’ it will rarely be attained.

Much hinges on a specific definition of what a collective good is. A common, collective, or public good is one that is enjoyed by all members of a group. It must have the characteristic that if it is available to everyone if it is available to anyone. A second characteristic of these goods is that the act of consuming it by one member of the group does not diminish the ability of other members of the group to consume it. As becomes quickly apparent, public or collective goods are very narrowly defined, but they represent some of our most important or cherished possessions. In the international realm,
peace is a typical example. That one state enjoys the benefits of a stable international peace does not infringe on any other state’s capacity to enjoy or share in it. Nor is the peace used up by the act of one state consuming of it first. This is not to say that a collective good cannot be provided in limited amounts – the peace may be unstable or only effective so long as one state does not engage in an arms race with another, but the amount of benefit any one state receives does not diminish the amount of benefit another state can receive.

An instantly recognizable example may be environmental strides accomplished via anti-pollution measures for factory or automobile emissions. The measures might not be sufficient to make the air pure, but all who breathe it will enjoy any incremental improvement without discrimination. Even though not everyone provides or partakes of the good equally, once provided it cannot be withheld. This is the entry point for the most infamous of Olson’s neoclassical actors, the free rider. Despite the fact that these goods are universally recognized as desirable, the ability of groups to provide them is almost always suboptimal. Indeed, the larger the group, the greater the number of free riders, and the less likely the good will be provided.

It is this specific problem of free riding that Olson tries to correct. The problem begins in the formation or recognition of the group itself. Once a group is identified (or created) it is
quickly apparent that it has collective goods. But it is the notion that an individual could (or should) further personal goals by forming or joining a group is precisely Olson’s point of fallacy: ‘All the members of a labor union, for example, have a common interest in higher wages’ [but since] at the same time each worker has a unique interest in his personal income [which depends not only on the rate of wages but hours worked], the interests of the individual and the group must conflict.

Groups form in various sizes, with relative efficiencies depending on their purposes. The size of the group has enormous repercussions for the ability of the group to provide common goods. When common goods are provided to their maximum level, the condition is optimality (an optimal public good might be free and unlimited solar power). Small groups, those in which each member has personal awareness and interaction with every other member, can for a variety of reasons, provide optimal or full public goods for their members. Here, each member’s efforts to provide or avoid providing for the collective good are transparent to all, and would bring about noticeable differences in the welfare of others in the group. Transparency makes cooperation likely. Strategic interaction, or bargaining, may be quite useful in the process of providing a common good here. More typically, in small groups it is possible that a single individual may receive such a large benefit from
the provision of a public good that she is willing to provide that good entirely on her own. This is a variation of the Cournot solution to the Coase theorem and can be distilled into the common-sense statement that an individual or firm will act to keep the price of its product (or the wage she receives) high only when the total cost of keeping the price or wage up is not more than its share of gain from the higher price. In other words, if the individual will receive a higher wage or price even after subtracting the cost of action, then the individual or firm may still act to do so, even though other individuals who do not act in the common interest will receive a benefit.

Thus, in a very small group, where one individual gains so much from bearing the entire cost, common goods can be provided by the actions of one or more self-interested and rational actors. Even so, the nature of common goods is such that they will not normally be provided on an optimum scale. That is to say, supplying members of the group will not provide so much of the good as it would be in the common interest of all to receive, but only in the amount of their own individual interest; just enough so that they could consume enough to optimize (not maximize) their own individual needs, but not necessarily enough for everyone else.

This predisposition toward suboptimality may help explain the apparent tendency for large countries to bear disproportionate shares of the costs of multinational organizations such as the
United Nations, International Monetary Fund, and the World Trade Organization. It also helps explain why these organizations continually complain that they are under funded. These are better defined as intermediate size groups, those in which no single member can get such a large benefit from the collective good that it would be willing to bear the entire cost itself, but in which the individual was so important in terms of the whole group that its actions will have a noticeable effect on the welfare of the other members. The now famous tragedy of the commons example is one of an intermediate group. Whether or not the public good is provided in the case of the intermediate group is indeterminate.

Large groups are those in which no single individual’s contribution or lack thereof makes a perceptible difference to the group as a whole. It is certain in these cases that a collective good will not be provided unless some outside inducements or coercion lead or force the individual members to act in their own common interest. It is possible, of course, that in the intermediate or large group individuals may cohere into smaller subgroups, and that one of these subgroups may act unilaterally in the common interest. Such a development would be effectively transforming the large group of individuals into a small group of groups. Olson calls this a type of federalism. The small group may get along without any group agreement or organization, since there
is an incentive for unilateral and individual action to obtain the collective good. In any group larger than this, no collective good can be obtained without some form of organization, group agreement, or other form of coordination. Moreover, the larger the group is, the more agreement and coordination it will need. This organization is not free. The costs of organizing include starting and maintaining communication among members, the costs of bargaining, and creating, staffing, and maintaining any formal organizations. These are costs associated with and in addition to those needed for directly providing the common good. This also means that the cost of the first unit of the collective good will be higher than subsequent units, thus making the problem worse.

There are now three separate but cumulative factors that keep larger groups from furthering their own interests: (1) the larger the group, the smaller the fraction of the total group benefit any individual acting in the group interest will receive; (2) the larger the group, the less likely any small subset of the group (much less any individual) will gain enough from the collective good to bear the burden of providing even a small amount of it; and (3) the larger the group, the greater the organization costs, and thus the higher the hurdle before any of the collective good (the first unit) can be obtained at all.

Under the neoclassical paradigm, ‘it is certainly in the interests of the individual to
agree to constrain behavior by setting up a group of rules to govern individual action, but it is also in the interest of the neoclassical actor to disobey those rules whenever an individualistic calculation of benefits and costs dictates such action.30 According to Olson, the only way that individuals in intermediate or larger groups can be stimulated to act in the common interest is through the provision of separate and selective incentives. The incentive must be separate so that no individual outside the group will receive the benefit, and selective so that no individual inside the group will receive it that does not contribute to it. In a significant way, it is the transformation of the public good into a private one. These incentives can be either positive or negative, reward or punishment. They are also called ‘side-payments’ in the jargon of the economist.

Usually, these separate incentives are lumped under altruism or group interest. Marx believed that individuals only needed to become aware of their class interests and they would naturally act in them. Olson argues (persuasively at times, though in a way that suggests the theory may not be falsifiable), that people acting in the common interest to win friends, prestige, respect, and other socio-psychological objectives are in fact acting for the attainment of individual, not collective goods. ‘The recalcitrant individual can be ostracized, and the cooperative individual can be invited into the center of the charmed circle.’31 These desires to be accepted are not the
focus of participation, and are collective goods. They are, nonetheless, effectively indistinguishable from the attainment of the public good, though they can work in powerful ways against the attainment of the public good when dealing with large groups, and only serve to strengthen his original statements. In a farming community, for instance, the most productive farmer (who sells the most and thus does the most to lower the price of her produce by increasing supply) is admired for her skills and usually attains the highest community status.

In a last word on altruism, Olson remarks, ‘selfless behavior that has no perceptible effect is not even considered praiseworthy. A man who tried to hold back a flood with a [bucket] is probably considered more of a crank than a saint, even [and especially] by those he was trying to help.’

We now have two methods to solve the dilemma of collective good provisioning. In the cases of peace and prosperity, the largest member or members of the international group of states (in terms of wealth and power) could come forward and provide those goods unilaterally, recognizing that the rest of the states will gain substantially from this largesse and will not have to bear a share of the cost burden. The other possibility is for this large state or group of states to pay the costs of organization, monitoring, and then enforce a regime that provides separate and selective incentives for the collective good. Smaller states would be required to pay a share
of the costs to partake in the good. The latter option is less expensive for the providing states, but it is far less likely to provide optimum levels of peace and prosperity. Following the perverse logic of the tragedy of the commons, in order to save it, it may have to be destroyed. The proposal hereafter is that the United States should eschew the latter option and embrace the former. It should assume the role of unilateral provider of the public good, forcing compliance with international norms of peace and free-market ones of openness and non-discrimination. Its costs will be high, but it will gain a greater benefit than any other state in doing so. No more efficient tool for accomplishing this than control of space through weaponization is available.

**Hegemonic Stability Theory**

One of the most valuable characteristics of Hegemonic Stability Theory (HST) is its parsimony. Simply stated, HST avers that a world liberal economy cannot exist without the parallel rise and dominance of hegemonic power with global reach. Only a hegemon, it is argued, can establish the system of rules, norms, and standards of behavior necessary to proper order. Moreover, and in keeping with Olson’s theory, only when the hegemon is at or near the height of its political prowess can it create a world-political economy that takes advantage of its pre-eminent position. When the hegemon is in decline, it finds it increasingly difficult to
maintain the system, and the liberal world economic system fails.

The indisputable conviction of the first years of the twenty-first century is that the United States is in an era of unprecedented hegemonic power (hyper-power, the French call it), eclipsing even its enormous economic hegemony immediately following World War II. Due almost entirely to the absence of a superpower challenger of equal military clout, most international theorists recognize that the United States is in a rare position of influence. Whether it will take advantage of this perhaps unexpected window of opportunity to restructure and strengthen the international system compatible with liberal, capitalist values, or vacillate until that window eventually slams shut, is the object of much deliberation. Whether it should take the opportunity is of even greater importance to those who see liberal, free-market values as some sort of Pandora’s box of evil set loose to ravage the innocents of the world.

It is useful, I believe, to continue the discussion of hegemony not with the now-classic version, but with the powerful insights of a neo-Marxist theorist, Immanuel Wallerstein.34 His model is more rigorous than the neoclassicists, and is highly heuristic. It centers on the rise and functions of the ‘Capitalist World Economy,’ evident from the so-called long sixteenth century to the present. Its original boundaries included (most of) Europe plus Iberian America but subsequently expanded to include the entire
globe. This totality is assumed to be a *system*, which Wallerstein defines as having ‘patterns that are explicable largely in terms of its internal dynamics.’ Hence the system has *structures*, and these structures manifest themselves in *cyclical rhythms* that are discernible. But no rhythmic movement ever returns the system to a previous equilibrium; rather these rhythms move it along a knowable continuum.

Hegemony refers to that situation in which the ongoing rivalry between the great powers is so unbalanced that one power is truly *primus inter pares*; that is, one power can largely impose its rules and wishes in the economic, political, military, diplomatic, and even cultural arenas. This is clearly not meant to imply omnipotence. The hegemon cannot do anything it wants. In such a case the hegemon would have transformed the interstate system into a world empire – omnipotence by definition cannot exist in an interstate *system*. Hegemony is therefore not a state of being but one end of a rather fluid continuum that describes the rivalries of great powers. At one end is an even balance – all major powers are roughly equal and no group of states has a preferred or continuous alliance. This is at least as rare as hegemony, and probably less stable. More common is a pattern of shifting alliances in which multiple great powers exist but they are grouped into two or more relatively equal camps with neither side able to impose its will on the other. In this situation the balancing or swing state often dominates. Perpetual
conflict and the ever-present threat of war is endemic. Near the other end of this continuum lies hegemony. Here, one state is unchallenged for primacy by any other power or combination of powers, but it is not omnipotent. In this case the primary state gains so much from the extant system that it is willing and able to pay the maintenance costs unilaterally. It does not have the power (or the desire) to create an empire, however, and this becomes the cause of its inevitable demise.
Using this restrictive definition, Wallerstein tells us there have been only three instances of hegemony in the capitalist world economy: the United Provinces, from 1620 to 1672; the United Kingdom, from 1815 to 1873; and the United States, from 1945 to 1967. In each case, four observations stand out. First, commercial enterprise within the hegemonic state achieved a competitive edge in global agro-industrial production, then in commerce (or the movement of goods), then in finance. Each lost its edge in the same order (this process having begun but not yet been completed in the third instance). Thus the period of hegemony can be precisely identified. It is that period when all three factors are dominated by the hegemonic power. Second, in their respective periods of hegemonic dominance, each power was the system’s primary advocate of free trade and enlightened liberal values. They opposed mercantilist restrictions on trade, began the process of decolonization, and championed the notion of the free movement of the factors of production to include a generally open immigration policy for foreign labor. Trade liberalism prompted political liberalism, and all supported democratizing political reform and recognition of civil liberties at home and abroad. Their support was not perfect, to be sure. But given their era, they were the most liberal and reforming of the major powers.

Third, in each case, hegemony was initiated at the conclusion of a thirty-year long
world war. This astonishing similarity coincides with the fact that there have only been three such wars in the modern era (a world war must include all of the system’s major powers actively reacting to an attempt by one or more of those powers to overturn the extant balance of power – this type of war is also called ‘hegemonic warfare’ by Robert Gilpin\(^35\)).

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<th>WAR</th>
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<tr>
<td>World War Alpha</td>
<td>1618-1648</td>
<td>Dutch triumph over Hapsburgs</td>
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<td>Thirty Years War</td>
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<td>Peace of Westphalia</td>
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<td>World War Beta</td>
<td>1792-1815</td>
<td>British triumph over French</td>
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<td>World War Gamma</td>
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The logistical pattern of the wars is instructive, as the process shapes a period of competitive economic and military expansion that results in the unique concentration of economic and political power required for
hegemony. Due to a *geographically protected* defensive position, the future hegemon protects its industry from direct harm, and provides the weapons and supplies necessary for the winning coalition to prevail. The ultimate victor avoids direct battle for most of the period, entering decisively at the end. In this manner, the new hegemon emerges from the thirty-year conflict with swollen financial coffers, a relatively fresh though veteran military, a dominating industrial base, and exhausted enemies. It is further instructive to note that the power that assumes hegemonic status is the major sea power – or today, sea-air-and space power – of its era. Indeed, this reliance on mobile forces may in fact be part of the reason for the rising hegemon’s liberalism.

The military is customarily understood to have two primary roles: defense of the state from external threat and defense of the government from internal rebellion. The former role is conducive to liberty and democracy, for it protects and nurtures society. Without a military force to shelter it, democratic society would fall prey to neighboring expansionist authoritarian states. The latter role is obviously not conducive to liberty and democracy. In effect, the military becomes a tool of oppression. Otto Hintze believed that a military structure dominated by the army is prone to succumbing to the latter role, but a structure dominated by the navy is not. This is, in Hintze’s view, simply because the navy is not organized to occupy territory.
Some navies may have tremendous power projection abroad, but they have little or no ability to direct their power sufficiently inland to influence internal public behavior. Hence, nations that have traditionally relied on naval power for state security (e.g. Britain and the United States) developed relatively more democratic and enlightened constitutions than their land-power contemporaries. Problematic for political idealists, however, is that Hintze was describing an historical tendency without making any recommendations for reform. Reliance on a navy is not possible in a state surrounded by hostile land-based powers. The good political fortune of Holland, Britain, and the United States came far more from their geopolitically isolated positions than from any conscious decision to pursue naval over land power.

Fourth, the outcome of each world war included a major restructuring of the interstate system consonant with the relative stability requirements of the now-dominant hegemonic power (see figure 4). It is worth noting that once the system starts to erode (beginning with the loss of efficiency in the agro-industrial sector), the hegemonic state becomes less willing to pay the costs of maintaining that system, and becomes less liberal and more mercantilist. A period of equivocal balance of power conflicts ensue as a new land power rises, and ultimately an attempt is made to assume hegemony by the rising power. The old hegemon opposes this, but is in too weak a position to defeat the challenger,
and must receive massive support from the rising naval/aerospace power. The rising power gains much of its strength by manufacturing the munitions of the countervailing coalition and taking over trade and supply routes necessary to the war effort – and by avoiding direct military participation until decisive moments of the conflict.

If we cling closely to the Wallersteinian model, we must conclude that the United States began to lose its grip on hegemony in 1967, the year Japan gained an edge in the production of electronic and other highly desired industrial products. The small number of cases makes projections tenuous, but it appeared in the late 1970s that the United States was indeed mired in a period of inevitable decline.

Wallerstein’s theories were undermined by the apparent resurgence of the United States after the collapse of the Japanese economy and the demise of the Soviet Union. The rapid and convincing victory of the United States in the Gulf War contributed to a general skepticism of Wallerstein’s small-\(n\) analysis. Yet, one could extend Wallerstein’s logic easily. With so few cases, the parallels require fine-tuning. It is possible that the third period of hegemonic dominance overlapped the period of a rising new challenger (the Soviet Union), and after a thirty-year war (World War Delta, or the Cold War 1949-89), the United States re-emerged in a period of fresh hegemony. In this interpretation, its second attempt to remake the world to its
advantage began in earnest in 1991, when President George Bush declared a ‘new world order’ at the conclusion of the Gulf War.

The neoclassic and Marxist HST tells us that hegemonies decline. It is inevitable. Renewals can occur, maybe, but perpetual renewal seems logically impossible. Still, a maximum extension of the beneficent hegemonic period of dominance does seem viable, and desirable. The notion is clearly Machiavellian. Strongly convinced that all governments must eventually fall, Machiavelli viewed the state in terms of a living thing. All must be born, grow, and die in a predetermined cyclical progression. The state must pass through the various sequences of tyranny, oligarchy, and republicanism, each born of virtù and destroyed by idleness, or ozio. The order of progression was fixed, but the length of each reign is pummeled by luck (fortuna). Particularly wise and able individuals might stave off the ravages of fortuna, however, and prolong the best kind of government, that being a republican form founded in law, for generations. This completes the foundation the argument here. An enlightened leader can act now to prolong the period of liberal American hegemony. But if nothing is done (idleness), the inevitable decline will come relatively soon – and its effects will be harsh.

The fundamental problem for hegemony is that the hegemon is structurally bound to demise by the needs of the system it creates. It
must be understood that a free market is not created or maintained without significant enabling costs; thus it is neither free nor spontaneous. It appears free so long as a government or power willing and able to enforce the openness of it exists. That power must provide, at a minimum, a political definition of property rights, an exchange medium (money), and a police and court system that can protect individuals and firms who make free and fair contracts from being swindled, robbed, or looted by others. When the market fails, there is no mechanism within the market that can right it (e.g. monopoly). Market correction is handled outside the system, and there is a cost to this. In the interstate system, no government exists, so any state that wishes to enforce an international free trade system must bear the costs, or pay the costs of forcing others to do so. The state will continue to do so only so long as the benefits of the system exceed these costs. In the meantime, not only will free riders be endemic, states that perceive the free trade system is not to their advantage will work to undermine it, adding to maintenance costs. Within the domestic economy of the hegemon, entrepreneurs will seek state interference in the market that gives them a competitive edge (tariffs, subsidies, embargoes, etc.).

Not only are a higher proportion of the costs paid by the hegemon, openness makes it impossible to retard the diffusion of organizational, technological, and economic
expertise. It is inevitable that entrepreneurs will come along who can enter into the most profitable markets with the most advanced technologies and newer facilities, inexorably eating away at the material base of the hegemon’s agro-industrial edge. Moreover, steady rises of real income of the working class within its borders will over time reduce the competitive advantages of the hegemon.

Once the clear productivity edge is lost, the structure cracks. A scramble arises to replace the relatively diminished productive capacity of the hegemon within the system. By this definition and analysis, Wallerstein argued that the late 1970s represented the immediate post-hegemonic phase of the third logistic of the capitalist world economy. The United States had lost its productive edge, but not quite yet its commercial and financial superiorities. It was, of course, just the beginning of the demise, and the United States could be expected to have periods of apparent resurgence.

Whether the United States is in a period of relative ascendancy due to the demise of its major competitor, but still in the process of declining hegemony, or it has entered a new, fourth phase of hegemonic dominance is of crucial importance. A hegemon in decline will withdraw; it will seek to preserve as long as possible its dwindling market share and its military advantage. A rising hegemon nearing the peak of its power will attempt to reinvigorate liberal trade and political regimes, creating a new
world order in its own image, one that is advantageous to the hegemon but that will expand economic and political power around the globe in order to make it more prosperous and secure.

The power, economic and military, of the hegemon is the tool used to coerce or convince other states to continue to participate in the public good/liberal world economy. Refusal of access to domestic markets, through tariffs, etc., can be used as a punishment for wayward states, as can the withdrawal of cheap credit or access to technology. Conversely, access can be used as a reward. States that blatantly reject the world order are punished militarily. This is the primary reason that HST can predict that the more one such power dominates the world economy, the more cooperative interstate relations – even, one presumes, to the point of empire, when international relations are transformed into internal ones and are thus totally integrated.

Two problems persist. First, given the obvious high costs to be a good or effective hegemon, why would any state want to be the hegemon? What gains could possibly be worth the costs? Second, how can the hegemon stay on top? These costs will undermine any absolute advantage in growth and allow other states to catch up, eroding the preponderance of power the hegemon needs to act as the hegemon.

The first dilemma is answered altruistically. International peace is a good worth pursuing, even if it must be pursued unilaterally
by the United States, on behalf of all the peoples of this Earth. Global prosperity, that is, a satisfyingly rising per capita income in all countries, even at the expense of the relative decline of United States per capita income, is also a morally good – and economically beneficial – outcome of a true free trade program shouldered by the wealthiest nation ever conceived. The second dilemma is a necessary outcome of the model. The hegemon will decline. Isn’t it better that it decline into a world of peace and prosperity than one of war and poverty? If the United States can establish, through force if necessary, a peaceful and prosperous world order, other states should recognize their beneficial places in it and continue to cooperate when the power of the hegemon has diminished so much that it cannot unilaterally provide those goods.38

**Space as Enabler of the New World Order**  
(Second US Hegemony)

The goals here are to establish the most beneficial global conditions for an extended and robust era of peace and prosperity – for all states. Requisite for the purpose is a maximization of the period of hegemony of the United States. Control of space is critical to this need.

Space has the unique capacity of being the “unflankable” high ground. So tactically advantageous is the high ground position that has
both line of site over and defensive domination of the battlefield that commanders have always sought it. Space control is not only tactically advantageous on the battlefield, it is strategically so in diplomacy. The entity in control of space has real-time presence and persistence over the globe. So strong is the fortified position at the top of the Earth’s gravity well that should *any* nation seize it, it could effectively deny access to space to any other state that should attempt to put assets there. A simple argument could be made that the United States has an imperative to seize control of space on this point alone, to prevent a dangerous enemy from taking it, but such a case could be made for any state that desired domination over the world. My point is that not only is the United States the sole country with the capacity to seize space (currently), it is the only great power that has a history of benign intervention and overall disdain of empire that it is morally important it do so before any state bent on world domination and oppression can.

**ABM vs NMD as a Case in Point**

To illustrate the advantages of a power projection capacity in outer space, a description of the technical and political pros and cons of ballistic missile defense (BMD) is offered for comparison. Not only is BMD the first step in a sequence of events heading to full space weaponization, the ‘most likely’ area in which the United States might ‘act unilaterally’ to put a
space-based weapons system in place is in the area of BMD. The debate over where the next generation BMD system is best placed is certainly not over, and a space-based system at this time is not the front-runner for deployment. But the advantages of a system that could eliminate the threat of accidental, rogue state, or terrorist launches of nuclear missiles is so compelling that it is highly likely to be attempted regardless of opposition efforts.

The now-defunct 1972 Anti-Ballistic Missile (ABM) Treaty placed strict constraints on the ability of the two superpowers to defend themselves from missile attack. The logic was simple, if morally perverse. The deployment of an effective ABM defense would eliminate the threat of guaranteed retaliation, the vaunted ‘second strike’ capability that would deter any state from attempting a crippling nuclear ‘first strike.’ The necessity of mutual and assured destruction was the dominant principle in the precarious balance of terror that would supposedly ensure world peace.

The logic was flawless, but not comforting. It meant that if a missile were launched, accidentally or on purpose, it would hit and destroy its target. There was (and still is) no means to protect the citizens of this or any country (excepting possibly the city of Moscow) from ballistic devastation. From this perspective, on 23 March 1983, President Reagan offered to the nation a vision for strategic missile defense, derisively dubbed Star Wars.
The core of negative views centered on two general arguments: the United States could not BMD, and it should not do so. The first argument is technical, the second normative. It is of more than passing interest to note that the bulk of the published technical opposition came from journalists and non-scientists, while the scientists tended to argue publicly that BMD was morally flawed. At any rate, the pared down technology argument was that the President’s ambitions were too complex. The possibility of a perfect nuclear shield could never be realized, regardless of the amount of research effort and expense was applied. The Soviets could simply overwhelm whatever capacity the United States could deploy. The normative or moral arguments were more diverse. The most compelling at the time was that if the United State could develop a nuclear shield capacity, the Soviets would be forced to attack before the shield could be deployed, or lose forever their ability to wage nuclear war (and be treated as an equal). The other prominent moral argument was that the vast amounts of money being spent on space defense could be better used on domestic programs like public education, highway and transportation upgrades, and the like. Besides, the protesters argued, the mutual deterrence of the balance of terror was apparently working, why fix something that wasn’t broken?

The first argument, that the technology to deploy a missile defense shield will never be developed, is quickly dispatched by analogy.
History is replete with scientific advances over the popular diatribes that a thing can’t be done (‘man will never fly,’ comes to mind). The ingenuity of the scientific community accepts such dares willingly. The real technical question is not can the task be done, but can the task be done for the amount of money available? Thirty-five to three hundred billion dollars, the original cost estimates, are in retrospect far too low. Three to five trillion dollars, however, might just turn the trick.

The second set of arguments is equally flawed. The first notion, that fielding BMD would compel the Soviets to attack in advance of operational deployment is astonishing. It presupposes that the United states, once safe from the Soviet nuclear threat, would be ready and willing, indeed anxious to devastate the Soviet state with a rain of nuclear bombardment. No other assumption could cause the Soviets to attack the United States prior to the deployment of BMD but still at a time the United States could launch a devastating retaliatory strike. Put bluntly, in order to believe the Soviets would be forced to peremptorily attack, one must assume that mutual assured destruction of both sides was preferable to the inevitable destruction of just the Soviet side by the Americans.

The latter in the second set of arguments is also problematic. It presupposes that spending on space weapons and technology will take away from the quality of life on Earth. Aside from the banal statement that the quality of life is
minimized by death, foregoing a defensive system to put increased funds into infrastructure also assumes that the funds for BMD research would have been made available instead for expenditures preferred by the opponents of the program. Not likely, as the state would simply shift the appropriations to more conventional areas of the military budget. Even if the death of a program gave an unexpected windfall of public funds, again unlikely since most of the proposed money was for future budgets, there was no guarantee that monies saved would not go back to the public in the form of lower taxes. It further assumes there is no productive benefit to the state from research and development in space weapons applications. To the contrary, the American and world economies have already benefited greatly in the miniaturization and computing technologies developed for BMD programs. Military space programs, not the least of which is a robust space launch capacity, are the backbone of many civilian space operations, and the resultant economic advantages of telecommunications, navigation, earth-sensing, and weather satellites are today obvious. The spin-off technology and follow-on economic effects of space research and development are abundant, and must be factored into the cost calculations of the state.

Nonetheless, the complaints of the naysayers were heard. The United States was unwilling to spend the massive amounts of money necessary to develop an imperfect shield
for missile defense. With the end of the Cold War, the old deterrence arguments fell apart, but so did the impetus for deployment. By the second half of the Bush Presidency, however, new threats emerged to challenge BMD planners. The prospect of having to deal with a limited or accidental missile launch increased in relative importance. Especially in the wake of rapid Russian military devolution, the security of ballistic missiles was threatened, and even the locations of nuclear missiles and materials were sometimes in doubt. Would the Russians, hard pressed for convertible currency, sell technology, warheads, and missiles to other states or perhaps terrorist organizations? Rogue states like Iraq and North Korea were known to be working on limited ballistic missile and nuclear warhead programs. The primary threat to the world in this new environment was less global conflagration from massive strikes, but localized devastation from limited ones. BMD no longer had to protect the United States and its allies from thousands of nuclear missiles, but now from just dozens. The technical and moral arguments against BMD with this new mission vanished.

The pro-deployment moral argument, that there ought be some protection against limited strikes, carried the day. The Strategic Defense Initiative (SDI) prototype Brilliant Pebbles/Brilliant Eyes ABM architecture was downgraded from a nuclear shield to a partial, global defense mechanism. The scheme would place a network of independent sensors and
kinetic kill batteries in space. If an unannounced or unplanned launch occurred anywhere in the world, it would be detected and evaluated (by the specific characteristics of its heat signature). If a threat, targeting data would be passed to the orbiting launch platform, and a tiny aerospace projectile would be sent down the earth’s gravity well to engage the missile. Using this design, from two-dozen to a hundred simultaneous launches of missile weapons anywhere in the world could be detected, engaged, and destroyed.

By 1990, the plan was changed to a simpler, single shot hit-to-kill kinetic engagement interceptor, with on board sensors. Advances in miniaturization and computer speed meant that these autonomous weapons could be mass-produced and would weigh less than twenty kgs each. These Brilliant Pebbles would be scattered about low-Earth orbit and could independently function. The expenses of the modified Brilliant Pebbles remained high, however, possibly up to three hundred billion dollars. With the 1992 changeover to the Clinton administration, the plan was scrapped. Clinton, a vigorous opponent of SDI before claiming office, was won over by proponents of the need to maintain at least research and development funding for BMD, and quietly submitted budgets that would allow minimal research requirements to be met. By 1996 Congress was passing authorization bills for new defense systems over the objections of President Clinton. With North Korea and Israel demonstrating medium range
ballistic missile (MRBM) potential, and at least Iraq, Iran and Libya thought to be developing similar capacities, and Pakistan detonating a nuclear device, in 1999 Clinton and Congress authorized the development of a light, mobile, ground-based BMD system to thwart very limited nuclear attacks against specific targets. The concept is generally known as Theater Missile Defense (TMD).

A ground based anti-missile system to defeat incoming ballistic missiles may be much less expensive than a space-based one, but vastly inferior. First because of the limited range of the interceptor, it must be assigned to a point target or area to be effective. A TMD battery in New York could not defend an attack on Los Angeles. A space-based system would have global presence. Wherever the threat occurred, the system would be ready to intercept. Surprise missile attack would be impossible. Secondly, because the TMD engages the incoming missile, collateral damage will occur in or near the defense point. As an illustration, the Patriot missile (model for the current TMD light BMD system) defense of American positions in Saudi Arabia during Desert Storm engaged Iraqi SCUDs in the unpowered, down side of the ballistic arc. In one instance, a Patriot missile successfully engaged a SCUD missile, knocking it off course. The rocket body landed on a barracks causing heavy casualties; perhaps more than if the rocket with warhead had hit its intended target. In a nuclear warhead scenario,
even if the warhead is rendered inoperable, radioactive material could be spread over a significant region in the defending state’s territory. Damage from chemical or biological weapons could also be severe, even with a successful engagement. A space-based system would engage the target in the boost phase of flight; meaning that whatever state launched the missile would likely suffer the collateral damage of its destruction. Another advantage to boost phase targeting is that missiles with multiple warheads will not have separated, maximizing the defensive effect and minimizing the defensive problem of multiple independent re-entry vehicles (MIRVs). Third, and tied in closely with the second factor, TMD systems will engage targets that are spiraling down the gravity well while they must propel themselves up the well. Space-based systems will do so traveling down, the energy and maneuver advantages of which have already been described, to attack slower-moving and hence more vulnerable targets.

Without question, from military applications and strategic perspectives, space-based BMD systems are superior to terrestrial (ground, sea, or air) based ones. They also have exceptional political advantages. Any BMD system will receive criticism from potential adversaries, as is evident with the routine vocal opposition that comes from Russia and China to any proposed TMD system. Because of criticism and retaliatory threats made by the opposing
states, domestic and allied support has been hesitant and unsure. If the state is willing to deploy BMD anyway, by using a space-based system instead of a ground-based one it should be able to gradually regain widespread popular support. One of the advantages of the mobile TMD system, say its advocates, is that it could be dispatched to threatened areas as needed. True enough, but imagine the problems associated with some possible deployments – to Israel, say, or to Taiwan. As much as the United States would insist that the deployment was for defensive purposes only, it would be a clear and possibly inflammatory sign of preference for one side over the other. A space-based system would forever be on alert, and would avoid the political problems of terrestrial basing altogether. The United States would not have to physically deploy to the threatened territory to be able to intercept and destroy hostile missile activity – regardless of the side that launches first. United States impartiality could be asserted and maintained. Retaliations, too, could be controlled. While a United States TMD battery in Israel could conceivably shoot down an incoming ballistic missile from Iraq, what would prevent the Israeli’s from shooting back in anger? The United States would need to deploy the system in both states. Eventually, they would have to be deployed in all states, and any hope of countering the space-based system with a fiscal restraint argument would be lost. Moreover, the human operators of the TMD battery would be at
risk. Their capture or casualties in their ranks could force the United State to get directly involved in the conflict. Knowing this, they could be particularly desirable targets for either side. In other instances, the United States might not have the time to deploy a TMD battery to a hostile theater, or may be politically unable to do so. The case of an Indian-Pakistan or an Iraq-Iran exchange comes readily to mind.

In all these described circumstances, with a space-based BMD system the United States could effectively uphold the principle that aggression is wrong in international politics, first stated in George Bush’s post-war declaration of a New World Order. The United States could stop the launching of missiles at any state from any state or sub-state actor, without taking sides or further inflaming the issue. If it were willing to do so, and would act decisively and non-arbitrarily to prevent any hostile aggression from crossing national borders, the United States owned and operated space-based BMD system could be seen (in time) as a global asset. The world would be free of the fear of missile-based nuclear war. As a critical element of an overall strategy, it has tremendous political advantage and virtually no political liability.

A Simple Space Weaponization Policy

By using its current and near-term capacities, the United States should endeavor at once to seize military control of low-earth orbit.
From that high ground vantage, near the top of the Earth’s gravity well, space-based laser or kinetic energy weapons could prevent any other state from deploying assets there, and could most effectively engage and destroy terrestrial enemy ASAT facilities. Other states should still be able to enter space relatively freely for the purpose of engaging in commerce, in keeping with the capitalist principles of the new regime. Just as in the sea dominance eras of the Athenians and British before them, the military space forces of the United States would have to create and maintain a safe operating environment (from pirates and other interlopers, perhaps from debris) to enhance trade and exploration. Only those spacecraft that provide advance notice of their mission and flight plan would be permitted in space, however. The military control of low-Earth orbit would be for all practical purposes a police blockade of all current spaceports, monitoring and controlling all traffic both in and out.

The United States would concurrently have to announce the policy that it will tolerate no launch of a missile (cruise or ballistic), no cross-border incursion of aircraft, no hostile and illegal position of unwanted naval forces within the twelve-mile limit of national territory. Any transgressions anywhere in the world would be stopped, immediately by force from space. States will complain that their sovereignty has been infringed, but the United States will be on the highest moral ground. Under no condition can a
state initiate cross-border violence, and therefore no state can credibly claim that it is defending itself. Thus the complaints of the state whose forces have been dispatched by space weapons will ring hollow. Yes, perhaps the United States had no international right to shoot down the nuclear or chemically tipped missile launched at a traditional adversary, but the launching state will have a hard time justifying its prior right to start such a war. Over time, and this is the key factor to make such a policy work for international stability and peace (which are at least intervening factors in the rise of global prosperity), the United States must rigidly enforce this policy without discrimination. It must not make any terrestrial military incursions of its own. It must act decisively and openly, and completely without bias. There will be cries of dismay that the United States is acting as an empire, but since the only limitations made on another state’s rights are on those to make war, eventually the loudest outbursts will ebb. People will get used to having American weapons flying overhead. They won’t like it, to be sure, but it will seem a waste of time to protest something that has brought so much good to the world. States will begin to cut back on traditional military forces, as they are less useful in a world where they cannot be used offensively, and unnecessary so long as the United States can guarantee state borders.

And so it would. Complete domination of space would give the United States such an
advantage on the terrestrial battlefield that no state could openly challenge it. Traditional war would be effectively over. An idealist vision would be secured by realist means. Strategic dominance of space would further force the United States to maintain the industrial and technical capacity to keep it at the forefront of hegemony for the foreseeable future. Nontraditional war, especially terrorism, would not be over, but it could very well be mitigated.42 The current dominant use of space for military matters is in the areas of observation and monitoring. These are the tools of effective police organizations, and have already been adapted in counter-terrorism plans. The details would be worked out in time, but the strategy clearly has benefits for the United States and the world.

The moral argument has many levels, and stems from both the high ground and modified sanctuary theses (accepted here) that the weaponization of space is inevitable. The operational level contradiction is quite simply that it is unconscionable to assign the military services the task of controlling space, and then deny the best means to do it. To the military, it is the equivalent of sending a soldier into combat without a rifle. At the strategic level it thwarts the gloomier predictions of the awful result of space weaponization by preempting the process. Most theorists who lament the coming inevitability of space militarization do so on some variation of the notion that once one state
puts weapons into space, other states will rush to
do the same, creating a space-weapons race that
has no productive purpose and only a violent
end. Other assumptions are generally along the
line that conflict and bloody war must eventually
reach the cosmos, and delaying or holding off
that eventuality is the best we can hope for. By
seizing the initiative and securing low-Earth
orbit now, while the United States is
unchallenged in space, both those assumptions
are revealed as faulty. The ability to shoot down
from space any attempt by another nation to
place military assets in space, or to readily
engage and destroy terrestrial ASAT capacity,
makes the possibility of large scale space war
and or military space races less likely, not more.
Why would a state expend the effort to compete
in space with a power that has the extraordinary
advantage of holding securely the highest ground
at the top of the gravity well? So long as the
controlling state demonstrates a capacity and a
will to use force to defend its position – in effect
expending a small amount of violence as needed
to prevent a greater conflagration in the future –
the likelihood of either scenario seems remote.
To be sure, if the United States were willing to
deploy and use a military space force that
maintained effective control of space, and did so
in a way that was perceived as tough, non-
arbitrary, and efficient, other states would
quickly realize no need to develop space military
forces. It would serve to discourage competing
states from fielding opposing systems much in
the same fashion that the Global Positioning System (GPS) succeeded in forestalling the fielding of rival navigation systems. In time, United States control of low-Earth orbit could be viewed as a global asset and a public good.

Conclusions

The United States has unprecedented power. It can use that power, threaten to use it, promise not to use it, or divest of it. The last option is unsound. The middle two are properly means of employing latent power, and infer an ultimate use of power. Thus, the only realistic option for the United States is to use its power. While it would take an incredible act of political will to follow the course I have laid out, here I have argued that the United States should use that power efficiently, and for noble ends.

It is perhaps a fact of human nature that no one, certainly no state, appreciates being told what to do; less so forced to take an action, even if the action is in that person or state’s best interest. In other words, no matter how the United States chooses to use its power (or chooses not to), there will be many who resent it. And it is precisely that power that is the focus of derision, and not prescribed action. This is evidenced by the routinely compatible foreign policies of Canada and the United States. Except in rare cases, these two independent nation-states hardly ever are in more than minor disagreement. Both jointly deploy forces overseas, enter into identical international treaties, and make similar
moral pronouncements of the behavior of others in domestic and international forums. Yet the United States is often reviled and accused of neo-imperialism, while Canada is held up as a champion of international rights.

If the United States were to follow the simple policies advocated here (and it seems extremely unlikely that it will do so), there would undoubtedly be a huge outcry from supposedly aggrieved international interests. Boycotts of American products would be called for, condemnation resolutions would ring from every political hall, and mass demonstrations would be broadcast continuously on CNN. It is even remotely possible that preliminary military planning and action would be initiated in response. Yet this would be the response regardless of how the United States chooses to use its power. Let us move beyond hand wringing over hurt feelings and cultural or ideological relativism and do the right thing. Let us create for ourselves and for all peoples of the world a safe and prosperous future. The immediate seizure and control of near-Earth space is one clear method to that end.

When President Reagan announced his vision of Strategic Defense, he made the startling promise that should the United States achieve its goal, it would be unconscionable not to share the knowledge and capacity of BMD with the world. His opponents ridiculed the offer, calling it mere propaganda. Genuine or not, the potential of space-based BMD – and follow-on advances that
would allow a single liberal state to engage hostile forces anywhere in the world intent on settling international issues by force – effectively enacts the Reagan promise. The world can be protected by a space-based BMD without need of distributing the technology or control of the weapons system. A public good is created and the United States reaps a Cournot benefit. It can have its cake and eat it, too.
Notes


5 Ibid., p. 100.

6 Ibid., p. 88.

7 Although the phenomenon was first empirically described by D. Singer and M. Small, ‘The War Proneness of Democratic Regimes,’ *Jerusalem Journal of International Relations* 1 (1976) pp. 50-69, it was Michael Doyle who provoked a storm of activity with his attempt to tie the observation to Kant’s claim that liberal democratic states would be naturally less prone to war with another liberal democracy. See ‘Kant, Liberal legacies, and Foreign Affairs, parts 1 and 2,’ *Philosophy and Public Affairs* 12 (1983) pp. 206-35 and 323-53.


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20 ‘Safe Havens,’ p. 191.

21 Ibid., p. 192.

22 This is a bizarre and common argument among foes of weaponization. Space is not that important, they say, so defending space assets is a waste of money (better spent elsewhere). This ignorance of the value - both commercial and military - of space assets is so ignorant that it denigrates their otherwise reasonable argument.

23 Ibid., p. 223.

24 “…we know from history that every medium – air, land, and sea, has seen conflict. Reality indicates that space will be no different. Given this virtual certainty … the US must develop capabilities to deter and defend our interests in space.” From the ‘Executive Summary of the Report of the Commission to Assess United States National Security Space Management and Organization,’ January 11, 2001 (Washington: GPO), p. 10.


28 Ibid, p. 33.


I. Wallerstein, ‘Three Instances of Hegemony in the History of the Capitalist World-Economy.’ *International Journal of Comparative Sociology* 24 (1983). Unless otherwise noted, the remainder of this section is but a synopsis of his work.


38 See Keohane, *After Hegemony* (Op Cit.)


41 This highlights the point made earlier. In the post-Cold War environment, the greatest threat to America’s vital national interests are not from a rational superpower capable of unleashing thousands of ICBMs, but of an irrational actor unleashing only a few. Deterrence by definition cannot work against the irrational, only defense can.

Introduction

There is no escaping the fact that one of the most important global security policy debates of the 21st century is about to be engaged by the administration of President George W. Bush – the question of whether the United States needs to develop and deploy space-based weaponry.

For nearly 40 years, there has been an unspoken agreement among the world’s space powers to refrain from putting weapons in orbit. Military use of space has been limited to surveillance and communications satellites, and scientific and commercial endeavors have largely been able to develop with minimal concerns about military interference or the possibility of becoming wartime casualties.

Even during the height of the Cold War, the two superpower rivals eschewed serious development of offensive space weapons – in fact, though they experimented with the technology, the two sides also refrained from actively deploying weapons that could shoot down satellites from ground, air or sea as well. They even signed a treaty, the 1972 Anti-Ballistic Missile (ABM) Treaty, which forbade
either side to tamper with the other’s “national technical means,” i.e., spy satellites.

Unlike in Star Trek, the “final frontier” has yet to become a battlefield. But if the current trends continue, that will change – not in the distance future of science fiction, but within the next several decades. Emerging Bush administration plans and policies are clearly aimed at making the United States the first nation to deploy space-based weapons. There are several drivers behind this goal, including the very real concern about the vulnerability of space assets that are increasingly important to how the U.S. military operates, and the administration’s decision to pursue missile defense.

Unfortunately, the administration has done little thinking – at least publicly – about the potential for far-reaching military, political and economic ramifications of a U.S. move to break the taboo against weaponizing space. There is reason for concern that doing so could actually undermine, rather than enhance, the national security of the United States, as well as global stability. Thus it behooves the administration, as well as Congress, to undertake an in-depth and public policy review of the pros and cons of weaponizing space. Such a review would look seriously at the threat, both short-term and long-term, as well as measures to prevent, deter or counter any future threat using all the tools in the U.S. policy toolbox: diplomatic, including arms control treaties; economic; and military, including defensive measures short of offensive
Weapons. There is nothing to be gained, and potentially much to be lost, by rushing such a momentous change in U.S. space policy.

**U.S. Policy and Military Planning: Going to Orbit?**

“...I believe that weapons will go into space. It’s a question of time. And we need to be at the forefront of that,” Pete Teets, undersecretary of the Air Force and director of the National Reconnaissance Office, told a March 6, 2002 conference in Washington.²

While Teets, who is now the Pentagon’s lead official for procurement and management of space programs, was careful to say that no policy decision to put weapons in space has yet been made, his views reflect a consensus among top Air Force leaders – and indeed, among military officials across the board. The prevailing wisdom in all branches of the services is that “conflict in space is inevitable.”³

This conclusion that warfare is going into orbit has not come out of nowhere. While there has been little public or policy-level discussion, the Air Force in particular has been seriously wrestling with the question for at least a decade (and even longer, if one counts early discussions in the post-Sputnik era). In fact, the debate continuing today had already reached national policy levels during the Clinton administration, up to and immediately after, the release of the National Space Policy in 1996.
the Bush administration’s seemingly wholehearted embrace of the need for space-based weapons – vice the Clinton administration’s much more qualified stance – and the military’s increasingly open advocacy.

The Bush administration’s views were directly reflected in the 2001 Quadrennial Defense Review (QDR), released Oct. 1, 2001. “A key objective … is not only to ensure U.S. ability to exploit space for military purposes, but also as required to deny an adversary’s ability to do so,” states the QDR.

The QDR cites the need to improve space systems as one of six critical goals of overarching military transformation – thus placing top political priority on the issue within the Pentagon. The appointment of Teets to his two-hatted job and his subsequent stand-up of two new positions – a deputy for Military Space and a Directorate of National Security Space Integration – were among the Pentagon first steps toward “national security space transformation.”

Even before the QDR, a report to the Office of Secretary of Defense from an independent panel called for robust efforts to assure “space dominance” as a key transformational capability. The report, called Transformation Study Report and dated April 27, 2001, states: “Space capabilities are inherently global, unaffected by territorial boundaries or jurisdictional limitations; they provide direct
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access to all regions and, with our advanced technologies, give us a highly asymmetrical advantage over any potential adversary.” The study recommended, among other things, the development of microsatellites for both offensive and defensive missions.

There also have been a number of other organizational changes at the Pentagon and across the U.S. government that reflect recommendations in the Commission to Assess the United States National Security Space Management and Organization, known generally as the Space Commission and chaired by Donald Rumsfeld until he was tapped as defense secretary by Bush.

For example, Rumsfeld on May 8, 2001, announced the creation of a Policy Coordinating Committee for Space within in the National Security Council as well as a number of other organizational shifts within the military structure for oversight of space programs. In addition, both the Air Force and the Navy have reorganized and centralized their space bureaucracies.

In fact, while now wrapped into the new flag of military “transformation,” the heightened attention to the issue of space defense by the Bush administration has its real roots in the Space Commission report. The report, released in January 2001, warned that the United States could face a “Space Pearl Harbor” if myriad actions were not taken to improve the security of space assets. Noting that the United
States is more dependent on the use of space than any other nation, the Space Commission report stated:

Assuring the security of space capabilities becomes more challenging as technology proliferates and access to it by potentially hostile entities becomes easier. The loss of space systems that support military operations or collect intelligence would dramatically affect the way U.S. forces could fight, likely raising the cost in lives and property and making the outcome less secure. U.S. space systems, including the ground, communication and space segments, need to be defended in order to ensure their viability.

While stopping short of recommending the development of space-based weapons, the report made it fairly clear between the lines that pursuit of such weapons would be desirable. “The Commissioners believe the U.S. government should vigorously pursue the capabilities called for in the National Space Policy to ensure that the president will have the option to deploy weapons in space to deter threats to, and if necessary, defend against attacks on U.S. interests,” the report stated.

The reference to the National Space Policy, however, could be seen as slightly disingenuous. The 1996 policy promulgated by the Clinton White House and still in effect, does
allow – or maybe even encourage – the military to explore technologies and capabilities for space weapons as both a deterrent and a hedge against potential developments by hostile countries. At the same time, the policy continues the restraints on actually deployment of weapons in orbit. This is consistent with U.S. policy ever since the original space race with the Soviet Union of the 1950s and 60s.

The sea change in thinking about space-based weapons signaled by the Space Commission report is a direct result of the long-running internal military debate. It follows from a path of strategic thinking emanating most prominently from the Air Force. For example, the U.S. Air Force’s Vision 2020 document and U.S. Space Command’s long-range plan for implementing that strategic vision, both released in 1998, are clear about the need to provide planning for the development of space weaponry. More recently, Air Force Space Command’s capstone planning document, “Strategic Master Plan for FY ‘02 and Beyond,” published in February 2000, carries the logic forward by calling for “full spectrum dominance” in space and “formidable and flexible options for prompt, global conventional strike” from space by 2045.6

And while there has been no formal change in national policy, current military thinking and strategy already has gone a long way beyond the past emphasis on use of space assets for force enhancement (i.e., surveillance, intelligence, communications, navigation and
targeting) to incorporate mission concepts for space-based weapons. Some examples of space-based weapons programs will be outlined below, however, former Pentagon officials say most of the development work is in the “black” (highly classified) budget and thus difficult, if not impossible, to either qualify or quantify.

At the same time, there is a wealth of discussion of the potential roles for space weaponry. Those most often cited by the military are: “space control,” missile defense and “force application from space.”

**Space Control**

Space control, defined as the ability to “assure freedom of action in space and deny same” to the enemy, is now a key military mission, and at the center of U.S. Space Command’s role. The key, but not only, goal of space control is to defend U.S. space assets, from space. Space control as explained by the military has four key aspects:

- **Surveillance**, including the ability to detect and track space objects;
- **Protection**, concentrating on passive measures to enhance survivability of U.S. space assets, such as electronic hardening;
- **Prevention**, prohibiting enemies from “exploiting U.S. or allied space services” through measures such as encryption or shutter control (shutting down access to imagery satellites); and,
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Negation, preventing enemies from using their own space forces, including through offensive means.\textsuperscript{8}

Thus, space control by definition includes potential offensive operations – i.e., possible use of space-based anti-satellite weapons (ASATs). There are a number of concepts for such weapons discussed in military and independent literature, including ‘bodyguard satellites’ that would shadow U.S. satellites and defend them if necessary; kinetic energy ASATs that could be launched in wartime; and so-called ‘space mines,’ stealthy ASATs that would linger in space near enemy satellites for later activation in the event of hostilities.\textsuperscript{9}

While U.S. Space Command is overtly charged with the mission, space control has particular resonance for the U.S. Army. Army leaders are keenly worried about the possibility that allowing hostile forces free access to space-based assets could erase the edge U.S. forces now enjoy through exploiting satellite imagery, communications and precision targeting. Army officials repeatedly claim that the famous ‘left hook’ maneuver of Operation Desert Storm could not have succeeded if Iraqi leader Saddam Hussein had possessed the imagery available today on the commercial market.

“The idea of being able to control what people are seeing is going to be an issue for the Army,” Lt. Gen. Joseph M. Cosumano Jr., commander of the Army Space and Missile...
Defense Command, told reporters July 15, 2001, at a conference sponsored by the U.S. Army Space and Missile Defense Command, Huntsville, Alabama.\(^{10}\)

Indeed, in an unprecedented move, the Pentagon late in 2001 entered an exclusive contract with U.S. firm Space Imaging, to buy up all the imagery of Afghanistan taken by the firm’s Ikonos satellite to prevent global media firms from obtaining pictures of U.S. bombing during Operation Enduring Freedom.\(^{11}\)

The Army is also the only service with an overt ASAT development program, the Kinetic Energy Anti-Satellite program. This effort was launched in 1990, and would use a ground-launched kinetic kill vehicle to hit an enemy satellite and destroy it. Currently, the program is capped at the development of three flight-tested ASATs that are to be shelved for possible future use. Some proponents of that program, notably (now former) Sen. Robert Smith, R-N.H., have been touting the expansion and continuation of the program. However, there are concerns within the military (including the Army) about the collateral damage to U.S. or other friendly satellites that might be caused by debris left after a kinetic kill of an enemy satellite.

The Army is by no means the only service worried about space control. The Navy and Air Force are concerned that allowing enemies to use space freely could diminish not only ground and sea operations, but also the edge U.S. forces have in command, control and
Communications, and precision targeting. Some experts have specifically identified the threat to U.S. military and commercial freedom of the seas as a critical issue if other countries are allowed to develop space-based weapons.

The Air Force alone is investing $185 million in fiscal year 2003 in space control, according to Lt. Col. John Hyten, chief of the space control division in the air and space operations staff and himself a proponent of weaponizing space. In speaking to a Feb. 27, 2002 conference sponsored by the Defense Industrial Association, Hyten said Air Force Space Command is developing a concept of operations for space control and, in addition, has launched a “red force” – the 527th Space Aggressor Squadron – to pinpoint vulnerabilities in U.S. systems.\textsuperscript{12}

Missile Defense

The second factor driving U.S. political-military thinking about weaponizing space is the push, now being rapidly accelerated by the Bush administration, to develop missile defenses. The administration already has announced its intent to withdraw on June 13, 2002 from the ABM treaty, not only opening the path for development of missile interceptors but also clearing the way for the United States to develop anti-satellite weapons targeted against potentially hostile spy satellites.
The Pentagon’s just-revised missile defense plans include a much greater emphasis on the potential for space-based systems, in particular for shooting down enemy missiles in their boost phase as they begin to ascend through the atmosphere. Although it is unclear if these plans are a deliberate foot in the door to the weaponization of space, their implementation would have that effect. A decision to move forward with space-based missile defense systems would end today’s policy of restraint – with or without an overt move to rewrite the National Space Policy.

The newly named Missile Defense Agency (formerly the Ballistic Missile Defense Agency) has proposed spending $1.33 billion from 2003 to 2007 on developing “Space-Based Boost” – in essence reviving the Reagan-era concept of Brilliant Pebbles, a constellation of orbiting, kinetic kill vehicles designed to knock out enemy ICBMs in their boost phase. “Concept assessment” is due to be completed in early 2003, according to Pentagon fiscal year (FY) 2003 budget documents, with an aim to “support a product line decision not earlier than FY 2006.” The development program is being designed to include at least limited experiments in space.

Research on the Space Based Laser has been ongoing for some time, and laser technology has slowly progressed. The program has experienced developmental trouble,
however, and Congress cut FY 2002 funding, bringing to a halt the program’s planned Integrated Flight Experiment of an early prototype. The Missile Defense Agency is now reevaluating the program, but intends to continue exploring technologies through 2007 – proposing $284.8 million in spending from FY 2003-2007. Deputy Defense Secretary Paul Wolfowitz recently testified to Congress that the Pentagon budget for FY 2003 includes about $103 million for directed energy technology (including Space-Based Laser). The Air Force also has begun openly discussing other potential missions for the Space-Based Laser beyond missile defense. According to a July 18, 2001, briefing at the Huntsville conference by Air Force Col. William N. McCasland, then system program director for the Space-Based Laser, such missions could include:

- “defense/offensive counter space operations” (i.e., anti-satellite missions);
- “deny access to space” (for example, knocking out enemy launchers as they blast off);
- “deny flow of information to/from satellite” (perhaps using low-power beams to disrupt rather than destroy a satellite);
- “defense/offensive counter-air operations”; and
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- knocking out high-altitude aircraft, cruise missiles, or unmanned aerial vehicles.\(^{16}\)

**Force Application**

The last mission mentioned for Space-Based Laser falls directly into the category of missions dubbed “force application” from space, i.e. attacking airborne and terrestrial targets (some officials and experts also lump missile defense into the force application category).

At the conference in Huntsville, Air Force Col. Ronald Haeckel, J-5 vice director of plans for U.S. Space Command, told reporters that the command is directly tasked to plan for “force application from space” – a mission he characterized as a hedge against potential future need. Weapon concepts include not only lasers, but also kinetic energy weapons and more conventional explosive warhead type weapons.\(^{17}\)

Pentagon exploration of space-based weapons also has received a recent boost from congressional interest in development of new types of earth-penetrating weapons for destroying hardened and deeply buried targets, particularly underground chemical and biological weapons facilities. The Defense Threat Reduction Agency has launched an Advanced Concept Technology Demonstration program on a ballistic missile-delivered penetrator weapon, called the Tactical Missile System – Penetrator ACTD.\(^{18}\) (The idea, however, is not new; as long
ago as the early 1990s, the Air Force was studying conventional ICBMs using tungsten and/or steel rods for taking out hard and deeply buried targets.) Some military experts also have touted the concept of dropping earth penetrating kinetic energy weapons from orbit, since such rod-like reentry vehicles could attain high speeds and thus deep vertical penetration.  

For example, the Air Force Research Laboratory has begun a study on a new earth penetrator that might be eventually fitted onto the Air Force’s proposed Common Aerospace Vehicle (CAV). The CAV would be a maneuverable reentry vehicle deployed from an orbiting satellite in low-earth orbit (there are also concepts for delivering the CAV from ICBMs or other missiles), and carry different types of submunitions, possibly including a penetrator. Then Air Force Chief of Staff Gen. Michael E. Ryan, himself a strong proponent of weaponizing space, told Air Force Magazine in September 2001 that the reentry vehicles could be carried into space by either a rocket or a reusable launch vehicle.

In addition, in the wake of the Sept. 11 terrorist attacks on the United States, space weapons proponents have been more vocal about concepts for using space weapons to attack a wide range of terrestrial targets anywhere on the globe. For example, Rep. Mac Thornberry, R-Texas, in March 2002 called on the Pentagon to begin studying possible delivery of precision-guided weapons from space in the
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wake of the Sept. 11 terrorist attacks on the United States. “We ought not to be afraid to think about studying those things right now,” Thornberry said in a speech to the Center for Strategic and International Studies.22

In sum, while a direct statement by the Bush administration of a new policy has so far been absent, the direction of U.S. policy and military planning is clear. Indeed, Haeckel told the Huntsville conference in summer 2001 that the military is expecting “new guidance for space” from the Bush administration relatively shortly.

The Threat: Vulnerabilities vs. Capabilities and Intent

Current Pentagon planning is driven by the perception of an urgent, emerging threat to U.S. space assets. The Space Commission report is seminal here, in the same way that the 1998 report of the Commission to Assess the Ballistic Missile Threat to the United States, also known as the Rumsfeld Commission, propelled the threat of ballistic missile attack to the forefront of U.S. national security policy. While the immediate impact of the Space Commission’s report was not as direct as that of its predecessor, the document has had a pervasive influence on administration officials, the military and Congress.

In a March 19, 2002 hearing of the Senate Armed Services Committee, U.S.
intelligence officials said the threat to U.S. dominance in space is growing. Navy Vice Adm. Thomas Wilson, director of the Defense Intelligence Agency, testified that potential adversaries would have significant means to disrupt U.S. space systems by 2010 – citing efforts abroad to explore directed energy weapons (lasers), methods of attacking satellite ground stations, jamming and computer attacks.23

During the same hearing, CIA Director George Tenet said the development of increasingly sophisticated reconnaissance satellites by countries such as China and India – as well as the growing commercial market in communications, navigation and imagery– is eroding the U.S. edge.24

While it is true that other countries are pursuing both space assets and counter-space options, there is some reason to question whether the current threat assessment is justified. Leaving aside the question of the ballistic missile threat, it is unclear what real threats to U.S. space assets exist today or will exist in the near and medium term.

Proponents of weaponizing space usually cite the emergence of an acute threat in the 2020 time frame or beyond; the Space Commission report puts the possible development of hostile anti-satellite systems at decades away.

They cite as an indicator of the threat trend the fact that there are more and more countries, now fifty-plus, with space capabilities.
Available technologies, from imaging to telecommunications to tracking and signals intelligence, are progressing rapidly; and many are available on the commercial marketplace.

The Space Commission report also includes extensive analysis of the possible vulnerabilities of U.S. space assets, especially commercial satellites and communications grids: “The reality is that there are many extant capabilities to deny, disrupt or physically destroy space systems and the ground facilities that use and control them.”

For example, a September 2001 report by the U.S. Department of Transportation, “Vulnerability Assessment of the Transportation Infrastructure Relying on the Global Positioning System,” highlights the fact that the GPS network is easily disrupted in part due to its low power signals and because its characteristics are well known due to its civil uses. The Space Commission noted that there already are available Russian-made, handheld jamming devices that can block GPS receivers for up to 120 miles. In addition, like other satellite networks, the 24 GPS satellites have stable and predictable orbits.

However, vulnerabilities do not necessarily result in threats. In order to threaten U.S. space assets, military or commercial, a potential adversary must have both technological capabilities and intent to use them in a hostile manner. There is little hard evidence that any other country or hostile non-state actor possesses
either the technology or the intention to seriously threaten U.S. military or commercial operations in space – nor is there much evidence of serious pursuit of space-based weapons by potentially hostile actors.

Currently, the simplest ways to attack satellites and satellite-based systems involve ground-based operations against ground facilities, and disruption of computerized downlinks. Hacking and jamming also are the least expensive options for anyone interested in disrupting space-based networks, because they do not require putting anything into orbit. The high cost of space launch (ranging between $5,000 and $10,000 per pound) is not a trivial matter, even for space-faring nations such as Russia and China, much less for ‘rogue’ states such as North Korea or non-state actors.

Indeed, the Space Commission report acknowledges that: “Attacking or sabotaging the supporting ground facilities has long been considered one of the easiest methods for a U.S. adversary to conduct offensive counter-space operations. Most of these facilities are relatively easy to get in close physical proximity to or access by way of a computer network, making them a prime target.”

It is true that the incidences of computer hacking against U.S. military, financial and industrial networks continues to rise and that several countries including China are known to be exploring information warfare capabilities. Many countries already have developed military
electronic jamming systems, and that technology is becoming widely available even on the commercial market.

It is obvious that the United States must ensure the integrity of its increasingly important space networks, and find ways to defense against threats to space assets. Still, there is little reason to believe that it is necessary for the U.S. to put weapons in space to do so. Space warfare proponents are making a suspect leap in logic in arguing that space-based weapons are, or will soon be, required to protect the ability of the United States to operate freely in space. One could argue much more rationally that what is needed most urgently is to find ways to prevent computer network intrusion; to ensure redundant capabilities both at the system and subsystem level, including the ability to rapidly replace satellites on orbit; to improve security of ground facilities (perhaps moving to underground facilities); and to harden electronic components on particularly important satellites.

Furthermore, the evidence of actual space weapons programs by potential adversaries is thin. There have been Chinese press reports about China’s military researching microsatellites (weighing less than 100 kilograms) or nanosatellites (weighing less than 10 kilograms) to attack U.S. satellites in space in a future war, but evidence of actual progress is scant. Russia also has long explored anti-satellite technology, but there is little reason to believe that Moscow has changed its policy against
deploying such weapons (Russia has had a unilateral ban on ASAT testing for some time), especially given the current cash-starved state of the Russian space program. No other countries have shown visible signs of interest (although obviously any space-faring nation, such as India or Pakistan, have latent capability).

Indeed, the technical barriers to development and deployment of space-based weapons cannot be overestimated, even for the U.S. military. There are serious, fundamental obstacles to the development of both kinetic kill weapons and lasers both for use against targets in space and terrestrial targets – not to mention the question of the staggering costs associated with launch and maintaining systems on orbit. Problems with lasers include power generation requirements adding to size, the need for large quantities of chemical fuel and refueling requirements, and the physics of propagating and stabilizing beams across long distances or through the atmosphere. Space-based kinetic energy weapons have their own issues, including achieving proper orbital trajectories and velocities, the need to carry massive amounts of propellant, and concern about damage to own-forces from debris resulting from killing an enemy satellite. Space-based weapons also have the problem of vulnerability, for example, predictable orbits and the difficulty of regeneration.

A detailed discussion of technology challenges is beyond the scope of this paper, but
a comprehensive primer on the myriad problems with developing space-based weapons is a September 1999 paper by Maj. William L. Spacy II, “Does the United States Need Space-Based Weapons?” written for the College of Aerospace Doctrine, Research and Education at Air University, Maxwell Air Force Base, Alabama.¹

As noted, there is also the question of intent. It is not obvious that any nation has any intention, or even incentive, to launch a war in space. Instead, most countries, including China and Russia, have been urging a global ban on weapons in space. Many experts, including a number of Air Force strategists, persuasively argue a U.S. move to put offensive weapons in space could have the perverse effect of creating a new threat because other countries would feel compelled to follow suit.²⁶

Nonetheless, it is impossible to completely assess any threat to U.S. national security without the benefit of classified information. That said, it also must be recognized that threat assessment is not the only necessary input to the creation of national security policy. Even assuming an urgent threat to U.S. space operations, an assessment of how best to counter those threats – including the pros and cons of the United States responding by becoming the first country to put weapons in space – would still be necessary.

¹ A revised version of the Spacy paper appears as Chapter 4 in this volume.
In particular, it is imperative to look at risks emanating from such a decision. These include: the potential for starting an arms race in space that does both military and political damage to the United States; and the possibility that the advent of space warfare might negatively impact the U.S. commercial space and telecommunications industry, which now dominates the world marketplace.

Could a Space Race Undercut U.S. Military Dominance?

The United States already enjoys an overwhelming advantage in military use of space; space assets such as the Global Positioning System satellite network have proven invaluable in improving precision-targeting giving the U.S. military a decisive battlefield edge. There would be even a more formidable military advantage to possession of weapons in space – global power projection and the enormous difficulty in defending against space weapons aimed at terrestrial targets. “It is…possible to project power through and from space in response to events anywhere in the world. Having this capability would give the United States a much stronger deterrent and, in a conflict, an extraordinary military advantage,” notes the Space Commission report.

Space weapons – even those primarily designed for defense of U.S. satellites – would have inherent offensive and first-strike
capabilities, however, (whether aimed at space-based or earth-based targets) and would demand a military and political response from U.S. competitors.

“To be sure, not deploying weapons in space is no guarantee that potentially hostile nations (such as China) will not develop and deploy ASATs. However, it is virtually certain that deploying U.S. weapons in space will lead to the development and deployment of ASATs to counter such weapons,” notes a new policy brief by the Cato Institute.27

China and Russia long have been worried about possible U.S. breakout on space-based weaponry. Officials from both countries have expressed concern that the U.S. missile defense program is aimed not at what Moscow and Beijing see as a non-credible threat from rogue-nation ballistic missiles, but rather at launching a long-term U.S. effort to dominate space.

Both Russia and China also are key proponents of negotiations at the UN Conference on Disarmament to expand the 1967 Outer Space Treaty to ban all types of weapons. The effort to start talks known as PAROS, for “prevention of an arms race in outer space,” has been stalled due in large part to the objection of the United States. For example, in November 2000, the United States was one of three countries (the others were Israel and Micronesia) to refuse to vote for a UN resolution citing the need for steps to prevent the arming of space.28
It is inconceivable that either Russia or China would allow the United States to become the sole nation with space-based weapons. “Once a nation embarks down the road to gain a huge asymmetric advantage, the natural tendency of others is to close that gap. An arms race tends to develop an inertia of its own,” writes Air Force Lt. Col. Bruce M. DeBlois, in a 1998 article in Airpower Journal.29

Chinese moves to put weapons in space would trigger regional rival India to consider the same, in turn, spurring Pakistan to strive for parity with India. Even U.S. allies in Europe might feel pressure to “keep up with the Joneses.” It is quite easy to imagine the course of a new arms race in space that would be nearly as destabilizing as the atomic weapons race proved to be.

Such a strategic-level space race could have negative consequences for U.S. security in the long run that would outweigh the obvious (and tremendous) short-term advantage of being the first with space-based weapons. There would be direct economic costs to sustaining orbital weapon systems and keeping ahead of opponents intent on matching U.S. space-weapon capabilities – raising the proverbial question of whether we would be starting a game we might not be able to win. (It should be remembered that the attacker will always have an advantage in space warfare, in that space assets are inherently static, moving in predictable orbits. Space weapons, just like satellites, have inherent
vulnerabilities.) Again, the price tag of space weapons systems would not be trivial – with maintenance costs a key issue. For example, it now costs commercial firms between $300 million and $350 million to replace a single satellite that has a lifespan of about 15 years, according to Ed Cornet, vice president of Booz Allen and Hamilton consulting firm.30

Many experts also argue there would be costs, both economic and strategic, stemming from the need to counter other asymmetric challenges from those who could not afford to be participants in the race itself. Threatened nations or non-state actors might well look to terrorism using chemical or biological agents as one alternative.

Karl Mueller, now at RAND, in an analysis for the School of Advanced Airpower Studies at Maxwell Air Force Base, wrote, “The United States would not be able to maintain unchallenged hegemony in the weaponization of space, and while a space-weapons race would threaten international stability, it would be even more dangerous to U.S. security and relative power projection capability, due to other states’ significant ability and probably inclination to balance symmetrically and asymmetrically against ascendant U.S. power.”31

Spurring other nations to acquire space-based weapons of their own, especially weapons aimed at terrestrial targets, would certainly undercut the ability of U.S. forces to operate freely on the ground on a worldwide basis –
negating what today is a unique advantage of being a military superpower. U.S. commercial satellites would also become targets, as well as military assets (especially considering the fact that the U.S. military is heavily reliant on commercial providers, particularly in communications). Depending on how widespread such weapons became, it also could even put U.S. cities at a greater risk than they face today from ballistic missiles.

The potential for strategic consequences of a space race has led many experts, including within the military, to tout a space arms control regime as an alternative. A ban on space weapons and ASATs could help preserve – at least for some time – the status quo of U.S. advantage (especially if coupled with U.S. moves to shore up passive satellite defenses). In a recent article in Georgetown Journal of International Affairs, Jeffrey Lewis, a graduate research fellow at the Center for International Security Studies at the University of Maryland, makes a good case for an arms control approach, arguing: “If defensive deployments in space cannot keep pace with offensive developments on the ground, then some measure of restraining offensive capabilities needs to be found to even the playing field.”

In any event, it is clear that U.S. policymakers must look at the potential strategic and direct military risks, and the costs, of weaponizing space.
Economic Risks in a Globalized Market

Besides the potential for undercutting, rather than strengthening, the U.S. military edge, there also is reason to be concerned about the possibility that moves toward weaponizing space could damage the competitiveness of the U.S. space industry, which currently dominates the international marketplace and therefore bolsters U.S. economic and military power.

The commercial space and telecommunications sector is also arguably the most globalized of today’s economic sectors. The customer base is international; the industry itself is largely comprised of multinational alliances among companies and consortia, as well as joint government programs.

Whereas space used to be available only to the most developed nations, there are more than 1,100 companies in 53 countries now exploiting space.34 Space is a major worldwide market accounting for many billions in revenue, and U.S. firms are dominant in the sector.

According to a 2000/2001 study by the Washington-based Satellite Industry Association, worldwide revenue (including both government and commercial customers) for the satellite industry was $85.1 billion in 2000, and $97.7 billion is estimated for 2001. Over the past five years, the average annual growth has been 17 percent. The industry association was predicting year-end numbers in 2001 to show 15 percent growth. The U.S. satellite industry pulled in $8.9
billion in 2000, and $10.3 billion in 2001 in satellite manufacturing alone, out of worldwide revenue of $17.2 billion and $20.7 billion respectively. Importantly, exports account for half or more of U.S. industry revenue.35

A parallel study, released by the Satellite Industry Association April 5, 2001, and conducted by Henry R. Hertzfeld, senior research scientist at George Washington University’s Space Policy Institute, showed worldwide spending on “civilian space programs totaled $20.8 billion in 2000 excluding spending by Russian, Ukrainian and Chinese governments. Government spending on space reached $35.8 billion when adding in military space budgets. The United States accounted for more than three-fourths of all spending on civil space (78 percent), while combined spending by European countries and all other governments (Japan, China, Brazil and others) accounted for the remaining spending.”36

While commercial space was a booming market during most of 1990s, the market for low-earth orbit satellites has collapsed over the past two years. Launch providers are predicting a flat marketplace for a number of years.37 In addition, the market for large geosynchronous orbit satellites for communications also is at near rock bottom and is expected to remain flat through 2011, according to a recent report by Forecast International/DMS Inc.38 The growth in the market is now being driven by satellite services, such as direct downlinks for Internet
There further is excess capacity in the commercial space market place, with five major manufacturers (three U.S., two European), according to Christopher E. Kubaski, chief financial officer of Lockheed Martin Corp. Kubaski and other U.S. industry leaders are predicting little growth in the commercial sector in the near term.

Corporate chieftains at major defense and space firms already are citing missile defense as a much more lucrative future market than commercial/civil space operations. Such a market assessment by U.S. industry is not without consequences. As one corporate strategist at a major U.S. defense/space firm explained, market assessments drive where corporate research and development dollars go. Considering that it is industry, rather than DoD and NASA, that carries out the bulk of R&D work in the defense and civil space arena, there is some possibility that an emphasis on space weaponization could shift technology investment from the commercial to the defense world.

Granted, this would hold only for those firms – such as Lockheed Martin Corp., Boeing Co., Raytheon Co., and TRW – that do large percentages of government businesses, rather than for those companies more vested in the commercial end of space operations (providing telecommunications and Internet services, for example.) Nonetheless, the ramifications of
shifting R&D on market edge in the commercial arena deserve some consideration.

Interestingly, the U.S. industry has not done as well over the past two years as the overall marketplace. Overall, the worldwide market rebounded in 2000 with a 23 percent growth in revenue, according to the Satellite Industry Association. The association data show that while the global market for satellite manufacturing grew by 9 percent in 2000, U.S. revenue declined by 11 percent. Similarly, worldwide revenue in the satellite launch segment grew by 29 percent in 2000, whereas U.S. revenue grew only by 17 percent.\(^41\) (Still, U.S. manufacturers snagged more than half the satellite orders in 2001, according to data from Futron Corp., a consulting firm specializing in the space market.\(^42\))

U.S. industry officials partially blame the government for their recent poor performance – worried about the effects of U.S. regulatory requirements and export controls on their bottom line. The global marketplace is highly competitive, and U.S. policy and regulations are a major factor in determining U.S. competitiveness.

For example, a RAND study of the remote sensing industry states: “Success for these new U.S. commercial remote sensing satellite firms heavily depends on both understanding and overcoming various risks (e.g., technical, market, policy and regulatory) that could diminish their prospects in the highly
competitive global marketplace for geospatial information products and services. Within this context, U.S. government policies and regulations exert a major influence on the ability of U.S. remote sensing satellite firms to realize their competitive potential in both the domestic and international marketplace. This is just as true for other segments of the space industry.

For example, in 1998 licensing of satellite exports was switched by Congress from the Commerce Department to the State Department and now is handled in a similar manner to weapon export controls because of national security concerns, particularly about technology leakage to China. In an open letter to Congress in June 2001 urging a reversal of the law, the Satellite Industry Association stated that the U.S. market share for geostationary communications satellites dropped from its 10-year average of about 75 percent to 45 percent during 2000, and it largely blamed the regulatory switch to State and the subsequent slowing of the export licensing process for the problem.

Thus, U.S. industry officials are concerned about Pentagon plans to deny “enemies” access to space assets, including commercial imagery and other services provided by U.S. firms. In his Huntsville address, Cosumano admitted that as “some of these assets belong to U.S. companies and they don’t feel too good about the idea that we might shoot them out of the sky.”
The U.S. Defense Department already has the legal ability to exercise so-called shutter control of U.S. civilian satellites – that is, the ability to shut down a satellite to prevent enemies from using images or data to help them defeat the U.S. military in wartime. In addition, U.S. export policy requires that any foreign government purchasing a U.S.-made imaging satellite must sign a government-to-government agreement to take into account American national security interests. While the Pentagon did not use its shutter control privilege in Afghanistan, as noted earlier, DoD did take commercial imagery off the market by buying exclusive rights to all pictures taken by Space Imaging’s Ikonos satellite. This was done despite the fact that Russia’s Cosmos satellite network could provide equivalent imagery.46

The Pentagon move immediately caused a stir overseas. Because the United Arab Emirates, a Space Imaging customer, was directly affected by the Pentagon buy, the six countries of the Gulf Cooperation Council commissioned a joint committee to consider buying their own military imaging satellite rather than rely on U.S. commercial providers.47 Besides the United States, France, Israel and Russia are in the imagery satellite business – and obviously, U.S. industrialists cannot like the idea that defense policy or actions may be rebounding to create stronger competitors for them.

The 15-nation European Union already is moving forward on plans to develop a European
version of the U.S. Global Positioning System
navigation satellite network, called Galileo, in
part due to fears that future access might be
denied or downgraded by the U.S. military.
“Europe cannot accept reliance on a military
system which has the possibility of being cut
off,” Rene Oosterlinck, head of the European
Space Agency’s navigation department, was
quoted as saying. 48

Some international customers also
already are questioning the reliability of U.S.
suppliers (and government-supplied products).
After the 1998 change in export-licensing
authority, German-controlled Daimler-Chrysler
Aerospace announced it would no longer
purchase U.S.-made satellite components.

The competitive and cost challenges the
U.S. satellite industry faces could be increased if
the United States moved to make space a
battlefield. Up to now, the threat that commercial
satellites could become direct wartime casualties
has been negligible. But an aggressive U.S.
pursuit of ASATs would likely encourage others
to do the same, thus potentially heightening the
threat to U.S. satellites. Space industry
executives, whose companies often are working
at the margins of profitability, are concerned
about U.S. commercial satellites and their
operations becoming targets, especially because
current commercial satellites have little
protection (electronic hardening, for example,
has been considered too expensive). There would
be costs to commercial providers for increasing protection, and it is highly unclear whether the U.S. government would cover all those costs.

Another area where Defense Department policy could threaten U.S. industry competitiveness is in access to the radio spectrum. DoD has been resisting calls from the telecommunications industry to free from government-only access a portion of the spectrum that companies believe is essential to providing high-speed Internet access over cellular phones. That portion of the spectrum (1755-1850 megahertz) is now denied to U.S. commercial users because it is the spectrum band of choice for military (and other government) communications, as well as precision targeting. However, that band is being used by many other firms abroad for commercial wireless communications, raising the possibility that a continued U.S. policy of denial, although perhaps making short-term military sense, will inhibit the ability of U.S. firms to compete abroad. Stephen Price, head of the Pentagon’s new office for spectrum management, recently said that the greater information demands of the war on terrorism and increased homeland security efforts are making DoD even more leery of freeing the disputed spectrum bands.49

The health of the U.S. commercial space and telecommunications industry is critically important to the computerized, globalized U.S. economy, but also directly to the U.S. military. The Department of Defense now uses
commercial satellite systems to cover about 60 percent of its satellite communications needs, and that dependence is growing. Military use of commercial assets is unlikely to significantly decline, in part due to the high costs of building and operating military-dedicated satellites.

Of course, it must be pointed out that some U.S. firms will no doubt benefit from any new U.S. programs to develop space-based weaponry – particularly the large defense contractors already involved in military space programs. Nonetheless, there remains reason to be concerned about the affect on other companies more involved in the commercial use of space. And since there are, and will remain, direct benefits to the military of maintaining a strong and competitive commercial space and telecommunications industry, the possibility that the deployment of weapons in space or a policy of aggressive targeting of satellites (and subsequent government regulatory restraints) may have negative industrial implications must be more fully explored.

Conclusion

As this paper has attempted to outline, there are a number of serious issues surrounding the question of whether the United States should deploy weapons in space. It is clear that there are measures that should be taken in the near- and medium-term to protect increasingly important U.S. space assets. However, what has yet to be
truly analyzed is whether doing so requires space-based weapons any time in the foreseeable future. Outside of the technical challenges and the non-trivial issue of whether the U.S. government is willing or able to take on the long-term budgetary investment required to sustain military operations in and from space, there are potential national security and economic risks involved with such a path. There is a fundamental question as to whether a U.S. policy to weaponize space would be a ‘silver bullet’ for future security, or a game of Russian roulette.

It is therefore crucial that before any change to today’s policy of restraint takes place, the U.S. government undertake an in-depth review of the possible consequences and alternatives. The short-term military advantages to the U.S. military of being first to utilize space weapons, however dramatic, must be weighed against the long-term military, political and economic costs. The burden lies on the administration to prove that any policy change would provide a net, and sustainable, improvement is U.S. national security writ large. Such a formal policy review should be undertaken immediately, given the Bush administration’s fast-forward missile defense plans. It is imperative that the missile defense program not be allowed to solely drive a decision to weaponize space, especially in absence of serious consideration of the potential strategic, military and economic consequences.
Under ideal circumstances, the National Security Council would put together an interagency group to look at options and alternatives including passive defenses for space assets and arms control solutions, and provide the opportunity for independent experts and industry to have input. Obviously, such a study could be done under the auspices of the new Space Policy Committee. Congress, too, should begin studying the issue – including holding near-term hearings to draw out the implications of a space-based element to a missile defense architecture, as well as to address the wider issue. A broad-based public debate is necessary to ensure that policy-makers fully understand the implications of breeching the “final frontier.”

Notes

1 The structural foundation of this paper is based on Theresa Hitchens, “Rushing to Weaponize the Final Frontier,” first published in Arms Control Today, September 2001.
6 “Air Force Space Command, “Strategic Master Plan for FY02 and Beyond,” Feb. 9, 2000, the online at:
Weapons in Space


8 Ibid.


10 Author’s own notes.


17 For a comprehensive look at potential space-based weapons against terrestrial targets, see Bob Preston, Dana J. Johnson, Sea J.A. Edwards, Michael Miller, Calvin Shipbaugh, “Space Weapons/Earth Wars,”
Project Air Force, RAND, Santa Monica, Calif., 2002. The study was sponsored by the U.S. Air Force Office of the Deputy Chief of Staff, Plans and Programs.

24 Ibid.
Weapons in Space

29 DeBlois, “Space Sanctuary.”
32 Spacey, “Does the United States Need Space-Based Weapons.”
34 Hyten, “A Sea of Peace.”
40 Interview with Author, March 25, 2002.
41 DalBello, “SIA/Futron Satellite Industry Indicators Survey.”


Author’s own notes.

Campbell, “US buys up all satellite war images.”


Chapter 4

Assessing the Military Utility of Space-Based Weapons¹

William Spacy, II

I. Introduction

The George W. Bush administration’s emphasis on developing a ballistic missile defense (BMD) system has reenergized the debate on weaponizing space. In order to pursue this effort, the U.S. unilaterally withdrew from the 1972 Anti-Ballistic Missile Treaty and cleared the way for the new Missile Defense Agency to develop a BMD system that may include orbital weapons. Other events adding relevance to the debate are conflicts highlighting the value of space-based assets in conventional warfare. Most recently, Operation Iraqi Freedom demonstrated just how critical precision weapons guided by signals from space are to modern warfare. Space-based assets also played key roles in providing the reconnaissance data and communication links that enabled the U.S. and its coalition partners to dominate the conflict.

Looking to the future, it is apparent that the U.S. military will continue to increase its reliance on space-based resources. This reliance prompts some to argue that we need to deploy weapons in space if we are to

¹ This is a revised and updated version of a paper with the same title published as Cadre Paper 4, Air University Press, Maxwell Air Force Base, September 1999.
protect these assets and deny our enemies access to theirs.¹ For example, the Air Force Space Command Strategic Master Plan, FY04 and Beyond, includes an objective of: “Transform[ing] space from being focused on Force Enhancement to also providing a range of Force Application capabilities beyond ICBMs in, from and through space.”² (Emphasis added)

While we should not dismiss space-based weapons from consideration without a thorough evaluation, arguments on both sides of the debate often fail to make this evaluation. They ascribe to these weapons broad capabilities that are either technologically unfeasible, or extraordinarily expensive to develop. Major questions that many fail to address include what capabilities space-based weapons provide that land, sea, or airborne weapons cannot, and what space-based weapons are likely to cost, both in terms of dollars and in political capital. A related concern is what capabilities these weapons will confer upon other nations if they develop space-based weapons of their own.

The primary focus of this paper is to explore the military utility and relative feasibility of space-based weapons. Cost will receive less emphasis because many of these concepts are in the earliest phases of development and very little cost data exists. Estimated costs are used where available, but in most cases, cost can only be treated qualitatively.

The political implications of weaponizing space are also significant, but others have published extensive works on this subject and only the most significant will be highlighted here.³ Similarly, this is not an in-depth
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discussion of space control doctrine, but more of a reference that lays out in detail the relative merits of space-based weapons.

Missions for Space-Based Weapons

Space-based weapons have been proposed for ballistic missile defense (BMD), space control, and attacking terrestrial targets. The concepts proposed for these missions range from high-energy lasers that can destroy satellites across thousands of kilometers, to kinetic energy weapons that destroy their target by physical impact. Many of these weapons, and lasers in particular, could be used for a number of applications.

To narrow the discussion to the most contentious issues, this paper considers space-based weapons to be only those systems for which the destructive component resides in orbit. Systems that rely on space-based assets for information collection, weapon cuing and guidance, as well as weapons that only transit space on the way to their target, are not considered to be space-based weapons.

The concepts discussed in this paper are based on open-source documentation of space weapons currently being pursued or under consideration. The paper is organized along functional lines, with space-based weapons and their more conventional counterparts being evaluated in terms of how effective they would be at performing the various missions proposed for them. An exception to this is the discussion on space-based laser weapons, which are discussed separately because of their theoretical versatility and very real technological
challenges.

II. Directed Energy Weapons—Not Ready for Prime Time

Directed energy weapons have been proposed for each of the missions mentioned above. They include radio frequency (RF) weapons, lasers, and particle beam weapons. Only lasers will be discussed here, since particle beam weapons have fallen out of favor and RF weapons are still mostly a theory.4

Lasers

Potentially capable of reaching across thousands of kilometers at the speed of light, lasers seem to be ideal candidates for space-based weapons.5 Since light has no mass, lasers are not constrained by orbital dynamics and can fire against any target within their range and line-of-sight, hitting them almost instantaneously.

The laser beam itself can be created in a number of ways and the beam’s power and characteristics depend on how it is generated. Lasers using solid crystals have demonstrated power levels up to 10,000 megawatts, but they can only produce this power in extremely short pulses and quickly overheat if used continuously. Pulse lengths of only a few milliseconds and efficiencies of only 1-2% make these lasers impractical as weapons.6 Continuous wave lasers, which operate at lower power but for longer durations, show greater promise for use as weapons.
Assessing the Military Utility of Space-Based Weapons

Estimating the Power Required

The main problem with making a laser into a weapon is generating a reliable, high-power beam with good beam quality. If you want to shoot down a ballistic missile from orbit, the role most often discussed for lasers, you need to deliver enough energy to fatally weaken the missile’s skin. This may require as little as 1 KJ/cm² for unprotected liquid propellant missiles, but the more robust construction of solid fuel missiles, or countermeasures such as ablative coatings, may raise this level as high as 30 KJ/cm². Richard Garwin, a physicist at IBM’s Watson Lab and consultant for Los Alamos Science Lab, calculates that for a missile hardness of 20 KJ/cm², a laser must focus a 25 megawatt beam into a spot 1 meter in area for 6 to 7 seconds if it is to deliver energy to the target fast enough to burn through the casing. It is reasonable to assume that if the U.S. starts testing and deploying space-based laser weapons, then potential adversaries will modify their missiles in order to make them less vulnerable. For this reason, a laser capable of producing a 25 MW, beam and focusing it into a spot of 1 m² at a range of 3,000 km for 7 seconds forms the baseline for discussion in this paper.

Engineering Challenges

Providing a 25 MW laser can even be built, the components needed to generate the beam will have to be huge. To date, the most powerful continuous wave lasers created by the United States generate only 1-2
megawatts. While one design (the Alpha laser) is said to be scalable to greater power levels, doing so would require massive space structures. The lasing chamber of the Alpha laser (the chamber that produces the beam) is over 2 meters long and produces a “megawatt power” beam. If we interpret this to be 1-2 megawatts and assume that the laser is linearly scalable, then the chamber needed to generate a 25 MW beam would have to be 25-50 meters (82-164 ft) long. One problem is that the laser is probably not linearly scalable; while another is that the highest power level achievable may be considerably less than 25 megawatts.

Building lasers with enough power is only one of the hurdles that must be overcome before practical laser weapons become a reality. Other obstacles include creating highly reflective mirrors able to focus and direct the powerful beams without overheating. To point the mirrors we will need to develop steerable assemblies precise and agile enough to maintain the beam on a moving target for the required seven seconds (for BMD) and then rapidly slew to another target. This will be difficult because of the relationship between the wavelength of the laser, mirror size, engagement range and energy delivered to the target. For ranges on the order of 3,000 km, the laser’s mirror will have to be approximately 10 meters (33 ft) in diameter. In addition, this mirror must be pointed accurately enough to prevent deviations of more than a few centimeters while the weapon travels about 50 km in one direction and the target travels about 40 km in another. While aiming devices with the requisite precision and accuracy have been demonstrated, these demonstrations have been made with the laser and its associated pointing
Equipment firmly bolted to the earth, not floating in space. The tests also did not have to track targets moving as fast as an ICBM, and have not incorporated the large mirrors necessary to handle lasers powerful enough to be weapons.

The nature of the chemical lasers proposed for use as weapons makes aiming these weapons even more difficult. Chemical lasers produce a beam by mixing volatile chemicals that react in a way very similar to rocket fuel, but in this case, the result is intense light with the energy concentrated in a very narrow band of wavelengths. The combustion process generates considerable vibrations, and the products are high-temperature, high velocity corrosive gases that must be continuously removed from the chamber for the lasing process to continue. Current plans for disposing of these gasses call for venting them overboard. The hard part will be to do this in a manner that prevents the chemicals from damaging the laser and avoids inducing vibrations or movement in the weapon platform.

System Size

The most promising candidate for a space-based weapon is a hydrogen-fluoride chemical laser based on the Alpha laser developed under the Strategic Defense Initiative. In 1991, this laser demonstrated the ability to produce “megawatt power” in a simulated space environment. The system envisioned for BMD would consist of a constellation of 20 laser platforms operating at an altitude of 1300 km and would provide “planetary coverage” for both theater and intercontinental ballistic missiles. A major problem to be overcome is
supplying the lasers with their chemical fuel. Each laser may consume as much as 375 - 750 kilograms of chemicals per second while firing, and engaging even 5 ballistic missiles requiring 7 seconds each would require 13,125 – 26,250 kg (28,875-57,750 lbs) of chemicals. This would require a total of 577,500 to 1,155,000 pounds of chemicals just to give each of 20 weapons the ability to fire five bursts of 7 seconds each. Supplying these chemicals to an orbiting satellite is more than just a small logistical problem; it is a fundamental weakness of the concept.

The need for large quantities of chemical fuel appears to make space-based chemical lasers unfeasible, but with efficiencies of about 25 percent, chemical lasers have the best combination of efficiency and power generation of any lasers available today. Lasers that require electricity to generate the beam have been largely eliminated from consideration as orbital weapons because of the difficulty in generating enough power. Compared to chemical laser efficiencies of 25 percent, solid-state laser efficiencies of less than 5% make generating sufficient power a serious obstacle. Added to this are losses inherent in generating the electricity in the first place, and the relatively low power levels attainable if the laser is to be fired in bursts as long as several seconds. These drawbacks make solid-state lasers even less practical than their chemical cousins.

Anti-Satellite Lasers

While boost phase BMD is the primary use for which space-based lasers have been proposed, they could also be used as antisatellite weapons (ASATs).
Assessing the Military Utility of Space-Based Weapons

The great distances inherent in space operations, coupled with the large amounts of energy required to change orbits, makes it difficult to physically intercept an enemy satellite. Lasers seem to offer the ability to sidestep these problems in the same way that they would for ballistic missile defense. However, designing orbital lasers to attack satellites is almost as difficult as designing them to attack ballistic missiles.

Orbital lasers designed to destroy ballistic missiles in the boost phase, could they be built, would probably also be able to destroy satellites. The orbital dynamics of the two problems are similar, and the relative velocity of two satellites in similar orbits would probably be within the range of velocities for which a BMD laser would have to contend. A BMD laser should also have the pointing and tracking accuracy needed to track and engage a satellite. The range at which BMD lasers would have to operate should also be adequate for some ASAT missions. However, designing an orbital laser to be effective against both ballistic missiles and satellites would require additional capability.

Satellites have characteristics that make using lasers against them difficult. Whereas ballistic missiles have an extremely bright infrared signature during launch and a structure that would collapse catastrophically, and visibly, if significantly damaged, satellites are quite different. While satellites generally have delicate components that are vulnerable to laser attack, such as solar cells and optical sensors, the destruction of these components would be difficult to verify. Causing greater damage, or damaging satellites without vulnerable sensors, may be necessary. And
while engaging a satellite should not be any more difficult than engaging an ascending ballistic missile, the much fainter infrared signatures of satellites would necessitate different sensors for target acquisition and tracking.

One problem orbital lasers will not be able to solve is the difficulty associated with attacking satellites at truly long distances. Ideally, an ASAT laser would be able to attack more than just the satellites in neighboring orbits. But the problems inherent in engaging targets at a range of 3,000 km are compounded as the range increases. For instance, if a weapon in low earth orbit (LEO)\textsuperscript{23} were to engage military communication satellites in geosynchronous orbits (GEO), it would need a range of almost 30,000 km.\textsuperscript{24} Building a weapon with such a long range would be extremely difficult. As mentioned above, there is a direct relationship between mirror size, the range of the weapon and the energy delivered to the target. Using the chemical lasers described above, a range of 30,000 km would require a truly enormous mirror 99 meters (325 ft) in diameter if the spot size on the target is to be kept to 1 m\textsuperscript{2}.

To overcome the difficulty of operating at extremely long range, it would be necessary to deploy some weapons in orbits closer to those of the target satellites. If the range could be brought down to 3,000 km or less, then lasers designed for BMD could be used. However, the cost of doing so would be very high. If the weapons envisioned for BMD were to be placed in significantly higher orbits, then massive boosters would be required, both to deploy them initially and to refuel the lasers if it became necessary.
Other Targets for Orbital Lasers

Another proposed use for space-based lasers is to attack airborne or surface targets. However, the lasers that have been proposed for BMD would be ill suited for attacking terrestrial targets. This is because the wavelength at which these lasers operate is heavily absorbed by water vapor in the atmosphere. Using other wavelengths could provide some capability against airborne and surface targets, but the nature of these targets makes them resistant to damage by orbital lasers.

The inherent “hardness” of most militarily significant surface targets coupled with the difficulty of maintaining the integrity of the laser beam as it transits the atmosphere makes destroying them with an orbital laser problematic. While high-flying aircraft would be somewhat vulnerable to an orbital laser, attacking them would pose significant problems for target acquisition and tracking, since they would be fairly cool targets against the varying background of the earth. These problems could conceivably be overcome, but the changes involved would add cost and complexity to an already expensive weapon.

Thus, if we could build an effective space-based laser for BMD, we could also give it considerable ASAT capability. Modifying it for use against airborne targets would add cost and complexity for little gain. These added capabilities would also complicate the problem of deciding which targets to attack, since fuel limitations would mean that every aircraft or satellite engaged would be one less ballistic missile that could be shot down. Given the fact that we have very good weapons
for shooting down aircraft, and adequate ones for use as ASATs, while the same is not true for ballistic missiles, using lasers to engage these other targets does not make sense.

One final problem is that of transforming a laser into a viable weapon. To do this, we will need to make it robust enough to survive years of inactivity in the hostile environment of space. The threat of being struck by space debris along with environmental factors such as radiation, charged particle bombardment, and thermal cycling make space a challenging environment in which to operate. While all satellites must contend with these problems, lasers are particularly delicate and are extremely dependent on the precise alignment of their components if they are to work. As demonstrated by the near failure of a test of the MIRACL laser, it is difficult to get a high-power laser to work reliably on the ground. Building such a laser to withstand the rigors of launch and subsequent storage in orbit will be extremely challenging. Couple these difficulties with the consequences of failure, since they would only used in times of dire need, and the prospects of a feasible space-based laser become dim indeed.
III. Ballistic Missile Defense

Boost Phase Kinetic Energy Weapons

Although directed energy weapons appear to have many properties desirable for BMD, their technological immaturity prompted the SDI program, and now the Missile Defense Agency, to evaluate kinetic energy (KE) weapons to fill this role. While current efforts are only in the earliest stages of concept development, a project initiated for SDI, and continued for its successor program, Global Protection against Limited Strikes (GPALS), provides insight into the problems that will have to be solved.

Brilliant Pebbles (BP) was a kinetic energy weapon system designed to defend against a ballistic missile attack. As envisioned for the GPALS concept, BP would consist of 700 to 1000 individual interceptors (small missiles called “pebbles”) deployed into approximately 27 different orbits at an altitude of about 400 km (250 miles). This architecture was designed to stop a limited strike of up to 200 missiles by destroying them during the boost phase of their flight. It would have been effective against all ballistic missiles except those with ranges less than 400-600 km or maximum altitudes lower than 80-100 km. Moving at about 5 miles/sec, the BP interceptors would have destroyed their targets by physical impact.

Significant Challenges

A system comprised of such a large number of
individual interceptors would require a sophisticated system to control it. Two approaches to this problem have been proposed. The first is a system architecture that relies on cross-linking the individual interceptor satellites so that the ground control system is able to contact individual satellites and the satellites are able to communicate with each other. Cross-linking allows the majority of the computing power necessary for directing an attack to reside on the ground, an important consideration in a system that must simultaneously engage many targets without wasting multiple interceptors on any single one.

A less centralized approach would be to give each interceptor almost total autonomy. As described by Lowell Wood of the Livermore Laboratory, once activated “Each pebble would carry so much prior knowledge and detailed battle strategy and tactics, would compute so swiftly and would see so well that it could perform its purely defensive mission with no external supervision or coaching.” Aside from the moral reluctance of many to give any weapon so much autonomy, a major problem with this concept is to devise a computer/software combination small, cheap and smart enough to do the job. Even with the incredibly rapid progress being made in computer technology today, developing such a computer is unlikely to be possible for quite some time.

A major problem with boost phase intercept is engaging missiles within the atmosphere. Doing this proved so difficult that Brilliant Pebbles was eventually refocused toward intercepting missiles after the boost phase. This change helped solve some problems with designing interceptors, but meant that more capable
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systems would be needed to detect, identify, and track individual warheads, and discriminate between warheads and decoys.

Brilliant Pebbles was initially estimated to cost $55 billion (in 1988 dollars), and would have been an extremely complex system. When you consider the technical challenges of building interceptors with enough speed, range and agility, as well as the detection, tracking, and command and control systems to go with them, even this estimate looks optimistic. These factors, along with a myriad of political considerations, prompted Congress to cancel the program. More importantly, while orbital weapons may offer some advantages over ground-based systems in theory, they are not the only way to attack post-boost ballistic missiles. In fact, the Missile Defense Agency is currently developing a layered system that relies on ground-based interceptors for post-boost-phase defense.

Other Weapons For Boost Phase BMD

If they could be built, orbital interceptors are probably the only way to stop ballistic missiles in the boost phase. While airborne concepts have been investigated or are being developed, all of these entail placing an aircraft fairly close to the launch site. Even the concept with the longest range, the airborne laser (ABL), will only have an effective range of several hundred kilometers. Against nations with a large landmass, ranges this short will make it extremely difficult to place the large, highly vulnerable aircraft needed to carry the lasers close enough to the launch
sites to be effective. Concepts that envision air-launched missiles to perform the intercept suffer from similar problems.

We could develop air-launched missiles to intercept ballistic missiles, but the aircraft carrying them would have to be even closer to the launch sites than would the ABL. Stealth aircraft may be able to safely loiter close enough to be effective, but the launch sites will probably be too dispersed or mobile to allow a reasonable number of aircraft to keep all of them within range. The aircraft would also be vulnerable during daylight hours, providing an adversary with the simple option of launching during the day. In any case, whether an airborne boost-phase defense uses lasers or missiles, virtual air supremacy will be necessary if the aircraft are to keep launch sites constantly within range.

Another problem with ABL, as well as ground and sea-based concepts, is that they would take days or weeks to deploy and could only be used after hostilities broke out. This is probably sufficient for defense within a theater of combat, but if continuous protection from a surprise attack is needed, then orbital weapons may be the only viable alternative for boost-phase defense. Developing such a system will be a major technological challenge and very expensive, since large numbers of satellites will be needed to defend against even a limited missile attack. Since these weapons will have to be in low earth orbits, they will also present lucrative targets for antisatellite weapons.
IV. Space Control—Space-Based or Launch on Demand?

Space control is comprised of two parts, protecting our space-based assets, and denying an adversary access to his. While these facets of space control are distinct in the abstract, the characteristics of the weapons that have been proposed to accomplish them are similar. This analysis will describe space-based antisatellite weapons (ASATs) first, and then move on to defensive weapons.

Space-Based Weapons

Although lasers appear to have many properties that would be desirable for antisatellite weapons, alternative weapons that physically impact their target are more feasible given current technology. These weapons either use the kinetic energy of a direct impact, or pass near enough to a target for an exploding fragmentation device to destroy it.

Kinetic energy ASATs

Mass-impact KE weapons rely on the large velocity differentials inherent in orbital dynamics to destroy a target. Given that a satellite in LEO travels at a velocity of about 7.8 kilometers per second (km/s), and that a pound of anything moving at 3 km/s has kinetic energy equivalent to a pound of high explosive, hitting something at these speeds can be catastrophic. If the target is as fragile as a satellite, then only small amounts of mass are needed for destruction upon impact.
However, the problem of actually hitting a target is complex.

If we want to keep the ASAT to a reasonable size, then we need to put it in an orbit that lets it intercept its target without expending too much energy. While there are many orbits that can accomplish this for any given target, the easiest way to visualize the problem is to consider an orbit that crosses the target’s orbit numerous times during a day. If the ASAT’s orbit is either higher or lower than that of the target, then only a relatively small booster motor would be needed to maneuver it to intercept the target. Using the most economical transfer orbit would require only modest amounts of propellant, although this would mean waiting until the orbital geometry was ideal. A weapon with more maneuvering capability would provide more flexibility, but would also have to be larger. \(^{37}\) In order to prevent the enemy from knowing that a satellite is in fact a weapon it would be necessary to use an orbit that would not reveal its nature. Fortunately, non-ASAT satellites are placed in a wide variety of orbits, so finding one suitable for an ASAT should not be difficult.

What makes intercepting satellites difficult is the combination of the large closing velocity inherent in KE weapons, and the relatively small size of the target. While the largest satellites may be about the size of a Greyhound bus, this bus is traveling at about 17,500 miles per hour (in LEO). The velocity of the intercepting weapon will be about the same, but in a different direction. The total closing velocity will be the vector sum of these two velocities and makes terminal guidance challenging.
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Once placed in an intersecting orbit, the ASAT must be able to “see” far enough and be agile enough to make the final corrections needed to intercept its target. While recent progress in developing kinetic kill vehicles for BMD shows that terminal phase challenges can be overcome, launch costs, along with the added systems needed for orbital maneuvers and to support the weapon for years in space, will make an orbital KE ASAT even more expensive than a BMD interceptor. Dealing with the cloud of orbiting debris resulting from a successful intercept would be an additional problem.

Co-orbital ASATs

Another method for attacking enemy satellites is a co-orbital or near co-orbital approach. The co-orbital ASAT closes slowly with its target, similar to the way two spacecraft rendezvous in orbit, and then uses an exploding warhead to destroy it. A problem with this type of ASAT is that it usually takes at least one orbital period, about ninety minutes for LEO and longer for higher orbits, to match orbits with the target satellite. If the ASAT is to remain inconspicuous (i.e. if the ASAT’s orbit is to disguise the nature of the weapon), then it cannot be placed in an orbit that is too similar to that of its target. This means that the co-orbital ASAT will have to make larger maneuvers than a KE weapon, especially if the target is in a different orbital plane. These factors dictate an interceptor with more maneuvering capability (more \( \Delta V \) available) than an ASAT using a high-speed impact, although the interceptor would not have to be as agile.
Once a co-orbital vehicle starts on its intercept course, it is possible that the target’s owners could detect the maneuver and initiate countermeasures. This would require a much better tracking system than any nation has now, but if the U.S. pursues an overt campaign to develop space-based weapons; potential adversaries will probably take steps to secure their satellites. The long period of time required for co-orbital ASATs to intercept their target may give the target time for either defensive actions or evasive maneuvers, depending on its capability. This combination of the co-orbital ASAT’s longer time to intercept and its need for more $\Delta V$ makes the KE ASAT somewhat more feasible as an antisatellite weapon.

Space Mines

Another popular ASAT concept is the “space mine.” This type of weapon is similar to the co-orbital ASAT just discussed, except in this case the weapon is placed near the target satellite well before any hostilities break out. The problems with this approach are similar to those of the co-orbital ASAT, compounded by the need for stealth. As mentioned above, attempting to close with another satellite usually requires a large vehicle expending large quantities of propellant. In contrast, a viable space mine would require a more covert method of approach.

One way to do this would be to design a very small “stealth” weapon that would slowly move into position over a long period of time. The weapon could be placed in an orbit such that it would not approach the target for days or weeks after launch, essential to avoid
alerting an adversary. When it finally approached the target, the weapon would have a low relative velocity. If done properly, only a short thruster firing would be required to match orbits and “park” the weapon near the target. When needed, the weapon would be activated and destroy the target by closing the final distance and exploding. The problem with this concept is that a space mine would have to be deployed well in advance of when it is needed, a fact that places considerable demands on its design: stealth vs. capability. One major problem with the space-mine is that it will have to perform station-keeping maneuvers (in order to keep itself near the target) while simultaneously keeping its most stealthy aspect pointed toward the earth (in order of avoid detection). Since virtually all satellites must maneuver to maintain their orbit, the space mine would have to mimic the target’s maneuvers if it is to remain close. Thus, the mine should be small and stealthy to avoid detection, but may need a large amount of propellant to do its job.40

Another major problem with a long-lived space mine is providing a power source for the weapon. Since it may be many years before the mine is used, a long-term power source will be necessary. Most satellites use solar power to provide electricity, but solar arrays are not very stealthy and cannot always be oriented to provide a small radar cross-section. Most other power sources, such as batteries or fuel cells, cannot provide enough power for long enough to do the job. Nuclear power is one potential solution, although its thermal signature makes it less than ideal for a space mine and it could send radioactive debris raining down on earth if it were used.41 While an intensive technology
development program may provide the means for surmounting these problems, the costs of doing so are probably not worth the effort.

The United States would probably not need true stealth, since most other nations have only a limited ability to monitor events in space, and it would be much easier to develop a non-stealth space mine, since such a weapon would avoid the greatest obstacles associated with one which must remain undetected. However, we probably do not need to pursue even a non-stealthy space mine. Not only would its development mark a clear break from the traditional sanctuary status of space, it would yield few benefits in return. The low-tech nature of an overt space mine would make it relatively easy for other nations to duplicate, and since we have already demonstrated the ability to destroy satellites with lower profile ground-based weapons (and that there are relatively few satellites we would want to destroy in the first place) it offers few benefits. The situation is not quite the same for our potential adversaries.

Space Mines in GEO

While an adversary of the United States will have many lucrative targets in LEO, our ability to monitor what is occurring in orbit would require them to overcome all of the problems inherent in developing a sophisticated space mine. Where we may have some vulnerability in the future is from less sophisticated space mines that could threaten our satellites in GEO.

The large distances involved in observing
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satellites in GEO, at least from the earth, means that an effective weapon would not need stealth. An opponent could develop a fairly small space mine that would “piggyback” on one of his communication satellites. Once the communications satellite is established in GEO, the space mine could be detached and could use low thrust levels to maneuver into position over a period of weeks. Recent advances in the development of micro-satellites show that they may have potential for this type of application, although our potential adversaries would probably need 10 to 15 years to develop them into weapons. 12

This kind of attack would have to be planned months, if not years, in advance. A nation would need to determine today that it might want to attack our satellites in GEO about 15 years from now. It would then have to initiate a multimillion-dollar program to develop the necessary technology and launch it on a suitable satellite. The real military utility of such a weapon is questionable, since the only potential targets are communication and early warning satellites.

The few nations that could truly benefit from this kind of weapon are ones that want to make a surprise missile attack on either their neighbors or the U.S. Unless the world changes drastically, nations with a nuclear strike capability will continue to view early warning satellites as a stabilizing influence. The other potential targets, military communication satellites, do not appear to be worth the effort needed to destroy them. Given the large number of commercial communication satellites, and the amount of money the U.S. would be willing and able to spend on communications in time of war, destroying these satellites does not seem cost

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effective. The utility of defending against this threat will be discussed below.

**Weapons that Degrade Enemy Satellites**

Rather than destroying a satellite, a better approach may be to capture or merely disable it, for instance by spraying paint on its solar cells or optical instruments. A more sophisticated approach would be to disable or degrade a critical sub-system of the target satellite, such as the attitude control system. Regardless of method, an advantage of this approach is that it would not produce a cloud of orbiting debris.

One concept along these lines is to develop a satellite capable of physically moving an uncooperative satellite. Devices for refueling or repairing uncooperative satellites are already being developed; giving them the capability to move or disable satellites should be relatively easy. If the satellite’s owners are unable to monitor other spacecraft in orbit, then this assault could well be made surreptitiously.

A potential advantage of weapons that degrade or disable enemy satellites is this possibility of using them covertly. The overall effect of doing this might extend far beyond the enemy’s loss of the satellite. Surreptitiously disabling or degrading an enemy satellite could cause the enemy to waste valuable time reevaluating and possibly redesigning the “failed” satellite. As a minimum, the satellite would probably have to be replaced. In any case, unless the United States is at war with the other nation, any tampering
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with its satellites must be concealed…which makes this alternative particularly attractive.

If designed as space-based weapons, these concepts suffer from the same problems as their more destructive counterparts. They will either need to be covert, like the space mine, or large and maneuverable, like co-orbital ASATs. In either case, they will be very expensive and technologically challenging. Alternatives to space-based weapons have the potential to be equally effective, more flexible, more technologically feasible and less expensive.

Ground-Based Alternatives

If we want to deny an enemy the use of his space-based assets, then the surest way to do so is to physically destroy the satellites themselves. Doing this from the ground makes use of the same principles as the space-based methods just discussed, and includes three types of weapons: ground-based directed energy weapons, KE ASATs, and co-orbital ASATs.

Ground-based lasers seem to offer many advantages over their space-based counterparts. They do not have to withstand long-term storage in space, they can be as big as necessary, and maintaining large supplies of chemical fuel is much simpler. Problems with ground basing include the tendency of the atmosphere to disrupt the phase front of the laser and absorb its energy, both of which weaken the attack. Taken together, these problems present significant obstacles to using lasers to do much more than burn out a satellite’s sensors. On the other hand, the ability to
build a laser as large as necessary, and the relative ease of building sophisticated devices to keep the beam aimed and focused, means that ground-based laser weapons may become practical. It seems wiser to invest in more ground-based laser research, before attempting to modify these weapons for use in space.

Ground-Based ASATs

Ground-based versions of KE and co-orbital ASATs also have advantages over their space-based counterparts. Probably the simplest approach is a direct ascent KE ASAT that does not actually enter orbit, but lofts an interceptor into the path of an oncoming satellite. To do this, the ASAT is launched into the path of a satellite from a location on or near the satellite ground-track, and shortly before the target satellite arrives overhead. Similar to a space-based weapon, the kill mechanism is the kinetic energy inherent in the velocity differential between the target satellite and the vertically ascending ASAT.

Another way to attack satellites in low earth orbit is to use a co-orbital ASAT. Here again, the ground-based version would be very similar to its space-based counterpart. The interceptor would need to have a similar ability to maneuver, but could be much smaller since the launch booster would place it into the same orbit as its target.

Reaching Higher Orbits

One limitation to direct ascent ASATs is that
they are only feasible against targets in fairly low orbits. If it is necessary to reach targets in higher orbits, then the size of the booster needed to launch the weapon will increase and eventually becomes too large to be practical. A better method is to place the ASAT into a more efficient transfer orbit. This would not be a co-orbital intercept, and expending resources on a co-orbital weapon is probably not necessary. While sufficient to ensure destruction of the target, the closing velocities between an ASAT in a transfer orbit and its target would be lower than for a direct ascent ASAT, and the final tracking and closing maneuvers somewhat simpler.45 While no nation is currently developing such a system (at least publicly), the ability to do so is inherent in the technology required to place a satellite in high earth orbit and many countries have this capability.46 Given sufficient incentive, developing an antisatellite weapon capable of reaching geosynchronous satellites should only be a moderate challenge for a spacefaring nation.

Current Efforts

The most recent U.S. effort to produce this type of weapon is the U.S. Army’s Kinetic Energy-Anti-Satellite (KE-ASAT) program. The weapon they are developing is a direct ascent ASAT comprised of a kill vehicle launched on a Minuteman or Pegasus booster. The program was estimated to be about three years from demonstrating an ASAT capability when the Clinton administration cancelled it.47 Congress kept the program alive for several years with low-level funding, and Army officials are now hoping to obtain FY-04
funding to demonstrate an actual satellite intercept.\textsuperscript{48}

\textbf{Proven Concepts}

Other programs have already demonstrated the feasibility of using both KE and co-orbital ASATs against targets in LEO. During the 1980s, the United States demonstrated an air-launched KE ASAT, while the Soviet Union demonstrated a ground-launched co-orbital system.\textsuperscript{49} In addition, the U.S. may be able to repeat its accomplishment with the current KE-ASAT program in approximately three years.

Regardless of whether they are co-orbital or direct ascent, ground-based ASATs have inherent advantages over their space-based counterparts. While it will take one ASAT to destroy one satellite regardless of where the ASAT is based, space-based ASATs are even more limited in that they will probably only be capable of destroying one \textit{particular} satellite. For a space-based ASAT to destroy an enemy satellite, it must be deployed in an orbit that will permit it to intercept its target in a reasonable amount of time and with the propellant available on board. If the ASAT is to be kept reasonably small, then it will probably be limited to engaging satellites that are in similar orbits. In many instances, this lack of maneuverability will limit the ASAT to being able to attack only a few targets, often only one. A ground-based system would avoid such limitations, and with large enough boosters and orbital transfer vehicles, any satellites could be engaged, even those in the highest orbits.

A non-destructive alternative to ground-based
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ASATs is a weapon that can physically move or disable an uncooperative satellite. Similar to the space-based version mentioned above, a ground-based version of this weapon would allow the U.S. to deny an adversary the use of space-based assets without actually destroying them. This weapon would have the same advantages over its orbital counterpart as the ground-based co-orbital ASAT, and would have the added benefit of not producing a cloud of orbiting debris when used.

Responsiveness and Cost

With a launch-on-demand capability, the responsiveness of ground-based weapons could also be nearly as good as that of their space-based counterparts. With the possible exception of the space-mine, intercepting a satellite with a satellite will often take as long as or longer than intercepting it from the ground. The nature of orbital dynamics is such that the time necessary to achieve the orbital geometry required for a space-to-space intercept will often be as long as waiting for an optimum launch opportunity from the ground.

Ground-based ASATs would also probably cost less than their space-based counterparts would, although both systems would require boosters of about the same size. What would make a space-based system expensive is the additional complexity needed for a weapon to survive months or years in orbit and then perform flawlessly. Ground-based weapons, on the other hand, could be stored in climate-controlled buildings or silos, which would add cost, but would make them accessible for maintenance. They could also be used against a larger number of targets. This latter
characteristic means that we would not need as many ASATs, since it would not be necessary to place them near targets that are never engaged.

**Defending Satellites**

Unlike ground warfare, where the defense is often considered to have an advantage, fighting a war in space is one in which the opposite is true. In both cases, the attacker has the advantage of choosing the time, strength and direction of the attack, but the defender in space enjoys few of the advantages of his land-based counterpart. Space has no terrain that can be prepared for defense, valuable assets cannot be dug-in and the enemy cannot be forced to attack from a specific direction. What’s more, space assets are in very visible and inherently predictable orbits that make them easy targets for anyone with the ability to strike at them.

The number of nations with the ability to develop weapons to attack space-based assets, at least those in LEO, is increasing steadily. Any nation able to place a satellite in orbit, and possibly some capable of building only sounding rockets, could build direct ascent antisatellite weapons. Since a direct ascent ASAT does not have to achieve orbit, the booster to lift it can be relatively small and simple. In contrast to the boosters required to place even a few hundred kilograms into orbit, one that only has to loft it a thousand kilometers weighs an order of magnitude less, only a few metric tons. Doing this is within the capabilities of many sounding rockets developed by nations pursuing space-launch capabilities or ballistic missiles. While a sophisticated KE ASAT would be out of reach even for many nations with the requisite boosters, a barrage of
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Rockets fired into the path of a satellite and exploding into swarms of pellets could be effective. Given the relatively low cost of the boosters, this type of attack may be considered feasible by those nations possessing them.\(^5\)

If someone wants to shoot down satellites, then they have to be able to track them with precision, but tracking information is not difficult to come by. With a concerted effort, a simple tracking system could be developed to track satellites well enough for a barrage style of attack.\(^5\) While the low probability of kill achievable with this type of attack would never be acceptable to the United States,\(^5\) some feel it presents too much of a threat for the defender to ignore, particularly when a nation depends heavily on space-based assets.

**Bodyguards**

One way to defend a satellite is the “bodyguard” concept. A bodyguard is a satellite that orbits near a high-value satellite and defends it against antisatellite weapons.\(^5\) These bodyguards could be designed around either directed energy or mass impact weapons. While doing this might seem logical at first glance, the problems with this concept mirror those of the offensive ASAT systems discussed above.

When designing a bodyguard, it is first necessary to determine what type of threat it will defend against and how much cueing information will be provided by off-board sensors. If it is not feasible for the United States to deploy space-based ASATs, then it is arguably
just as infeasible for an adversary to do so, an assumption that would limit the problem to defending against only ground-based ASATs. Couple this with the fact that the U.S. already has the capability to track any boosters launched from the surface of the earth, and capabilities required of a bodyguard would drop dramatically. However, potential adversaries may realize this and pursue orbital ASATs regardless of their other drawbacks. Alternatively, they could launch an ASAT into an orbit that appears to have no relation to the target, for instance a geosynchronous transfer orbit, and then have the ASAT change orbits later in its trajectory. While such an approach would entail a much more sophisticated weapon and a much larger booster, a peer competitor could realistically build such a system.

If war in space becomes likely, the United States will have to take steps to closely track all maneuvers enemy satellites make once they are in orbit. For the purposes of this analysis, it is assumed that these steps are taken and that a bodyguard system would have warning of impending attacks.

**Lasers are not the answer.** The high-energy laser (HEL) appears to be an ideal candidate for the job of bodyguard, but it is just as difficult to design a laser for the bodyguard mission as it is for ASAT or BMD missions. To be effective, HEL bodyguards must have a range almost as long as for BMD. This is because it would have to engage the target far enough away to allow time for damage assessment and for the protected asset to take evasive action. Even with a relatively slow closing velocity of 4 km/s, a laser would need to engage the ASAT at a range of 1,000 km just to have 250 seconds to react. (While space is so big that an ASAT
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will probably not achieve a kill without terminal guidance, we would probably still move the protected satellite in order make sure it remained safe.) With performance requirements close to those of a BMD system, and given the near-term state of the art, a HEL bodyguard would probably cost far more than the satellite it is protecting.

**KE defenders will be expensive.** KE-based bodyguards will also be expensive. This is because a KE bodyguard intercepting a KE ASAT faces even greater challenges than do KE ASATs themselves. Given the nature of orbital dynamics it will need both good sensors and high maneuverability, since it will be even more important to intercept the ASAT at a long distance than was the case for the HEL. (In order to minimize the chance that debris generated by the interception will finish the ASAT’s job.) The weapon needed to intercept a fast-moving satellite at long range will be very large and need a large amount of ΔV available.\(^5^6\) In other words, a bodyguard designed to counter a KE ASAT will probably look much like its nemesis, but must be able to react and travel much faster.

Assuming there is a robust space tracking system and limiting the scope of the problem to defending against only the most likely threats makes defending satellites somewhat more feasible. These threats are the direct ascent ASAT, the co-orbital ASAT, and to a lesser extent the space mine. As described above, a direct-ascent ASAT is one that is launched from the earth directly into the path of the target and is only practical against satellites in LEO. Since these ASATs must be
launched from close to the orbital path and shortly before the target satellite is overhead, the problem of detecting the ASAT and training a weapon on it is reduced considerably. In essence, all that would be needed is a system to scan the earth in front of the satellite and along its direction of travel. This sensor would be coupled to a very fast missile having a range of several hundred kilometers (as opposed to thousands for BMD).

It would also be relatively easy to defend against the co-orbital ASAT. Launch detection and trajectory tracking would provide warning of an impending attack, and the long time to intercept would allow the bodyguard to be oriented in the proper direction. Since the lower velocities involved during the intercept would make defending against a co-orbital ASAT less demanding, a system designed for KE ASATs should be more than adequate.

**Defending Satellites in GEO**

Defending against a non-stealth space mine in GEO may be somewhat more feasible. Similar to the space mine itself, a defender could “piggyback” on the defended asset for launch, and could be stored there until needed. If it only has to defend against a slowly approaching space mine, then it would need much less speed, range and agility, which would reduce considerably the need for power and propellant. If the “brains” of the system are designed into the defended asset, so that it can detect and track the attacker and guide and control the defender, then the defender could be quite simple. This arrangement would allow the
defender to be small and (relatively) cheap, making it possible for a high-value asset to carry several. The problem is to determine just how the defender will stop the space mine.

Defending against an attack will be difficult. Simply destroying an approaching space mine may not be a good idea, unless it can be done at a very long distance, because debris from the explosion could damage the protected asset. Similarly, attempting to latch on to the attacker in order to drag it into a safe orbit will also be problematic. This is because the enemy weapon will probably detonate as soon as it is approached, and if it does not, moving an uncooperative object in space is inherently difficult.

Unlike a device intended to merely disturb the attitude of a target satellite, the defender would be trying to move the attacker in a specific direction. This means that the method of attachment will have to be secure, and that the defender’s thrusters will have to act through the combined center of mass of the two satellites. This will be difficult because the design details of the attacker will not be known in advance; but failing to do this will simply cause the two satellites to tumble. While we could possibly make a defender large enough to completely enclose a small space mine, and capable enough to compensate for the resulting new center of gravity, such a defender would be neither small nor cheap.

Too Expensive

The biggest drawback to actively defending
satellites from orbit is the likely cost of the systems needed to do this. In order for an independent “bodyguard” to have a service life comparable to that of the asset being protected, it will have to be a very capable weapon able to withstand years of inactivity and still reliably accomplish its mission. Even the comparatively simple defender would have to be fairly large and capable to counter even small space mines. While the defended satellite could be designed to provide long-term power, station keeping, and even guidance for the defender, this concept would drastically increase the cost of an already expensive satellite.

Alternatives to the concepts just discussed include derivatives of both BMD and ASAT concepts. The most notable of these are ground-based lasers to destroy enemy ASATs, and a space-based BMD system, which could prevent an enemy from launching any satellites at all. Other concepts for counter-ASATs would in essence be the bodyguards described above.

Other Approaches To Space Control

Maintaining access to space requires the protection of all parts of a complex system. These include the satellites themselves, the ground stations that control them, and any mobile ground stations capable of receiving satellite-generated data. The latter of these range from handheld mobile phones to tactical terminals capable of receiving satellite imagery. Each of these components, as well as the communication links between them, is susceptible to attack.
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Attacking Ground Stations

The simplest approach to keeping an enemy from using his space-based assets may be to destroy the ground stations needed to communicate with the satellites. Relatively large, fixed ground stations are necessary both to control satellites and to receive the information they are gathering. While mobile ground stations could be developed, most systems in use today rely on stations whose locations are known with a high degree of accuracy. These ground stations are soft targets that are extremely vulnerable to either sabotage or conventional attack by systems currently in the inventory.

A drawback of this approach is that it may be difficult to determine if an attack on a ground station was effective. While the destruction of the ground station would be readily apparent, the possibility would exist that a yet undiscovered ground station would take over the function of the one destroyed. Changes in the behavior of the satellite may or may not be great enough to confirm the effectiveness of the attack. It is for these reasons that many ASAT advocates consider this approach inadequate.

Attacking Launch Sites

The potential for using a ballistic missile defense system to deny an enemy access to space has already been discussed, but using these expensive-to-replace weapons against an ascending satellite booster does not appear to be cost-effective. More importantly, creating such a system just to perform a job that conventional
weapons could more easily accomplish would be even less prudent.

As with ground stations, virtually all space launches are made from fixed locations that are well known and within the range of either stealth aircraft or cruise missiles. The facilities needed to prepare the satellites and boosters for launch are highly vulnerable, especially during the days before a launch when the vehicle is positioned on the launch pad. Since the status of an upcoming launch is readily evident to U.S. airborne or satellite reconnaissance, it should not be difficult to time an attack to take advantage of this most vulnerable condition. Such an attack would not only destroy the spacecraft on the pad, it would probably cause so much damage to the launch complex that it would prevent or delay subsequent launches.

An adversary might try to mitigate this vulnerability by creating a mobile launch system, but this system would also be vulnerable to attack since it would need very large, slow-moving land vehicles or sea vessels. Air-launched systems may present a more difficult target, but current systems are only capable of launching the smallest satellites into the lowest orbits. If we need to deny an enemy even this limited capability, then attacking the airfields from which the systems operate would be little different from attacking any other military airfield and could be accomplished by other means.

An often-cited problem with the idea of attacking satellite launch facilities is the possibility that political considerations will place these facilities off-limits, particularly if they are located in a third party’s territory.
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If this is the case, then ground-based ASATs should be more than adequate for destroying an enemy’s space-based assets.

Defensive Considerations

Our satellite ground stations are just as “soft” and immobile as those of our potential adversaries, and our launch facilities are just as vulnerable. While attacks against these targets are possible, America’s military predominance should ensure that threats to them would be limited to terrorist attacks, at least within the U.S. The vulnerability of these facilities has received considerable attention in the wake of the terrorist attacks of 11 September 2001, and measures are being taken to ensure their security. It is only necessary to note that any investments made in space-based weapons would be wasted if the ground stations needed to make use of them were neutralized.

Non-Destructive Alternatives For Space Control

Jamming

A less controversial approach to denying an enemy use of his space-based assets may be to jam the communication links between the satellites and the ground stations. Since this approach would not damage the satellites, it could be used even when third parties own them.

One method of doing this would be to prevent the satellites from receiving commands from the ground. While jamming the large, highly directional antennas of
the ground stations might be difficult, the antennas on the satellites themselves are much more vulnerable. The results of jamming these signals would vary from slow degradation of the orbit, to disrupting satellite communication networks, to preventing adversaries from tasking their reconnaissance satellites. This latter effect may be useful, but its effectiveness would be difficult to verify, since it might not be obvious that a reconnaissance satellite is no longer performing its mission.

Rather than jamming, a potentially more effective approach may be to take command of a problem satellite. It may be possible to break the codes used to command the maneuvers of a satellite and send it spurious instructions. If transmitters were placed so that they could overpower legitimate commands, or send commands when the legitimate transmitters are out of range, then a satellite could be prevented from performing its mission. In contrast to jamming a satellite, the reactions of the satellite would make it possible to verify that the attack had been successful. A drawback of this approach is that the necessary equipment would probably have to be near the enemy ground station if it is to engage the satellite while it is listening for commands. This may be difficult during a high-intensity conflict or when the ground station is located in the territory of a third party.

Jamming the users’ communications is another avenue of attack, particularly for satellite-dependent communication systems that rely on low power, non-directional antennas on the ground and sensitive receivers on the satellite. On the other hand, it may be more useful just to listen in on the enemy’s
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conversations, as long as they are not encrypted, and this may well be the case for an adversary using a third-party commercial system.

**Blinding surveillance satellites.** Jamming is also possible against remote sensing satellites that provide imagery. This is a non-destructive concept that uses portable devices to track a satellite while it is overhead and train a laser on it. Experiments have shown that even low-power lasers can temporarily blind or “dazzle” optical sensors. The simplicity and low power requirements of these systems are such that they could easily be deployed on small vehicles, and with further development, could be made man-portable. It should be possible to jam radar-imaging satellites in a similar manner. The drawback of this approach is the same as for most jamming: its effectiveness tends to be difficult to verify. Since it would not be possible to tell if a satellite was actually blinded, there would be no way to determine that the enemy remained unaware of the information that was to be denied him.

In spite of the drawbacks, temporarily blinding reconnaissance or surveillance satellites has the potential to deny an enemy the use of third-party satellites without unduly antagonizing the third party. One strategy may be to declare a total exclusion zone over the theater of operations and give warning that any satellites overflying the region would be liable to engagement by potentially damaging lasers. It would then be the satellite owner’s responsibility to ensure that it was oriented so as to protect its sensors. In a variation of this approach, small satellites could be built to rendezvous with the satellite in question and verify that
the satellite was indeed pointed away from the area of concern.

**Diplomacy**

The least expensive approach to denying an enemy access to space is only practical against nations that rely on leasing third-party assets. This has the potential to become more prevalent as commercial enterprises devoted to providing communications and surveillance compete for business. In these situations, it may be possible to convince the corporations or nations providing the service to cut off access during a conflict. In fact doing much more may be politically unfeasible, since direct attacks would be difficult to justify without concrete evidence that a corporation was providing an adversary with satellite support. This approach would also require the United States to have considerable international support, and would be problematic in situations where the United States must act unilaterally.60

Alternatives to physically destroying space-based assets are the least controversial methods of denying an enemy access to space. These approaches would be most effective against a less capable foe, while a peer competitor may have the ability to counter them.

**Other Defensive Measures**

**Redundancy and Rapid Reconstitution**

U.S. satellites tend to be very large, very capable and very expensive. These satellites present an
opponent with lucrative targets, where the loss of even one would often constitute a dramatic loss in capability. This is particularly true for current generation reconnaissance satellites since these are very capable, relatively few in numbers, and very vulnerable owing to their need to be in low earth orbits. Fortunately deploying defensive space weapons is only one way to protect these assets.

Large numbers of small, less capable satellites could comprise a distributed network that emulates today’s large reconnaissance satellites. Experiments conducted by the Clementine spacecraft demonstrated that even very small and inexpensive satellites could collect militarily useful data. While the highest resolution imagery may still require large satellites, a network of these small satellites could meet many needs and would provide graceful degradation in the event one is lost. With total costs on the order of only 12 percent of that of large satellites, small satellites seem to be a viable alternative.

Another step that can be taken to assure access to space is to develop a responsive space-lift capability. In addition to its potential for deploying ASATs, the ability to launch a satellite within days could quickly replenish combat losses. This approach would be most cost-effective for small, cheap satellites, but would also be effective for larger satellites, particularly if an enemy had only a limited number of ASAT weapons.

These defensive measures would assure access to space through essentially passive means. Instead of defending our space-based assets, we would be making them resistant to attack. While these approaches might
not provide as much protection as a *truly effective* defensive system, creating such a defensive system is problematic. On the other hand, these approaches would assure continued access to our space-based assets in the event of attack, and present an adversary with a much greater challenge. They should also be much cheaper than space-based weapons.

**Attacking Enemy ASATs on the Ground**

If it is determined that passive measures will not provide adequate protection for space-based assets, more active ground-based methods are available. A potentially less controversial, and less expensive, alternative is to attack the enemy’s ASAT capability on the ground. Similar in concept to an offensive counterair strategy, such an approach is well founded in airpower doctrine. When applied to the satellite defense problem, attacking ASAT weapons on the ground is even less complicated. Whereas combat aircraft are normally dispersed to many airfields in time of war, sophisticate ASATs will probably be restricted to relatively few easily identifiable launch sites. Once hostilities begin, these sites will be open to attacks by conventional assets such as stealth aircraft and cruise missiles.
V. Attacking Terrestrial Targets—Orbital Bombardment or Cruise Missiles?

...a sword of Damocles [to] hang over the heads of the imperialists when they decide the question whether or not to unleash war.

Nikita Krushchev, Pravda, December 9, 1961

KE Weapons For Terrestrial Attack

Possibly the most controversial types of space-based weapons are those designed to attack targets on the ground or in the air. The idea of having weapons orbiting overhead, awaiting a signal to begin raining down upon whomever the United States determines to be an enemy is alarming to many nations. The political costs of deploying such weapons means that the United States should only do so if there are compelling advantages to be gained.

The primary mission proposed for orbital kinetic-energy weapons is to attack very hard, high-value, terrestrial targets. These weapons seek to destroy their targets by converting the kinetic energy associated with the weapon’s high velocity (5 to 11 km/s) into destructive force. Such projectiles could have a number of configurations, including long thin rods, ultra-hard penetrating warheads, or warheads that fragment shortly before impact. The ability of these weapons to attack any point on the surface of the earth with little or no warning coupled with the defender’s virtual inability to
counter an attack from space once it has been launched, make orbital KE weapons particularly attractive.  

As with most weapons, trade-offs must be made when designing weapons for orbital bombardment. To attain velocities in the range of 10 to 11 km/s, satellites must be in orbits with an altitude of more than 40,000 km, but these high-altitude orbits sacrifice responsiveness to achieve high impact velocities. For instance, a weapon in a 40,000 km orbit would impact at about 10 km/s, but would need 5 hours to reach the earth’s surface. Lower orbits could yield shorter response times, but a weapon in LEO would impact at less than 5 km/s.

**Rods from God**

One design for a KE projectile is a thin, heavy, metallic rod one to two meters in length. Such a weapon could be used against hard targets that are not too deeply buried. Depending on what it is made of, the rod can penetrate two to three times its length into a target. As long as the rod impacts at a velocity in excess of 3 km/s, the depth it penetrates varies only slightly for specific “hard” target materials. The results of hitting a target with one of these rods is similar to boring a hole, placing in the hole an amount of explosive comparable in weight to that of the rod, and detonating it. For example, a two-meter rod weighing 50 pounds and penetrating to a depth of 6 to 8 meters is similar to detonating 50 pounds of explosive in a 6 to 8 meter deep hole slightly larger in diameter than the rod. As long as the rod penetrates to the interior of the target, the results are devastating. A drawback of this type of weapon is
that very deep targets would necessitate rods too massive to be practical.\textsuperscript{69}

**Ultra-Hard Penetrator**

Another method for making use of the high velocities provided by orbital weapons is to use an ultra-hard penetrator with an explosive warhead. With this approach, the weapon would remain intact and could penetrate much deeper than eroding rods. After it has reached a preset depth, or enters a zone of low resistance like a room or tunnel, the warhead detonates. From a feasibility standpoint, materials hard enough to remain intact during the penetration phase have yet to be developed. Materials readily available, such as tungsten carbide, are generally unable to withstand impact at velocities much in excess of 1.5 km/s.\textsuperscript{70}

**Attacking Softer Targets**

For orbital bombardment of softer targets, a weapon could be designed to slow down considerably before impact. Since speeds of Mach 6 to 8 (4,500 to 6,000 mph) are all that is necessary for small, hardened projectiles to penetrate all but the most heavily armored vehicles,\textsuperscript{71} extremely high velocities are not required. These lower velocities allow the weapon to maneuver to attack moving targets, like surface ships or armored formations. Shortly before impact, the weapon would explode into a cloud of high-velocity projectiles. The detonation height and the projectile shape would be optimized to achieve the desired effects against the type of target being attacked.
Challenges of Terminal Guidance

In addition to problems with orbital timing and responsiveness, precisely hitting a terrestrial target from orbit is far from simple. While it is probably feasible to hit a target as large as an armored formation with an area-type weapon, striking small, truly hard targets is far more difficult. Even assuming that the location of the target is precisely known, which is feasible for fixed targets, the weapon must be “aimed” accurately enough that atmospheric disturbances will not deflect it too severely. Great improvements in accuracy have been achieved for ICBMs, the only weapons that currently need to do this, but while 100-meter accuracies are good enough for nuclear weapons, they are not nearly good enough for attacking hard targets with KE weapons. Solving this problem will be essential if weapons moving at orbital velocities are to be effective against very hard targets.

The conventional method for improving the accuracy of weapons, providing guidance and course corrections during the last seconds before impact, is not likely to work for weapons moving at orbital speeds. The nature of these weapons means that using airfoils to provide directional control is problematic, since they tend to burn off during reentry. In addition, the plasma surrounding a weapon reentering the atmosphere at velocities in excess of 4.6 km/s makes it unlikely that signals of any kind, such as GPS, could reach the weapon to provide control inputs in the first place. While adequate terminal guidance systems are available for comparatively slow-speed weapons, those for orbital
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weapons traveling at 3 to 11 km/s will require significant technological improvements in guidance and materials.

Common Aero Vehicle (CAV)

A concept that could solve some of the technical problems associated with orbital bombardment deals with the problem of high reentry velocities by using a maneuverable reentry vehicle. Deployed from an orbiting satellite, the weapon would slow, much like the shuttle, to speeds low enough to dispense conventional munitions. As it slowed, the weapon would be capable of aerodynamically maneuvering thousands of kilometers to either side of the orbital track without needing additional propellant.74

The Armament Product Group at Eglin AFB Florida has proposed a weapon of this type called the Common Aero Vehicle (CAV). An orbital system based on this concept would be comprised of large numbers of CAVs stationed in LEO and de-orbited when needed. Using guidance, navigation and aerodynamic controls within the atmosphere, the CAV would dispense its submunitions at the appropriate geographic location. Prior to releasing them, the CAV would provide each individual submunition with updated target coordinates.75 The submunitions could be optimized for specific missions, such as anti-armor, area denial, or hard-target penetration.76 While the CAV overcomes the problem of accurately delivering weapons by slowing down and dispensing “smart” submunitions, it gives up the advantage of being able to hit hard targets at orbital velocities.
Alternatives to Orbital Bombardment

When deciding to attack hardened targets, it is worthwhile to consider just exactly what is important enough to protect so carefully. During WWII these targets ranged from Adolf Hitler’s bunker in Berlin to underground weapons factories used to build V-2 rockets. More recent examples include command and control facilities such as Cheyenne Mountain, the U.S. underground command and control center in Colorado. However, the advent of precision weapons has made burying some of these types of facilities ineffective.

As demonstrated in recent actions in Afghanistan, GPS-guided weapons make underground facilities much more vulnerable than before. For instance if a nation were to place its weapons factories in underground bunkers today, it would be fairly easy to strike the entrances and exits every few days to prevent raw materials from being taken in and finished products from being delivered to the field. The same holds true for command bunkers and other fixed targets. The difficulty in doing this today centers on locating the targets, a problem that applies equally to both orbital and ground-based weapons.

Before developing a new weapon system, it is also necessary to consider the countermeasures available to an opponent. If a facility is dear enough to a nation, then it is possible to make it virtually immune to attack, even from orbital weapons. Granite is more than three times as strong as reinforced concrete against a projectile traveling at 1 km/s, and is still almost 20 percent stronger if hit at 4 km/s. If a target is
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important enough, then an adversary may well bore into a granite massif where even nuclear weapons would be unable to destroy it. Provided the points of access could be concealed, attempts to use orbital bombardment weapons against such a target would be futile.

If the high-value asset is at all portable, a much easier and less expensive method of protection may be to make it mobile. The 1991 Gulf War against Iraq showed how difficult it could be to find even relatively large vehicles, such as mobile Scud missile launchers, in a relatively barren desert environment.

Some targets are too large to make mobile and do not merit the heroic measure of tunneling kilometers into granite. These targets are the ones for which orbital weapons would be best suited, but most of them can also be attacked by conventional weapons such as artillery or long-range bombers. While no single conventional weapon has the range and hitting power theoretically available with orbital KE weapons, a variety of conventional weapons can destroy almost all of the targets that would be vulnerable to orbital bombardment.

Manned Bombers

New ordnance has the potential to give manned bombers striking power close to that of orbital KE weapons. Orbital Sciences Corp. has tested an air-launched Pershing II missile with a penetrating warhead that had an impact velocity of 1.2 km/s, far less than orbital weapons, but still sufficient to penetrate 13.7 meters of granite. While the demonstration used a B-52 to drop the weapon, further development should be
able to optimize the design so that virtually any heavy bomber could carry these weapons, although high threat environments would necessitate the use of stealth assets.

Stealth technology gives the B-2 the ability to strike anywhere on the globe, including areas with a robust anti-aircraft defense, with a very low probability of being intercepted. It has already demonstrated its effectiveness using the GPS-guided Joint Direct Attack Munition (JDAM) against targets in Afghanistan and Iraq. If combined with rocket assisted penetrating warheads the JDAM/B-2 combination could have a range and striking power similar to that of orbital weapons.

A disadvantage of manned bombers, including the B-2, is their response time. Strikes against the most remote targets will require the pre-positioning of aerial refueling aircraft to get the bombers within range. This pre-positioning combined with the relatively low speed of aircraft will generally slow response time to days rather than hours. However, we rarely need to strike a target within hours unless we are already engaged in a war, in which case the bombers will already be available.

Another potential drawback to manned bombers is the possible loss of effectiveness for stealth technology. Were this to occur, many targets currently vulnerable would become less accessible. Orbital weapons offer the ability to strike these targets regardless of what happens to the effectiveness of stealth. On the other hand, improved cruise and ballistic missiles also have the potential to make these targets vulnerable, and at a lower cost.
Conventional Missiles

Conventional missiles are able to attack and destroy many of the same targets proposed for orbital weapons. Air- and sea-launched cruise missiles with ranges up to 1,200 km for non-nuclear missiles, and ranges of 2,500 km for nuclear-tipped versions, already have the ability to destroy many of the targets suggested for orbital weapons.\(^7\) While these missiles are somewhat limited in range, extending their range should be relatively straightforward. Even with today’s cruise missiles, B-52 or B-1 bombers can carry them to launch points within range of most targets that are of interest. Submarines and ships can also be used to provide global range, and could also loiter within range of their targets for months, a persistence comparable to a large constellation of orbital weapons.

Cruise Missiles. Originally intended for nuclear strike, cruise missiles have also been modified to dispense submunitions and attack up to four separate targets apiece,\(^8\) giving them some of the characteristics of the space-based CAV. They are also gaining some of the characteristics of orbital KE weapons through the development of new warheads. With currently deployed warheads, a typical cruise missile has the ability to penetrate up to four meters of reinforced concrete. This makes them effective against many hardened surface targets, such as aircraft shelters, and even some underground installations. The new warhead designs have the potential to penetrate 6 to 9 meters of compacted soil and then still penetrate 3.6 to 5.5 meters of concrete. While this capability is still less than that of
orbital bombardment weapons, this improvement threatens all but the most deeply buried targets.\textsuperscript{81}

A disadvantage of cruise missiles when compared with orbital bombardment weapons is their responsiveness. This is the same problem experienced by manned bombers, and as argued above may not be a significant shortfall. If better responsiveness is absolute necessary, it can be attained without having to resort to orbital weapons.

ICBMs. Problems with cruise missile responsiveness and penetration capability could be overcome with intercontinental ballistic missiles that are modified to carry non-nuclear KE weapons. By using a lofted trajectory, ICBM-launched KE weapons would be able to strike at speeds of about 5 km/s. While this is far less than the 11 km/s of some orbital concepts, 5 km/s is still more than current penetrating warheads are able to withstand. While ICBMs based in the continental United States would not provide global coverage, these warheads could also be adapted to submarine launched ballistic missiles (SLBMs) providing global capability for the system as a whole. A combination of ICBMs and SLBMs would provide coverage and hitting power on par with orbital weapons, but without placing the weapons in orbit.\textsuperscript{82}

While this approach is promising, ICBMs delivering KE weapons must first overcome problems of accuracy. As mentioned for orbital weapons, accuracy good enough for nuclear weapons is inadequate for precision weapons aimed at hardened targets. Improving the accuracy of the missiles will face the same problems as orbital weapons and will be equally
difficult to overcome.

Until technology catches up, the CAV may be able to solve the problem of giving ICBMs a conventional attack capability. Since the CAV concept evolved from research into maneuverable ballistic missile re-entry vehicles, launching them with ICBMs (or SLBMs) is inherently feasible. The ICBM/CAV combination could provide the United States with a conventional global strike capability, although it will come at considerable cost. With a procurement cost of $7M the Minuteman III is not cheap, the fact that the missile has been out of production for over 20 years means that building new ones would probably cost even more. However, this cost is likely to be far lower than even the launch costs of an orbital weapons platform.

Perhaps the biggest drawback of using ICBMs to deliver conventional weapons, either KE weapons or CAVs, may be the rather heavy nuclear baggage associated with them. Regardless of what warhead they carried, ICBM launches would look exactly like a nuclear attack. While this aspect may be minimized by new launch sites, necessary since launches made from current silos drop expended booster stages on the United States and Canada, even using “non-nuclear” launch sites would probably cause anxiety among less-than friendly countries. Assurances from the United States regarding the nature of the warheads and their intended targets may be enough to prevent third-party nations from launching back, but the potential for escalation would exist.

Pegasus. Should the problems inherent in ICBMs prove insurmountable, existing boosters such as
the Pegasus XL could be used to deliver KE weapons. The Pegasus XL is an air-launched booster that can deliver a payload of 1100 lbs to LEO with a response time of about 15 days.\textsuperscript{84} With improvements in responsiveness and reliability, it could serve as a launch-on-demand system for delivering weapons at orbital velocities in the near term. Weapons like the CAV could also be designed to make use of this booster, but the Pegasus is quite expensive with a typical cost of about $14 million.\textsuperscript{85} While high, this is comparable to the probable cost of procuring non-nuclear ICBMs, and would be feasible for a “silver bullet” weapon to be used against the highest priority targets. A Pegasus-derived weapon would also avoid looking like a nuclear strike when launched, another factor in its favor.

Whether used for precision strikes against deeply buried hard targets or to dispense area-type weapons, ICBMs or expendable launch vehicles are viable alternatives to space-based weapons. If placed on alert, each of the systems described above could deliver KE weapons almost as quickly as those placed in orbit. Launch-on-demand systems would be as difficult to intercept as orbital weapons, and would be more difficult to attack before launch. While launch-on-demand KE weapons face most of the same technological hurdles, as do orbital KE weapons, they are likely to be much less controversial.
VI. OTHER FACTORS BEARING ON SPACE-BASED WEAPONS

Surveillance for Space Control

If the United States is to maintain dominance in space, then the first thing we need to do is improve our space surveillance system. Whether we only intend to defend our satellites, or reach out and destroy the satellites of another nation, we will need a surveillance system with comprehensive coverage. Undersecretary of the Air Force, Peter Teets, recently alluded to our shortfall in this area when he noted that “We track objects, but we don't know an awful lot about what all those objects may be.” In fact, our ability to track objects in space falls well short of keeping them under the constant surveillance needed to defend our space-based assets.

The most technologically feasible solution to this problem would be to construct a worldwide system of ground-based surveillance stations. The problem with this approach is that it will not be possible to gain secure, dependable access to the locations needed to provide global coverage. The only real alternative is to construct a system of surveillance satellites, but developing such a system will not be easy.

While the U.S. already has space-based systems to warn against missile launches and nuclear detonations, we have not yet deployed satellites able to monitor other satellites once they are in orbit. An effective system would have to be able to detect a much more diverse array of targets, and survey a much larger volume of space than do current space-based systems. We can avoid the need for a large number of ground
stations if the system is comprised of a network of cross-linked surveillance satellites, but developing a system that can do this will not be cheap.\textsuperscript{87}

Since ASAT weapons deployed in space (particularly space mines) would have relatively weak infrared signatures, a \textit{passive} surveillance system would require large numbers of satellites in a variety of orbits. Alternatively, an \textit{active} surveillance system using radar might require fewer satellites, but each one would require large amounts of power and could still be defeated by stealthy ASAT weapons. Regardless which approach we take, the system would probably have to be deployed in multiple orbits ranging from LEO to GEO in order to provide adequate coverage. This kind of space-based surveillance system will be complex and technologically challenging, but it will be necessary if we think our space-based assets may soon be at risk.

\textbf{System Architecture}

Something that has been neglected in virtually all discussions of space-based weapons, are the steps that must be taken to knit these different weapons into a robust system. Ideally, the architecture for a system of space-based weapons will ensure that they operate in a mutually supporting and coordinated manner. It will have to include a tracking and targeting system that can determine how quickly a target must be destroyed and which satellite or method of intercept will have the highest probability of kill. This information will have to be fused and presented in such a manner that a decision-maker can quickly select the optimum response. The vast number of variables involved may well argue for a
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computer to make the decision, although this would entail a whole new discussion about the desirability of letting computers decide to employ weapons. While the computer and communication technology needed to effectively control a system of orbital weapons is advancing much more rapidly than is the development of orbital weapons themselves, such a command and control system would be considerably more complex than any yet developed. The high cost of the system, as well as its vulnerabilities, must weigh heavily in any decision to deploy space-based weapons.

Cost and Responsiveness of Space Lift

The most significant economic factor affecting the decision to deploy space-based weapons is probably the cost and availability of space lift. This will be particularly true for systems requiring large constellations of satellites. Launch costs for expendable boosters currently average $3632 - $4587 per pound for LEO, and $9243 – $11243 for geosynchronous transfer orbit. These costs vary depending on the booster used and assume that the payloads weigh exactly as much as the launcher can lift. At these prices, launch costs could comprise as much as 25 to 30 percent of a satellite constellation's total cost. Reducing launch costs by a factor of 10 would radically alter the economics of space-based weapons, but most efforts to do this have been terminated due to the slump in the satellite launch market.

Another facet of operating in space is achieving responsive, routine access. This kind of access entails
the ability to launch and/or recover multiple spacecraft in a manner and with a regularity similar to that enjoyed by aircraft. Routine, responsive access would require a robust and redundant launch system and would be essential if access to space is to be assured through rapid reconstitution. While the recent fall-off in demand from the commercial satellite industry has resulted in significant overcapacity in the launch industry, launching satellites is still far from being either routine or responsive. Achieving this kind of access would entail large investments into launch systems and infrastructure, but would probably be less costly than developing space-based weapons.

An additional point about passive defense bears consideration. While nuclear weapons are not a primary focus of this paper, rapid reconstitution may be the best way to overcome the effects of a high-altitude nuclear detonation. While the international political repercussions may prevent most potential adversaries from using nuclear weapons even in space, there are those who may not be dissuaded. If one of these nations develops and uses nuclear ASATs, space-based defensive weapons would be of little use. The ability to quickly reconstitute space-based assets may well be the only practical solution.

A final concern relates to an aspect of the launch cost and access problem that may not be readily apparent. While the advantages of reduced cost and increased space access for the United States are obvious, the options this will give potential adversaries may be equally important. If the technology necessary for cheap and routine access to space were to proliferate, then more nations would be able to launch their own satellites
and hence their own space-based weapons.

VII. Keep Space as Sanctuary?

Space has long been treated as something of a sanctuary and kept free of weapons, a situation that is somewhat curious given the intense competition in technology and arms between the United States and the Soviet Union during the Cold War. The reasons for this traditional sanctuary status are a little ambiguous, beginning with an initial inability to build practical weapons, and gradually becoming a situation in which both sides had more to lose from space-based weapons than they had to gain. With respect to the United States, this argument may carry even more weight today.

While the post-9/11 environment does not present the U.S. with potential opponents as powerful as the Soviet Union, we are more dependent on space now than ever. The wars in Afghanistan and Iraq, and particularly the notable success of the GPS-guided Joint Direct Attack Munition, illustrate this point. Less flashy, but just as important were the intelligence gathering assets that let the U.S.-led coalition do everything from locate enemy forces, to listen in on their phone conversations. Current initiatives promise to further increase our reliance on space-based assets, and include building satellites to gather real-time targeting information about ground targets, much like the airborne Joint Surveillance Target Attack and Radar System (JSTARS) provides today. As the search for invulnerability drives more functions from aircraft to satellites, a space sanctuary strategy may benefit the United States now more than ever.
Perhaps the most compelling reason to keep weapons out of space is the capability it would give to other nations once we paved the way by developing the necessary technology. Right now the U.S. can strike almost anywhere in the world with either nuclear or conventional weapons, while few nations can strike the U.S. in any manner at all. Were we to deploy space-based weapons unilaterally, particularly orbital bombardment weapons, then other nations would probably follow suit as soon as they were able. The arguments made here, that these weapons would not provide the U.S. with much added capability, would not apply to other nations. For an emerging U.S. competitor, deploying space-based weapons may be easier, and would certainly be far cheaper, than fielding military forces comparable to those of the United States. It does not make sense to goad prospective adversaries to greater efforts by developing weapons that offer us only marginal advantages.

VIII. Conclusions

The United States enjoys an overwhelming advantage in space-based systems. This advantage gives us a decisive edge in military conflict by providing commanders at all levels with unprecedented battlefield capabilities. Protecting these assets and maintaining U.S. dominance in space will continue to be critical to the defense of U.S. national interests. What part space-based weapons will play in protecting these systems remains to be seen, but based on this analysis, some tentative conclusions appear to be in order.
Lasers

Often considered ideal candidates for both antisatellite weapons and boost-phase ballistic missile defense, their primary advantage is their ability to strike in any direction at the speed of light. However, lasers have major limitations in terms of the power levels available with current technology, the need for large quantities of chemical fuel, and the enormous space structures needed to support them. If we think we need space-based laser weapons, then we need to focus on developing better lasers.

Ballistic Missile Defense

Boost-phase ballistic missile defense, using either lasers or KE weapons, is the one area where orbital weapons appear to be the only alternative; however these weapons do not appear to be practical. Even if an effective system could be created; doing so could prompt adversaries to re-direct their weapons development into other areas, such as long-range cruise missiles. Nations such as Iraq, North Korea and Pakistan have been able to develop effective ballistic missiles, while they have been less successful developing long-range cruise missiles. The question becomes whether or not removing ballistic missiles as a viable option for potential adversaries is worth the extremely high cost of an orbital defensive system. It is entirely possible that a ground-based BMD system would provide enough of a disincentive without space-based weapons. If we need a defense against ballistic
missiles, then it makes more sense to put the sensors in space and keep the weapons on the ground.

Denying Access to Space-based Assets

Denying enemies access to space is also best accomplished without placing weapons in orbit. The combination of orbital dynamics and laser physics, at least with current technology, make developing effective space-based antisatellite weapons problematic. A better alternative is to develop ground-based weapons that jam or disable enemy satellites. If ASATs do become necessary, then there appears to be no advantage gained by putting them in orbit. It would be more feasible and less controversial to develop ground-based, launch-on-demand weapons capable of disabling or destroying enemy satellites.

Defending Space-based Assets

It appears that space-based assets are best defended without space-based weapons. Similar to offensive ASATs, orbital dynamics and the limited capabilities of lasers conspire to make defending satellites at least as difficult as attacking them. The bodyguard concept looks good at first glance, but actually entails most of the problems of conventional ASATs. Bodyguard satellites would force effective ASATs to be more sophisticated and minimize threats from enemies other than peer competitors, but a decision to deploy these weapons must take their costs and limitations into consideration.
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In contrast, assuring access to space through redundancy would be much less controversial and probably sufficient, as long as no other nation starts aggressively pursuing antisatellite weapons. While attacking satellites may be easier than defending them, the expense of doing so should dissuade other nations from starting down this path. With the threat to our space-based assets low for the foreseeable future, developing an orbital defensive system would be a waste of resources.

Orbital Bombardment

The types of space-based weapons that make the least sense are orbital bombardment weapons, even without political consequences. Conventional weapons such as stealth bombers and cruise missiles can destroy nearly all of the targets envisioned for orbital bombardment. For the few remaining target sets, such as deeply buried hardened targets, sub-orbital weapons appear to hold as much promise as orbital concepts. Either ICBMs or weapons launched by expendable boosters could produce the same results while being less vulnerable to preemptive destruction. Because they only pass through space, these weapons should also be far less controversial. We should consider developing these weapons if conventional weapons become less viable.

Caveats

The conclusions presented here are based on relatively conservative assumptions regarding the technology available to produce space-based weapons.
These conclusions would change considerably if we were to make major breakthroughs in either of two areas of technology: lasers or launch costs. A major breakthrough in laser technology could make it feasible to generate enough power for these weapons to be effective, although the weapon system as a whole would still be expensive. A dramatic reduction in launch costs would have a more pervasive benefit, and would make all space-based weapons more feasible.

**Recommendations**

Today, few nations with access to space consider the United States to be a threat, but this could change as less friendly nations gain space capabilities. If the U.S. decides to deploy weapons in space unilaterally, then even some friendly nations might change their outlook, and nations that already view the U.S. with suspicion may decide that space-based weapons will now be worth the cost. While the consequences may or may not be this severe, they do not argue in favor of deploying these weapons.

If instead, we try to keep weapons out of space, but others start developing them anyway, then the U.S. is already in a position to win the ensuing arms race. The United States has invested large sums of money and time investigating these kinds of weapons. An adversary attempting to deploy space weapons of its own would need a similar amount of time. This lead-time combined with the difficulty inherent in keeping the needed orbital tests secret should give us ample warning.
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The question remaining is what to do now. Based on this study, several courses of action appear to be appropriate. First, we should assure our access to space by transitioning to larger numbers of small satellites to provide capabilities currently obtained from fewer, larger satellites. Second, we should focus on developing an inexpensive, responsive space launch capability to allow rapid reconstitution of our space assets. Finally, we should invest in a robust space surveillance system that allows us to track activities in space. If we decide at some point in the future that we need to actively defend our space-based assets, then defensive weapons in GEO may be necessary, but we should base other weapons on the ground.
Notes
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4 Despite some promising results in a 1989 test, the U.S. neutral particle beam program was eventually cancelled in 1994. Aside from cost considerations, major remaining challenges included development of a suitable power source. Phillip Clark, ed., *Jane’s Space Directory*, (Coulson, England: Jane’s Information Group Ltd., Sentinel House, 1997], 169; Orbital RF weapons with antennas of 100 to 1000 meters in diameter would theoretically allow these weapons to burn out unprotected electronics. *New World Vistas, Air and Space Power for the 21st Century, Space Applications Volume* (Washington D.C.: USAF Scientific Advisory Board, 1995), 84-5. Unfortunately, the requisite antennas will remain beyond our capability until the cost of access to space is reduced to the point that extensive experimentation can be undertaken.

5 According to Dan Wildt, TRW's space-based laser integration program manager, a space-based chemical laser “would have a ‘lethal range’ of 4,000 to 5,000 kilometers.” Joseph C. Anselmo, “New Funding Spurs Space Laser Efforts,” *Aviation Week & Space Technology*, 14 October 1996, 67.


7 Attacking ballistic missiles during boost has a number of advantages. Tracking is simplified because the missile is easy to see due to its intense infrared signature. Successful attacks during this phase are the most effective since a missile during boost has not yet started deploying multiple warheads or decoys. A final advantage is that the missile may fall back on the launching nation, and will at a minimum fall short of its target.
William Spacy

8 Yevgeni Velikhov, Roald Sagdeev, Andrei Kokoshin, *Weaponry in Space: The Delima of Security*, (Moscow: VTI Press, 1986), 22, 24. For example, an ablative coating 3 mm thick could protect the aluminum skin for almost one minute. Solid fuel rockets are another option, since they have a glass-reinforced plastic case coated with epoxy resin built to act as the combustion chamber instead of a liquid fueled missile’s thin aluminum skin containing highly volatile, pressurized fuel. The considerably thicker walls of this design will require the laser to deliver more energy before it bursts. Examples of missiles that use this type of construction include most submarine launched ballistic missiles and the U.S. Minuteman III. Duncan Lennox, ed., *Jane’s Strategic Weapon Systems*, (Coulsdon, England: Jane’s Information Group Limited, Sentinel House, 2002), Tab: Offensive Weapons, Issue 36 January 2002.


10 The requirement of a 3,000 km range for a space-based laser is derived from analyses of the number of satellites required to provide global protection against a major missile attack by the Soviet Union. While recent initiatives for BMD do not envision such a massive attack, longer range lasers are assumed in order to reduce the number of weapons that need to be orbited. Evidence of a 3000 km baseline range is further supported by the development of components for an 11 m diameter light-weight mirror for the recently terminated U.S. space-based laser program. This mirror size implies a range of about 3,200 km. Details on the relationship between range and mirror diameter are discussed in subsequent footnotes. Garwin (note 9), 288; John R. London III and H. A. Pike, “Fire In the Sky: U.S. Space Laser Development From 1968,” Paper no. 97-2306, (New York: American Institute of Aeronautics and Astronautics (AIAA), 1997), 8.
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12 The actual power levels achieved by military lasers are classified. For the purposes of this paper “megawatt power” is interpreted to be 1-2 megawatts. This is based on the assumption that power levels much above these would be referred to as “multi-megawatt.” The term “megawatt power” was used in London and Pike (note 10), 6.

13 The chamber probably cannot be made with a larger diameter because the flow of gasses through the chamber would be changed significantly. Similarly, flow rates for the chemicals probably cannot be increased since they are presumably optimized for maximum power already. This leaves lengthening the chamber as the only method for creating more powerful beams.

14 Garwin (note 9), 288.

15 These mirrors are for infrared lasers operating at a wavelength of 2.7 µm. The wavelength of the laser drives mirror size since the proper mirror size will minimize diffraction for a laser operating at a particular range. This relationship is: \( R = \frac{\pi d \lambda}{4} S \), where \( R \) is the range, \( d \) is the mirror diameter, \( \lambda \) is the wavelength of the laser, and \( S \) is the diameter of the spot the laser makes on the target. This paper assumes that laser weapons will have a perfect mirror of the optimum size for the weapon’s range. Hans Bethe and Richard Garwin, “Appendix A: New BMD Technologies,” Daedalus: Weapons in Space 2, no. 114 (Summer 1985), 338-339.

16 At an altitude of 1,300 km, the planned altitude for the U.S. space based laser, the weapon will be traveling at about 7.2 km/s and cover about 50 km during a seven second firing. \([\text{velocity}=\sqrt{\mu/r}, \text{where} \ r \text{ is the radius of the circular orbit and } \mu \text{ is the gravitational parameter for the earth (398,600 km}^3/\text{s}^2)\] The accelerating missile will cover a slightly shorter distance. Dave Dooling, “Ballistic Missile Defense,” IEEE Spectrum, September 1997, 59; Garwin (note 9), 288.
“In 1991, the space-borne Relay Mirror Experiment (RME), relayed low-power laser beam from a ground site to low-earth orbit and back down to a scoring target board with greater pointing accuracy than needed by SBL.” John Pike, “Space Based Laser,” FAS Space Policy Project Special Weapons Monitor, 7 February 1998, 3, available at http://www.fas.org/spp/starwars/program/SBL.htm

Dooling (note 15), 58.


The Star Lite demonstration laser satellite will require 30 kg/s to “operate at megawatt levels” according to LTC John London, the Space-Based Laser program integrator at the Ballistic Missile Defense Organization. Interviewed by Dave Dooling (note 15), 59. With the assumption that “megawatt levels” means 1–2 megawatts, 25 megawatts should require a reactant flow 12.5 to 25 times greater (375 – 750 kg/s) assuming linear scalability.


The need to cool the crystal generally makes it difficult to sustain high powered beams with a solid state laser. While advances in cooling technology may make 25 KW lasers feasible in the near term, and 100KW lasers possible in 10 years, these lasers only have efficiencies of 1-10%. This means that not only would a 1 MW laser need at least a 10MW power source, it would have to dissipate 9MW of heat while it is being fired. These technological hurdles look to be insurmountable for the foreseeable future. Sandra I. Irwin, “Tactical laser weapons still many years away,” National Defense, vol. 87, Arlington: December 2002, 32-33.

Low earth orbits are considered to be those with altitudes up to 2,000 km. John V. Evans, “New Satellites for Personal Communications,” Scientific American, April 1998, 73.

Assuming the most favorable alignment of a LEO weapon in a 1000 km orbit, firing from directly beneath the higher altitude satellite, the laser would need a range of about 29,000 km to reach a satellite in GEO.
This is considered to be an advantage of this type of orbital laser, since it could not inadvertently injure people on the ground.


GAO/NSIAD-92-91, 8-10.


Shorter range ballistic missiles do not leave the atmosphere and the BP system is not designed to operate within it. Long-range missiles fired with depressed trajectories present similar problems since they do not leave the atmosphere until shortly before they burn out.


The General Accounting Office determined that the schedule upon which this cost estimate was based entailed a great deal of risk due to the highly concurrent nature of the development. It is reasonable to assume that had the system been pursued further, it would have cost considerably more than $55 billion. United States General Accounting Office, Report to the Chairman, Legislation and National Security Subcommittee, Committee on Government Operations, House of Representatives: Strategic Defense Initiative, Need to Examine Concurrency in Development of Brilliant Pebbles, GAO/NSIAD-91-154, (Washington, D.C.: General Accounting Office, March 1991), 6.

This system is described in “Ground Based Midcourse,”


“ΔV available” is a direct measure of the ability of a satellite to change its orbit. Large orbit changes require large ΔVs, for instance changing the inclination of a satellite in a 400-km altitude orbit by ninety degrees (an admittedly extreme change) requires a ΔV greater than the existing orbital speed. Muolo (note 6), 70.

While there are electrically driven ion thrusters that do not consume much propellant, they require long-term power sources and only produce microscopic amounts of thrust. Such small thrust levels may make it difficult to keep the space mine close to the target satellite. “Edwards Lab Seeking High-Payoff Technology,” Aviation Week and Space Technology, 5 April 1999, 21.

Ibid., 154-157.


It should be noted that airborne lasers could also be used in the ASAT role. Such an approach would yield increased
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mobility and avoid firing the laser through most of the atmosphere, although it may be difficult to generate enough power.

44 Although satellites in very low inclination orbits would not be directly accessible from U.S. territory, there are few low-altitude satellites in these orbits. Should it be necessary to attack these targets, then a somewhat more capable weapon would be needed.

45 Whereas intercepting a satellite in LEO requires systems capable of handling velocity differentials on the order of 8 km/s, the velocity differential between a transfer orbit and a satellite in GEO is only about 1.4 km/s.

46 The nations currently able to place satellites in geosynchronous orbit include the United States, Russia, Ukraine, Japan, India, China and France. The other members of the European Space Agency (ESA) also have access to GEO, but political ramifications may make launching weapons somewhat problematic. “Outlook/Specifications: Launch Vehicles,” Aviation Week & Space Technology 2002 Aerospace SOURCE Book, 14 January 2002, 144-152.


50 This is because the energy needed to reach a given satellite is the same regardless of when it is expended.


52 Ibid., 20-21.
A barrage-type attack would require launching tens of rockets to achieve even a 50 percent probability of destroying a target. Since the United States would by definition be using an ASAT against another space-capable foe, the low odds coupled with the escalatory nature of such an attack would make it an untenable option. If the United States is going to run the risks of attacking satellites, then the decision-makers will demand a virtual guarantee of success. Conversely, a nation that relies heavily on large, expensive, space-based assets cannot totally ignore even such a limited threat. For a detailed review of what a low-tech adversary could accomplish against an enemy satellite, see Thomson (note 50).


It is apparent from descriptions of the U.S. system that the detailed tracking necessary to counter attacks by a determined foe will not be possible without substantial steps being taken to bolster current capabilities. Michael J. Muolo, *Space Handbook: An Analyst’s Guide, Volume One* (Maxwell AFB, Ala.: Air University Press, December 1993), 74-84.

Intercepting an ASAT that is approaching at an angle of ninety degrees will likely require considerable ∆V and an improbable amount of lead-time. Muolo (note 6), 70.

The Sea Launch system is a joint venture between Boeing, the Norwegian ship builder Kvaerner, and Russian and Ukrainian aerospace firms RSC-Evergia and NPO-Yuzhnoye. The system employs an ocean launch platform and can place satellites directly into equatorial orbits.

“Outlook/Specifications: Launch Vehicles” (note 45), 152.

For example the U.S. system is comprised of three space operations centers located in the United States and nine remote tracking stations scattered around the world. Muolo (note 54), 75-79.

Even relatively low-power lasers have demonstrated the capability to damage the optical sensors of satellites. A test was conducted which directed a 30 watt laser at an orbiting test satellite (the test was supposed to be made with the 2 megawatt MIRACL laser but it malfunctioned). Even such a
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low powered laser caused enough damage to create “a lot of panic” in the Pentagon. Gertz (note 25). In a related area, the Starfire optical range at the Philips Laboratory used a tracking system constructed from an Atari computer and electronic parts available at retail outlets. Maj Mark Jelonek (Ph.D., laser physics) interviewed by the author, 12 May 1998.

The potential problems with a diplomatic approach were highlighted during the Gulf War of 1991. The Iraqi government had been buying satellite imagery from the French company SPOT Image prior to the war, but international condemnation of Iraqi actions prompted the company to cut off access. SPOT Image also refused to provide imagery to television and other media organizations, thus preventing Iraq from gathering the information from these sources. A potential shortcoming of this approach is illustrated by the fact that SPOT Image retained the option of selling imagery to the media if another source started doing so. In fact, the Earth Observation Satellite Co. (EOSAT) did start selling imagery to the media, although it was prohibited from selling directly to Iraq by the U.S. embargo. Fortunately the images available from EOSAT were of a lower resolution than those produced by SPOT (30 m vs 10 m) and SPOT Image held to its initial decision. Peter B. DeSelding and Andrew Lawler, “SPOT Halts Sales of Gulf Area Imagery,” Space News, 13-19 August 1990, 3. Renee Saunders, “Eosat Sees High Demand for Gulf Images,” Space News, September 24-30, 1990, 3. For a more thorough discussion of this topic, see Cynthia A. S. McKinley, “When the Enemy Has Our Eyes,” (Maxwell AFB, Ala: School of Advanced Airpower Studies, June 1995).

Clementine incorporated seven sensors, along with the atttitude control, power, and the computer systems required to control and point them, for a total dry weight of only 500 lbs. Its Lidar High Resolution Camera weighed only 1250 grams and produced images with a resolution equivalent to 6 meters from a distance of 380 km. Pedro L. Rustan, “Clementine Test Results,” unpublished research results, Ballistic Missile Defense Organization, The Pentagon, Washington D.C.: 31 October 1994, 1.; and U.S. Naval Research Laboratory,

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As an example: A constellation of 143 satellites, weighing 100 kg and operating in 367 km orbits, provides the same coverage and resolution as a constellation of 4 satellites, weighing 10,000 kg and operating at 3666 km. Each of these would meet the need for 10 percent instantaneous global coverage at a resolution of 1 meter (or equivalently, 1 m resolution of a given point on earth for 10 percent of the time). The importance of this is that 100 kg satellites can do the same job for only 12 percent of the cost of the larger satellites.


This is for a de-orbit burn that minimizes fuel consumption. A quicker de-orbit time can be achieved by using a higher energy de-orbit burn. This is particularly true for higher orbits where a reduction of de-orbit time by 40 to 50 percent can be attained for a relatively modest increase in energy expenditure. Bob Preston, Dana J. Johnson, Sean J.A. Edwards, Michael Miller, Calvin Shipbaugh, Space Weapons Earth Wars, RAND Report MR-1209-AF, (Santa Monica, Calif.: RAND, 2002), 148-149.

For instance, a satellite placed in a 500 mile (926 km) orbit could strike in less than 12 minutes if the orbital geometry was ideal. Such a satellite de-orbited over the North Pole and impacting at 60 degrees north latitude would impact at approximately 5 km/s if it is assumed that the earth has no atmosphere. The atmospheric drag due to reentry would slow the weapon and degrade accuracy, but this could be minimized by optimizing design and de-orbit trajectory. For a detailed evaluation of the optimal re-entry trajectories of prospective weapons, see Preston et. al. (note 63), Appendix B.

The ideal shape for the weapon would actually be a blunted,
narrow-angle truncated cone. Preston et. al. (note 63), 138-140.

67 Above 3 km/s, the depth of penetration is a function of the square root of the density ratio of the rod to the target material \(\sqrt{\frac{\rho_{\text{rod}}}{\rho_{\text{target}}}}\) and is largely unaffected by increasing the impact velocity. For example, a tungsten rod penetrating concrete will penetrate approximately three times its own length. Smith (note 35).

68 Ibid.

69 A length-to-diameter ratio of 15 to 20 is required for these weapons to be effective. [Smith, (note 35)] As an example, a rod 3 meters long and 15 cm in diameter would have length-to-diameter ratio of 20. If this rod was made from tungsten (density 19.3 gm/cm\(^3\)), then it would weigh 1,022 kg (2,250 lbs). This is rather massive for a device to penetrate only about 9 meters (30 ft). In order to penetrate really deep, a rod as long as the Space Shuttle’s cargo compartment, about 13.7 meters (45 feet), would have a diameter of 0.68 meter (2.25 ft), weigh 95,976 kg (211,148 lbs) and penetrate 41 meters (135 ft).

70 Smith (note 35).

71 Ibid.

72 The accuracy of current U.S. ICBMs is reported to range from 90 meters circular error probable for the Peacekeeper, to 120 meters for the Minuteman III. Lennox (note 8), Tab: Offensive Weapons, LGM-118 Peacekeeper and LGM 30G Minuteman III.

73 The Space Shuttle encounters a communications and telemetry blackout until it decelerates below 15,000 ft/s (4572 m/s) and descends below 180,000 ft. W. Williamson et. al., "Technical Analysis of a Contingency Conventional Surgical Strike System," (Albuquerque, NM: Sandia National Laboratories, June 1995), 42. (Secret) Information extracted is unclassified. It is reasonable to assume that guidance commands would also be blocked until these conditions are reached.

Upon re-entry the CAV would determine guidance and navigation updates from either an inertial reference system (INS) closely coupled with the global positioning system (GPS) and/or an INS which uses stellar “fixes” for updates.

Comparison is based on the stagnation pressure at the tip of a penetrating body, which is proportional to the maximum stress on the penetrator. Preston Carter, “HyperSoar, A Concept for Global Reach - Global Power,” Lawrence Livermore National Laboratory. Briefing to the author on 15 January 1998.

In fact the U.S. is already studying a conventional warhead for the Trident II D5 SLBM that would impact at speeds of 1.2 km/s. Hewish (note 77).

As an example, the Space Based Infrared surveillance system was split into two programs because of extensive cost overruns due to technology-related factors. The cost for half of the system (SBIRS High) was increased by $2.5B to $4B over the next six years. Anne Marie Squeo, “Officials Say Space Programs, Facing Delays, ‘In Trouble’,” The Wall Street Journal; New York, NY: 2 December 2002; “Air Force

88 One barrier to giving computers the ability to fire weapons is a law passed by Congress. This law stipulates that “No agency of the Federal government may pay for, fund, or otherwise support the development of command and control systems for strategic defense in the boost or post-boost phase against ballistic missile threats that would permit such strategic defense to initiate the directing of damaging or lethal fire except by affirmative human discretion at an appropriate level of authority.” National Defense Authorization Act for FY 1988-89, H.R. 1748, Division A, Title II, Part C, Subpart 1, Section 224.


90 The SDIO projected the launch costs of Brilliant Eyes, the sensors that were to cue the Brilliant Pebbles weapons, to be 25 percent of total life-cycle cost. John R. London III, *LEO on the Cheap*, (Maxwell AFB, AL: Air University Press, 1994), 1.


93 The effects of a high-altitude nuclear detonation include an electromagnetic pulse (EMP) produced during the detonation and the creation of large quantities of charged particles that can become trapped in the Earth’s radiation belts. The EMP can damage or destroy the electronic components of
unhardened satellites that are within line-of-sight of a detonation, and even hardened satellites can be rendered inoperative for days or weeks due to the effects of either the EMP or the charged particles.


This paper's basic argument 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 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.
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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 paper 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 advanced systems for this purpose. But nor should it preclude the possibility, either by treaty or by excessive constraints on its basic research and development activities.

- In fact, the United States will soon possess a latent form 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. But it will soon obtain more advanced capabilities through its ballistic-missile defense programs. In particular, the midcourse intercept system soon to be 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). And the airborne laser will 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. Specifically, even if there is a real worry that other countries may already be developing—or for that matter building—microsatellites with ASAT capabilities, the United States should abstain (though the case for using microsats as self-defense weapons would strengthen under such circumstances; see above). This country has enough advantages in any ASAT competition in the form of its ABL and midcourse ballistic missile defense programs that it need not ensure it is first in each and every technology category.
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. 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. 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. 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.

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).\textsuperscript{5} Data transmission rates need 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.\textsuperscript{6} It can also be done by maximizing the amount of analysis done by the platform obtaining the data.\textsuperscript{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).\textsuperscript{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 rigueur. 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. So as satellites are designed and produced in the coming years, such possible enemy capabilities should form part of the assumed future threat environment.

**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. 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. 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.

In addition, it is conceivable that 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. As discussed in Chapter 5, 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
Preserving U.S. Dominance

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. The Pentagon’s February 2002 budget request included money for a number of broadly-defined programs that may or may not have ASAT relevance, and may or may not include more than basic scientific research: $40 million for directed energy technology, $14 million for space control technology, $65 million (in three different accounts) for high energy laser research, and $122 million for ballistic missile defense technology in a part of the budget that had previously included funding for the space-based laser program. In the 2004 budget request, DoD requested about $250 million for very
general space technology programs, about $85 million for high-energy laser research, and $15 million for space control technology. It also requested $82 million, a doubling from 2003, for “counterspace systems.” More information and transparency on the part of the Pentagon would be helpful for understanding the nature of these funds and the activities they support.15

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. That system is nearly halfway through its scheduled flight test program and is slated for initial operational deployment on a provisional basis in 2004. Even today, a test missile and kill vehicle would probably have a respectable chance of destroying a satellite in LEO if launched at the proper time. In that sense, the United States already has a latent nonnuclear ASAT, even if its prototype missiles developed for launch from F-15s in the 1980s are no longer functional.

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 two to three years if the program stays on course.

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 not undesirable. 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. 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.\textsuperscript{17} 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. 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). 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). 20

Other options should include 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.

Notes
5 Communication to author at Vandenberg Air Force Base, November 8, 2002.
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-frequency 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.
12 See Tom Wilson, “Threats to United States Space Capabilities,” Paper prepared for the Commission to Assess

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I. Introduction

The U.S. Armed Forces are now capable of responding to global threats with unprecedented speed, agility and precision. Their new approach to warfighting is enabled by a suite of satellite technologies that offer ubiquitous communications and navigation coverage. As the military value of space systems has increased, so has the likelihood that space will become a theater of conflict or that space assets will become targets in some future crisis. As one senior military official has recently noted, “The US is beyond the point where we can successfully prosecute a war without space systems and that is not lost on our adversaries.”

The current space capabilities of the U.S. Armed Forces are built, in part, on a new level of cooperation between the government and the private sector. It has been widely reported that nearly 80 per cent of the satellite communication traffic generated by Operation Iraqi Freedom traveled over commercial communication satellites. Given the tremendous reliance on commercial assets in Operation Iraqi Freedom, it is also clear that for the near-to-mid term the DOD will continue to rely on commercial
satcom to meet its expanding requirements. This fact has important implications for the commercial communication satellite industry and its government users.

Within the United States, there is a growing realization that – apart from their role in supporting military operations – commercial space systems constitute an important element of the “critical infrastructure” of the United States. Like energy, the broader telecommunications network, or the transportation network, space plays an important daily role in U.S. commerce and a critical role in disaster relief and recovery efforts.

This growth in the importance of space systems has caused some to argue that the United States must achieve “space control,” i.e., the ability to use the unique advantages of space systems while simultaneously denying those same advantages to our adversaries. Others, noting that the United States is more dependent on space systems than other nations, argue that the United States should seek international treaty limits on weapons based in space or capable of targeting space systems. Some argue that commercial satellite communication operations will be jeopardized by increased military activities in space.

This is an important debate, the intricacies and implications of which will, no doubt, occupy policy makers and analysts for some time. However, it is not yet a debate that has commanded the broad attention of the
commercial satellite industry. Industry discussions have tended to be focused on somewhat nearer-term issues. Since commercial communication satellites are already important – some would argue critical – to our national and homeland security, one must assume that they are already a potential target for hostile action. This likelihood has compelled an examination of the real and potential vulnerabilities of commercial satellite systems. It has also prompted a series of examinations focused on defining the nature of possible threats and assessing the physical and operation responses likely to be required. Given that this assessment process is already underway and that the problems being addressed must be regarded as real and immediate, concerns about additional, future problems, although important, have received less attention.

This paper begins by providing a brief overview of the commercial satellite industry, its relevance to our economy, and its close relationship with our national and homeland security communities. The paper examines a range of possible threats to commercial communication satellite systems and discusses the impact that such threats may have on current industry practices. Next, the paper attempts to distinguish between threats that are a natural result of the role that satellites play in our economy and national security, and threats that might be characterized as a response to a more aggressive U.S. military posture in space. The
paper concludes that while arms control approaches may be able to limit the deployment of certain types of space-based weapons, they are unlikely to have any effect on many of the threats already faced by commercial satellite networks.

II. Commercial Satellite Industry Overview

A. Role in the Economy

Commercial communication satellites play an important and growing role in the US domestic and global economies. Every day, billions of data, credit, and banking transactions take place using satellites. Very Small Aperture Terminal (VSAT) services deliver data and information to small and large businesses in places as remote as an African village and as developed as New York City. VSATs provide thousands of companies with private, secure corporate communications for a broad array of purposes including inventory management, point of sale data collection, credit card validation, and e-mail delivery. They also provide a decentralized telecommunications network for document storage for a variety of financial institutions and global trading operations.

Satellites provide the backbone for TV, radio, and print media distribution. All major news organizations throughout the world use satellites to gather the news and satellites play a role in almost all television entertainment distribution. Roughly 80 million people subscribe to Direct Broadcast Satellite (DBS) for
their television programming worldwide and many more receive cable broadcasts that originated on satellites. Finally, satellites are the primary source for weather forecasting and prediction as well as disaster relief and recovery operations.

Despite the well-publicized financial problems of some segments of the satellite industry in the late 1990s and some high-profile consolidations, the satellite industry continues to grow. In the midst of one of the most significant telecommunications market corrections ever experienced, satellite related revenues have done reasonably well. Total revenues from all sources grew in 2002 to over $86 billion. Growth in the satellite services sector is being driven by consumer-oriented video services with the introduction of modest, but important, growth in the provision of internet and satellite radio services.
Traditional transponder leasing revenues have declined in recent years as a result of the overall downturn in telecom spending. (See Figure 2) As a result of recent global events, demand from the military and news media has helped to reenergize the satellite marketplace. The satellite manufacturing and launch service
sectors experienced the slowest growth in the early 2000s but are now showing signs of recovery as the overall economy improves and the demand for replacement satellites increases.

B. Role in National Security

During Operation Iraqi Freedom, with over 250,000 coalition troops in the Gulf region, commercial communication satellites provided the U.S. military with a range of essential services. Much of the burden of the logistical communications essential to operational success were routed over commercial satellite circuits. Unmanned Aerial Vehicles were flown remotely by pilots halfway around the world using commercial satellites. Commercial communications satellites provided soldiers and airmen with the ability to communicate with their families (via email or satellite phone) half a world away.

Commercial remote sensing satellites provided the military with high resolution images of the battlefield to supplement the information collected by government satellites. Such imagery was made available globally through the major media outlets. Crystal clear images from space have allowed global viewers to virtually “fly” over Iraq and through the troubled streets of Baghdad. Reporters, hundreds of miles from the nearest wired or wireless phone system, were able to provide live reporting and imagery. Satellite dishes mounted on the roofs of Humvees and compact satellite
phones, slightly larger than cellphones, have enabled a new breed of backpack journalists who provide viewers throughout the world a second by second “live” account from the battlefield.

Within the last decade, satellite technology has moved from the periphery of DOD operational concerns to the center current warfighting doctrine. Figure 3 demonstrates the dramatic nature of this transition. In the early 1990s during Operation Desert Storm with over 500,000 troops deployed, the United States was using a mere fraction of the bandwidth that it would need during Operation Enduring Freedom. In rapidly and dramatically changing the way that it fights, the U.S. military has created a large and enduring demand for global satellite communications. Commercial communications satellites, initially a small adjunct to military systems, have begun to play a major role. For the near-to-mid-term, this demand can only be met by relying on the available capacity of the commercial communication satellite industry.
The demand for commercial satellite capacity is driven by the fact that it is a cost effective way for the government to meet its nonsecure communications needs. A recent study reported that there are 232 commercial satellites in geostationary orbit with another 59 scheduled for launch in the next three years. Since each satellite serves multiple regions, this means that every potential “hot spot” on earth can be served by dozens of commercial satellites. The size and complexity of the civilian fleet means that it can respond rapidly to unfolding events anywhere on the globe and, with backup capacity on multiple carriers, can provide a highly reliable communications network.
Richard DalBello

Figure 4: Regional Coverage of Commercial GEO Satellite Communications Fleet

In addition to their resilience and near ubiquity, commercial satellites have other strengths. Commercial satellites, when used abroad, can often be licensed more quickly than their military counterparts. Obviously, this matters little when troops are operating in hostile territory. However, since the bulk of the military’s logistical burden is often handled from adjacent friendly nations, avoiding licensing delays can be an important factor. Commercial satellites can also provide an enhanced level of interoperability with allies and coalition partners that might not be granted access to the most secure U.S. milsatcom. Commercial hardware, pre-deployed or already operating in foreign countries, offers a communication link with allies that would otherwise require the coordination and fielding of militarily-unique hardware.
Finally, commercial satellite communications is a tremendous bargain for the government and the taxpayer. While short-term satellite capacity-on-demand must accept market prices and availability, that capacity costs nothing after the conflict ends. Furthermore, the government’s capital investment in the building of the civilian fleet currently encircling the globe has been approximately zero.

C. Role in Homeland Security

Whether responding to a natural disaster such as a hurricane, or to a man-made disaster such as 9/11, satellites have always played an important role in disaster relief and recovery efforts. Satellite phones and portable VSAT terminals have long been essential tools of state and federal emergency management officials. As the nation transitions from an “emergency response” to an “emergency preparedness” mindset, it is assured that satellites will play an important and expanding role. Some of the attributes of satellites systems which make them uniquely capable of contributing to the Homeland Security mission are:

- **Independence** – Satellites provide a redundant communication network that is independent in many respects from the terrestrial telecommunications systems
- **Mobility** – Handheld satellite phones are now common and almost any vehicle can be configured to receive or to transmit
satellite data, providing critical communications “on the move” for crisis response

- **High bandwidth** – Satellites can delivery broadband access virtually anywhere allowing internet access, phone banks and video distribution to aid in emergency management

- **Distance Insensitivity** – Terrestrial wireless technology may be unavailable in remote regions or across difficult terrain while satellite are distance insensitive capable of providing service to small, lightweight terminals

Satellites are also a powerful tool for gathering information. News organizations rely on satellite phones and satellite trucks to report news from the heart of U.S. cities and from around the work. Satellites can provide data telemetry for monitoring U.S. infrastructure in remote areas such as pipelines or from remote biological or chemical sensors. When combined with the powerful Global Positioning Satellite (GPS) navigation network, satellites can be used to track dangerous shipments or monitor progress of relief supplies. For its part, the GPS system is enhancing public safety by preventing transportation accidents and by reducing the response times of ambulances, fire fighters, and other emergency services.

Satellites’ superior multicasting characteristics make them a preferred means for
disseminating information. Satellites are a primary source of television and entertainment for millions of American households. Satellites are also the primary distribution tool for nearly all the news and information redistributed by cable TV systems. New commercial satellite radio companies provide broad and uninterrupted national coverage and a potential platform for future emergency broadcast channels.

Commercial space technology extends beyond the communication industry. Commercial satellite imagery supplies another powerful tool from space. Widely available and relatively inexpensive, commercial satellite imagery allows for rapid damage assessment and the coordination of relief efforts. It can also play a vital role in tracking the plume of dangerous fires or pollutants. Multi-spectral sensors flown on government research satellites can provide even more complex tracking of wind-borne chemical, nuclear, or biological pollutants.

Satellites will also provide the backbone for the next generation air traffic management system. Satellite technologies will make planes safer and more cost-effective to operate. Advanced satellite communication technologies can provide in-flight surveillance of both cabin and cockpit. Such technologies will also supply a broadband information stream that could augment and, perhaps, eventually replace the traditional “black box” in-flight data recorders.
Specific Homeland Security applications for commercial communications satellites might include:

- **Surveillance and Warning Networks** – Existing commercial communication satellites could be used to create surveillance and warning networks. Such networks could, upon detection of certain events, provide warnings to affected agencies and authorities for decision-making and action.

- **Emergency Response/Disaster Recovery Networks** – The 9/11 disaster destroyed many Internet routers, along with a major New York Telephone 5-ESS digital switch, several fiber hubs, major cellular telephone facilities atop the twin towers, and satellite teleport interconnects. The result was a massive outage with its attendant overload on any remaining capabilities that remained intact for days. Commercial communication satellites could also be used to provide immediate response and recovery support to switches, hubs, routers, etc. that have been disabled as a result of some disruptive force(s).

- **Overlay Networks** -- Overlay networks could be designed to partially or completely replicate any terrestrial facilities in a designated area. The development of a deployable overlay
network will require some effort in the areas of switching, network engineering, and integration of data interfaces with satellite transmission systems.

III. The Uncertain Future

It is clear from the preceding discussion that commercial communication satellites already play a pivotal role in our economy and our national security. For this very reason it is important to assess the relative security of these commercial networks. Recently, the General Accounting Office (GAO) did an assessment of U.S. Government reliance on commercial communication satellites. The report concluded:

In 1998, Presidential Decision Directive 63 was issued to improve the federal approach to protecting our nation’s critical infrastructures by establishing partnerships between private-sector entities and the Federal Government. However, the satellite industry has not been included as part of this national effort. In light of the nation’s growing reliance on commercial satellites to meet military, civil, and private-sector requirements, omitting satellites from our nation’s approach leaves a critical aspect of our nation’s infrastructures without focused attention.
Because of the importance of the satellites industry to our nation, we recommend that steps be taken to promote appropriate revisions to existing policy and the development of new policy regarding the security of satellite systems, to ensure that federal agencies appropriately address the use of commercial satellites, including the sensitivity of information, security techniques, and enforcement mechanisms. In addition, we are recommending that commercial satellites be identified as a critical infrastructure sector (or as part of an already identified critical infrastructure sector) in the national CIP strategy, to help ensure that these assets are protected from unauthorized access and disruption.10

As the GAO was reaching its conclusions, others in the U.S. Government were also beginning to examine the commercial communication satellite industry and the government’s reliance on that industry. In Fall 2003, a private sector Satellite Task Force was created to provide advice on this topic to the Office of Homeland Security.11 The group is currently examining the vulnerabilities of the commercial satellite infrastructure. The group’s report is due in early 2004 and will likely include policy recommendations designed to mitigate vulnerabilities identified by the group.
To date, most of the analysis in the area of satellite system vulnerability has focused in three areas: 1) threats to ground-based satellite facilities; 2) electronic threats – such as jamming, spoofing – originating on the ground; and 3) physical threats to the satellites themselves.

A. Potential Threats – Physical Attack on Ground Facilities

Even before September 11, the U.S. Government and industry were working together to examine the critical infrastructure on which the nation relies. In October 1997 the President’s Commission on Critical Infrastructure Protection issued a report recommending a number of measures designed to reduce national vulnerabilities. The Commission’s recommendations included industry cooperation and information sharing, the creation of a national organization structure, a revised program of research and development, a broad program of awareness and education, and reconsideration of certain laws effecting infrastructure protection.

Since the release of the Commission’s report, and particularly since the September 11 attacks, each of the critical sectors of our economy -- food, water supply, information and communication, energy, transportation, power, and others – have been examined to determine both their criticality and vulnerability. Many of the most critical sectors were developed with
little thought to intentional terrorist attack. Recent assessments have revealed a number of important vulnerabilities.

Compared to many of the other critical sectors of the economy, satellites have fared reasonably well when scrutinized for critical vulnerabilities. A high level of scrutiny has always applied to satellites systems simply because they are so expensive (a satellite and launch vehicle often worth in excess of $250 million). The high value of satellite systems compelled the use of basic security techniques, such as controlled access, and in some cases, redundant facilities and encrypted satellite command links. In addition, the industry’s historically close ties with the military and its role as supplier to and manufacturer of military space systems have meant that some of the technologies and operational procedures used in military satellites have also found their way into the commercial satellite industry.

Nonetheless, the ground control elements of the satellite control and distribution system were not designed with terrorism in mind. The ground elements of a satellite network generally include:

- Satellite Operations Center (SOC) – responsible for satellite housekeeping functions such as station keeping, fuel management, and attitude control
- Network Operations Center (NOC) – responsible for payload control, data
transmission, and circuit and network establishment and teardown

- User terminals – providing service to the end user

Since user terminals are relatively cheap and easily replaceable, their loss is more inconvenient than disruptive. The sheer number of user terminals and their geographical diversity means that they are unlikely to be the focus of physical attack. SOC’s and NOC’s, however are few in number, very expensive, and their loss could be extremely damaging to a satellite network.

These facilities will have to be examined and evaluated for weaknesses. Should such a review identify significant risks, then a range of alternatives can be investigated, such as:

- Increased cooperation and sharing between commercial operators
- Collocation of commercial facilities on secure government facilities
- Establish a "universal" backup facility for commercial comsats.

B. Potential Threats – Electronic/Cyber attack

Although a physical attack on satellite ground control facilities could be extremely disruptive, in the near term electronic or cyber attacks are probably the greater threat. Electronic attacks can be carried out from
foreign countries, they require only a modest level of technical sophistication, and the required equipment can be obtained fairly easily. Satellites are susceptible to a range of electronic attacks:

- Transponders can be jammed. Jamming is the insertion of noise-like signals into the satellite link which can mask or prevent the signal from being received. In July 2003 signals from Cuba effectively interfered with US programming intended for Iran.\(^{13}\)
- Transponders can be “taken over.” If the power of the interfering signal is significantly stronger than the traffic signal, the interfering signal can take over the transponder. This apparently happening in June 2002 when the Falun Gong interrupted the World Cup signal from a Chinese satellites and inserted Falun Gong images and content.\(^{14}\)
- Network control and satellite operational centers are susceptible to cyber attack. Like other computer-based systems, satellite control systems could be subject to a range of cyber attacks and viruses.
- The command links controlling the satellite could be captured. If its command links were captured, a satellite could be instructed to take
such damaging actions as venting all of its control fuel or altering its operational orbit. Typically, tracking, telemetry and control (TT&C) links are encrypted. High-power RF uplinks and spread spectrum signals are other techniques available to prevent the capture of a satellite’s TT&C links.

While acknowledging the importance of potential electronic attacks, it is also important to note that concerns about satellite signal vulnerability can be exaggerated or misunderstood. For example, in the recent Iranian jamming incident, the process was facilitated by the fact that the satellite was broadcasting an analog TV signal, and, to encourage viewership, the broadcast frequencies had been published on the internet. Digital carriers and private networks are much harder to jam than broadcast signals. Also, once intentional jamming is identified, it is often easily remedied by relocating the signal.

Considerable work is now underway to ensure that commercial communication satellite control and service links are hardened. New technologies can also greatly reduce chances that jamming will be effective:

- TDMA Systems use frequency hopping to shift the carrier across available commercial spectrum
Outbound and Inbound carriers can be set up across multiple transponders
Diverse Hub transmissions can be established

C. Potential Threats – Direct Attack on Space Assets

Preventing the physical attack on space assets, either from weapons based in space or on the Earth, is often a key objective of arms control advocates. On the one hand, it is true that most commercial satellites are relatively fragile. With their large, thinly supported solar panels and their minimal to non-existent shielding and structural support, satellites are hardly up to even a modest physical assault. On the other hand, physics imposes a high burden on the would-be attacker. Once a commercial communication satellite reaches its operational orbit of 23,000 miles, there are, today, very few countries that possess the technology necessary to reach and effectively strike it.

Nuclear detonations in space have received a fair amount of attention recently. A nuclear weapon exploded at high altitude or in low earth orbit would have a significant impact on satellites in low and medium orbits (approx. 100 – 15,000 miles). Satellites caught in the weapons blast radius would be destroyed, but, more importantly, the blast would “pump” the Van Allen belts with energetic electrons. Satellites that fly through the newly energized belts would be rapidly degraded and eventually
It is important to note that, while a high altitude or low earth orbit nuclear explosion would be catastrophic for satellites in LEO, most of the commercial satellite fleet, and nearly all of the commercial satellite revenues, are generated from geostationary orbit. Because this orbit is 23,000 miles from earth, it is relatively immune from the destructive effects of enhanced radiation. (A nuclear blast would, however, severely disrupt communications for several days.) The most significant losses would be suffered by the U.S. military which has many high value assets in low earth orbit.

IV. Conclusions

Commercial communication satellites are part of the “critical infrastructure” of the United States and are important to our economy and our national and domestic security. As such, the vulnerabilities of the commercial satellite industry must be addressed. This process is underway and it appears that many of the identified vulnerabilities can be addressed through the application of available technology and creative risk management. The commercial communication satellite industry, working alone, and in partnership with the government, has sought to address the most obvious weakness in the global satellite infrastructure. For the most part, arms control issues have not played a significant role in their
common agenda. This is the result of many complex factors, including:

- Many current threats involve technologies or practices that are not susceptible to control through multilateral agreement.
- The nature of the threats that might be deterred by multilateral arms control are not perceived to be of immediate concern.
- Much of the risk to today’s commercial satellite networks is from non-state actors who would not be parties to, nor deterred by, government-to-government arms control agreements.
- Today, government assets (many of which are in low earth orbits) are more at risk than commercial assets from state actors who might engage in offensive space activities or development programs.
- It is not yet clear whether national decisions to pursue “space control” will increase or decrease long-term risk for commercial industry.

The debate between the “arms control” and “space control” approaches to national security will, no doubt, continue. It is unlikely that the commercial communication satellite industry will play a leadership role in these discussions and their ultimate resolution will turn on other complex issues. Nonetheless, a
thorough understanding of commercial assets, practices and their contributions to the national well-being are important in fashioning effective national security policy.

Notes
1 The views expressed here are those of the author alone and do not necessarily reflect the policies or positions of the Satellite Industry Association, its member companies or affiliates.
6 Futron Corporation, Briefing to OASD C3I, February 2003.
7 Since one satellite serves multiple regions, total of satellites seen by all regions exceeds total of all satellites. Futron Briefing to OASD C3I, February 2003.
8 This section derived from Robert Berry and Richard DalBello, “Importance of the U.S. Commercial Communications Satellite Fleet in Support of America’s National Interests”, an unpublished white paper.
10 Ibid., p. 4.
11 The Satellite Task Force was established by the Industry Executive Subcommittee (IES) of the National Security Telecommunications Advisory Committee (NSTAC). NSTAC is a Presidential Advisory Committee operating under the auspices of the Federal Advisory Committee Act. It is established under the National Communication System (NCS), which has now been incorporated into the Office of Homeland Security.
14 Chinese government: Falun Gong tapped into nationwide satellite system, Associated Press, September 24, 2002
15 See, for example, Dennis Papadopoulos, “Satellite Threat Due to High Altitude Detonations,” The Eisenhower Institute, Report of the First Meeting of the Scientific Panel. Available at: http://www.eisenhowerinstitute.org/programs/globalpartnerships/fos/newfrontier/scientific_panel_1st.htm
16 Ibid.
Chapter 7

A Sea of Peace or a Theater of War?
Dealing with the Inevitable Conflict in Space

Col. John E. Hyten, USAF

In many ways, the future of the United States is tied to the future development of space. Given the many issues facing this development and the potential for conflict, one would expect widespread and vigorous debate on the subject. Such is not the case, however. Even though debate has begun within limited political and military circles, no one has addressed space in any real depth on a national level.

During the 1970s and 1980s, in the midst of an active Soviet space threat, the debate was loud and vigorous, involving not only leading military officers, presidents, and congressmen, but also many members of the scientific and academic community. Significantly, the national media gave close attention to this discussion. Today, however, the debate lacks any such national attention and committed involvement, as evidenced by the lack of response to a major speech delivered at Tufts University’s Fletcher School of Law and Diplomacy in November 1998 by Sen. Bob Smith (R-N.H.), then the

1 Col. Hyten made a presentation to the Security Space Forum that was based on this paper, which originally appeared in Air & Space Power Journal, Fall 2002. Reprinted with permission.
chairman of the Strategic Forces Subcommittee of the Senate Armed Services Committee. In this address, he proposed in very strong terms the need for space weapons and perhaps even a separate space force to develop and operate these weapons.¹

Media response to these bold and radical proposals was almost nonexistent. For many weeks, the only media coverage to be found was in primarily defense-related periodicals such as *Inside the Air Force.*² The first mainstream American newspaper that even mentioned this speech was the *Washington Times* in an editorial by James Hackett on 11 January 1999 (nearly two months after the speech).³ Senator Smith, however, continued to press his ideas in the Senate, and Congress passed legislation, included in the Defense Authorization Bill for fiscal year 2000, which established a special Space Commission to evaluate many of these proposals.⁴ Still, the public in general has largely ignored the issue.

**The Space Commission**

Formally called the Commission to Assess United States National Security Space Management and Organization, the Space Commission began its work in the summer of 2000 and issued its report on 11 January 2001. Donald Rumsfeld chaired the commission until President George W. Bush nominated him to serve as secretary of defense as the commission
A Sea of Peace or a Theater of War?

was finalizing its report, which recommended numerous actions by the executive branch of
government and specifically by the Department
of Defense (DOD). Due to congressional
interest, the report likely would have spurred some changes in any administration, but due in
great part to the position and leadership of
Secretary Rumsfeld, DOD has pursued many of
the commission’s findings. Changes did not
occur immediately, and many of the
recommendations and initiatives have still not
taken effect; nonetheless, significant change is
under way.

All of national-security space has
undergone reorganization within DOD. The
most significant change has been the naming of a
single military service—the Air Force—as
DOD’s executive agent for space. Peter B.
Teets, undersecretary of the Air Force, now has
direct responsibility for all national-security
space, including the National Reconnaissance
Office. For the first time, one person has the
authority to lead and direct all US national-
security space activities. The executive agent is
also responsible for establishing a virtual major-
force program for space that will clearly identify,
for the first time, the true magnitude of the
resources expended on national-security space
efforts.

One of the most important aspects of the
Space Commission’s report, however, is the
clear and logical way it describes how essential
space has become to all aspects of our existence. It explains the importance of the civil, commercial, defense, and intelligence space sectors in detail—as well as US vulnerabilities. In some of its more vivid language, the report points out that with the growing commercial and national-security use of space, US assets in space and on the ground offer many potentially vulnerable targets. In discussing the future, the commission concludes that “history is replete with instances in which warning signs were ignored and change resisted until an external, ‘improbable’ event forced resistant bureaucracies to take action. The question is whether the US will be wise enough to act responsibly and soon enough to reduce US space vulnerability. Or whether, as in the past, a disabling attack against the country and its people—a ‘Space Pearl Harbor’—will be the only event to galvanize the nation and cause the US government to act. We are on notice, but we have not noticed.”

The events of 11 September 2001 add to the importance of these words. Once again the United States experienced an improbable event—and responded. The nation will pursue the war on terrorism for a long time to come, but it must also continue to understand and work to protect its other potential vulnerabilities. The Space Commission pointed out that threats to US space systems could arise under a variety of conditions “in peacetime, as a terrorist act.”
In more normal times, the report of the Space Commission, combined with an active and involved secretary of defense keen on implementing many of its recommendations, would spawn active, public debate. However, many of the critical issues necessary to define the path of this nation in space are still not being addressed in any significant way in public. In light of the notable changes currently taking place in both the substance and management of national-security space, now is the critical time for just such a debate.

Unfortunately, the limited public discourse thus far seems to focus on two very strong, opposing positions: the need for space weapons versus the need to maintain space as a sanctuary. But the focus should be on choices that can help define the future of this nation, and the world, in space. Many aspects of conflict in space, certainly in the near term, can be assuaged without requiring the controversial development and use of space weapons—or even military intervention in space. To do so, however, requires the aggressive implementation of other instruments of national power—specifically, of an economic and political nature. Like public debate on space, this has yet to occur.

Gen Richard B. Myers, chairman of the Joint Chiefs of Staff, observed in early 1999, “Just as we can’t expect to successfully fight the next war with the equipment of the last war, we surely won’t see victory in the next war using the
policies of the last war. To best prepare for the future, we have to energize our thinking too. We need the national debate on the existing policies and open questions affecting military capabilities and possibilities in space. And we need resolution of that debate sooner rather than later.” Over three years later, however, we still lack both resolution and debate.

In the past few years, some significant steps have taken place, although they were not well publicized or noticed by the public at large. In the national-security strategy of December 1999, President Bill Clinton for the first time declared the unimpeded access to and use of space a vital national interest of the United States. Shortly thereafter, the Space Commission described the nation’s interests in detail. Despite such progress, the United States still lacks a coherent, long-term space vision. Although the current national space policy (1996) provides top-level guidance for each of the nation’s space sectors—civil, commercial, intelligence, and military—it does not fully integrate the US space program or provide a long-term vision. If conflict in space were not inevitable or already occurring, such a stance would be appropriate. These divergent approaches, however, make it difficult to deal with the foreseeable conflicts of the future.
Conflict

The pressures on space are enormous—from both an economic and a military perspective. Even one of these pressures is severe enough to create conflict. Combined, they create the risk of war—either on Earth, in space, or both. On the economic front, conflict has already occurred due to crowding in geostationary orbits and through saturation of the available radio spectrum. On the military front, the United States has managed to avoid clashes because of the effective monopoly it would exert on the use of space during conflict.

In the year 2000, the commercial space industry alone generated over $80 billion in worldwide revenue. Conflicts in this arena are beginning to grow as crowding increases due to the finite number of unoccupied geostationary slots and the limited amount of unallocated spectrum. Militarily, one cannot imagine the United States allowing an enemy either to threaten US space capabilities or use space systems to put Americans at risk. Space systems could become a significant part of any future military conflict involving the United States.

The military leadership is fully convinced that the United States will need weapons to deal with space-related conflict. Although other nations and many Americans who see such a plan as disastrous have called for the United States to negotiate both bilateral and multilateral treaties, currently none are under consideration.
The Clinton administration determined that the current limits on placing weapons of mass destruction in space were sufficient and did not consider negotiations regarding the peaceful uses of outer space in the best interest of the nation.\textsuperscript{14} The Bush administration has not modified this position—at least publicly. In short, national space policy remains confusing.

The issue of antisatellite (ASAT) weapons provides an interesting example of the United States sending mixed signals to the international community. In the fall of 1997, the Clinton administration allowed the testing of the US Army’s mid-infrared advanced chemical laser (MIRACL) against an orbiting Air Force satellite, the stated objective of which involved collecting “data that will help us improve computer models used in planning protection measures for U.S. satellite systems.”\textsuperscript{15} Despite the fact that this decision to test a high-powered laser against a space object came under heavy criticism from President Boris Yeltsin of Russia, some members of the US Congress, and many people in the scientific community, all of whom viewed it as an ASAT test, the administration allowed it to proceed. Almost at the same time, President Clinton used his line-item veto to implement policy for the first time (an action since ruled unconstitutional) when he vetoed three programs with the potential for exploring space-weapon technology—the Clementine II microsatellite program, the Army’s kinetic-
energy ASAT system, and the military space plane. The administration argued that (1) the MIRACL test was not an ASAT demonstration, (2) one could achieve space control without weapons,\textsuperscript{16} and (3) the United States did not need the three programs for its future defense. Understandably, the media and much of the world concluded that the Clinton administration did not have a clear policy for space control.\textsuperscript{17}

The Bush administration has the same problem. During a press conference on 8 May 2001 to announce implementation of the Space Commission’s report, Secretary of Defense Rumsfeld fielded a question about putting weapons in space:

What I brought along was some space policy, the National Space Policy, which it might be useful to read. It’s just an excerpt. This is from September 19th, 1996. It is the policy today, and it says basically that: “DoD shall maintain the capability to execute the mission areas of space support, force enhancement, space control and force application. Consistent with treaty obligations, the United States will develop, operate and maintain space control capabilities to ensure freedom of action in space, and if directed, deny such freedom of action to adversaries. These capabilities may also be enhanced by diplomatic, legal and military measures

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to preclude an adversary’s hostile use of space systems and services.” That, I would say, is the policy of the United States government. And it has been, and it is today.18

This excerpt shows that the national space policy is very broad, allowing any number of responses. But the actions of the United States have not been consistent—and national debate still has not occurred. Thus, the vision for the future of the United States in space remains unclear.

Similarly, concerning the commercial aspects of space, neither Congress nor recent administrations have effectively dealt with the growth of space business and its impact on national security. Even though Congress, after much delay, passed the Commercial Space Act in 1998, it did not fully resolve the critical issue of remote sensing (imagery). Matters regarding commercial imagery satellites (e.g., Space Imaging’s Ikonos) with one-meter (or better) resolution remain confusing at best.19 During the ongoing Afghanistan conflict, the US government initially decided to buy up all satellite imagery of the area of interest from Space Imaging for about $2 million per month. Shortly thereafter, the government discontinued these purchases but did not provide the media clear reasons for doing so.20

Neither has anyone fully addressed the true impact of global satellite communications
from constellations such as Iridium and Globalstar. Again, the commercial sector has the potential for affecting national security—not only of the United States but of other countries as well. Every new step that exploits the benefits of space has tremendous reverberations throughout society. No one can make effective decisions regarding commercial, civil, and military space systems without considering their full impact.

The “Commons” of Space

Space has been described as both a frontier for exploration/exploitation and a fuel for the economy, but perhaps a more accurate descriptor is the term *commons*—an area for use by the community as a whole. In a legal sense, it also refers to an area open to use by one nation without interference from another. As a frontier, space is a commons because of its availability to any nation with the desire and wherewithal to explore it. As a fuel, it is a commons because no national restrictions exist regarding its exploitation. That is, the use of space, as both a frontier and a fuel, is open to the community of nations as a whole and is not restricted to any single nation. Therefore, one must deal with areas of conflict such as geostationary spacing or spectrum allocations from the viewpoint of the commons, as well as that of an individual nation.

The international nature of the space commons makes dealing with space conflict
difficult. In the absence of a coherent national strategy, the US military, as a minority player in space, has problems developing the means to deal with space issues as they relate to national security. In reality, it is a national problem that the executive branch must address by integrating all the elements of US power into a coherent policy.

As a commons, space demands continued engagement in the international arena. One must continually explore and update laws, treaties, and agreements to allow for effective growth while minimizing conflict. The United Nations (UN) International Telecommunications Union (ITU) is well positioned to negotiate many of these multinational issues. As is the case with the commons of the sea, however, disagreements and conflicts will continue to occur whenever one nation achieves a distinct advantage and other nations want to challenge that advantage. Exploration of the sea gave rise to new international laws, treaties concerning fishing rights and defense, and a new legal framework—all of which served to resolve conflict. When these measures did not work, however, nations defended their rights to the seas with military power.

At sea, however, strategic military advantages and economic advantages are more easily discernable. Usually, ships of war and ships of commerce look quite different, but in space, satellites of war and satellites of
commerce may be one and the same. Similarly, the national response to a threat from a ship of war is clear, but such a response to a satellite that has both military and commercial uses (“dual uses”) is not so clear. The twenty-first century in space will be driven by dual-use technologies, which will greatly affect future conflict. To maintain an advantage in space, the nation must pursue ways to deal with these technologies effectively. Again, the military cannot do it alone.

The UN offers opportunities to advance US interests in dealing with dual-use technologies. These include such forums as the Conference on Disarmament and other UN committees that look at commerce and outer space. Possibilities exist for exploring negotiated agreements for controlling these kinds of systems and technologies. Perhaps more likely, however, are opportunities for negotiating international “rules of the road” for space that can better define the operating framework. Like other nations of the world, the United States will always have the right to defend itself from attack—which should remain the driving principle behind US operations in space. Engaging other nations within the structure of the UN makes progress possible—at least in terms of defining some of the additional laws and agreements necessary to operate in the commons of space.

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One should not view the UN and other arenas for peaceful negotiations as a panacea. The current competitive advantage enjoyed by the United States gives it the opportunity to continue to develop the commons of space commercially and to serve as the leading provider of space services around the world—from telecommunications, to navigation, to remote sensing, to anything produced by space industry in the coming years. It is essential that the US government not take any action or implement regulations that would encourage other nations to develop a particular space market. This requirement raises continuing conflicts with national-security interests, once again stressing the need for an integrated approach from the US government.

Every nation, the United States included, has its own unique national-security interests in space. As the world’s most space-dependent nation, the United States must prepare itself to respond to threats to its national interests should negotiations fail. These threats might involve attacking—directly or indirectly—space systems, denying commercial space capabilities, threatening forces/citizens with space weapons, or using international space capabilities in some fashion. Political and economic means could effectively control certain of these threats while others might require military intervention, possibly consisting of nonlethal action (e.g., jamming), lethal action confined to terrestrial
targets, or, ultimately, lethal action against targets in space. Most likely, the United States would respond to a purely commercial conflict through nonlethal means, using lethal space weapons only when foreign space systems threatened American lives or property. Each of these threats is significantly different, and the nation must consider each one as it develops a strategy for the twenty-first century.

Recommendations
As a critical element of the future, space will play an essential role in allowing for economic growth and enhancing national security. In order to take full advantage of this future, however, the United States must integrate all of its elements of national power into an effective national strategy. The following recommendations are designed to help develop such a strategy and respond to these challenges.

Reconstitute the National Space Council
The Space Commission’s top recommendations concerning organization and management recognize the critical leadership role of the president in “developing a long term strategy for sustaining the nation’s role as the leading space-faring nation.” It also suggested the creation of two organizational constructs to advise the president on space matters—a Presidential Space Advisory Group to provide independent advice and a Senior Interagency Group within the
National Security Council—as well as the establishment of a closer relationship between the secretary of defense and the director for central intelligence. Although the secretary and director have certainly developed a much closer relationship as regards national-security space, the two recommended groups have not been implemented.

The original National Space Council (disbanded in 1992) effectively integrated different elements of the executive branch and helped develop coherent strategies. Since the vice president chaired the council, it had the authority it needed to make tough decisions. We should charter a similar body with the power and authority to make critical policy recommendations to the president. It should include senior representatives from all the affected segments of the government, including DOD, the Department of State, the Department of Commerce, the Central Intelligence Agency, the National Aeronautics and Space Administration, and the National Security Council. The space council should first define the nation’s overarching space policy and include a clear vision for the next century. This vision must call for more than a simple commitment to “the exploration and use of outer space by all nations for peaceful purposes.”

The Space Commission attempted to produce these results by recommending the formation of both an advisory and interagency
group, mentioned above. These organizations have yet to receive the charter and visibility necessary to adequately address the complex issues involving space. Combining these efforts into a National Space Council would give them the necessary standing in the government to function successfully.

Develop a New National Space Policy

The current national space policy is out of date. The issues that need attention are so complicated that only a national body within the executive branch, such as a National Space Council, could possibly consolidate the various positions and integrate the policy. The new policy must effectively encompass all the instruments of national power, allowing continued economic expansion and pursuit of vigorous research and exploration, while at the same time protecting US national security.

On paper, the National Science and Technology Council is still “the principal forum” for resolving issues related to national space policy. Unfortunately, very few of the critical decisions regarding the future of space are issues of science and technology. Rather, they cross the boundaries of many agencies in government, affecting everything from national security to economic prosperity. Addressing these issues in the context of science and technology gives them the wrong focus.
In March 2001, a Space Policy Coordinating Committee was established under the National Security Council, including senior-level representatives from all federal departments and agencies. Although the committee intended to issue a report in six to nine months, only sporadic activity has occurred.\(^{25}\) We still need an integrated national strategy documented in a new national space policy.

Recently, however, promising efforts appear to be addressing these needs. In May 2002, Dr. Condoleezza Rice, the national security advisor, announced plans to conduct a thorough review of US space policy, stating that “many of the national policies governing our space program have been in place for several years, during which time there have been a number of changes and developments.” She then requested that departments and agencies consider by January 2003 whether existing policies should be revised, consolidated, or eliminated. The Space Policy Coordinating Committee is expected to lead this effort with support from throughout the government.\(^{26}\)

The nation must effectively utilize all of its instruments of power as it moves forward in space—an effort that requires new direction. For that reason, a new national space policy is essential. The remaining recommendations address the political, military, and economic aspects of this problem.
Negotiate the Future of Space

Through international agreements, the United States can move forward in a number of areas, most significantly in further defining the international norms for behavior in space—“the rules of the road.” The US position on space has remained consistent for many years. Specifically, the United States does not claim any sovereign right to space, rejects any nation’s claim to such sovereignty, and promotes the availability of space for use by all humanity. At the same time, this country considers the use of space a vital national interest—one that Americans are willing to protect if called upon to do so.

During any negotiations in which it might participate, the United States should be careful to preserve its current strategic advantage, taking no action that would lessen the precision or effectiveness of US military forces. For example, if an enemy denied Global Positioning System (GPS) signals to our precision weapons, should the United States attack to prevent this denial or simply revert to older, less precise weapons—with the resulting increase in collateral (civilian) damage? Preserving this strategic advantage should be a guiding principle for future US initiatives.

Potential enemies (nations, groups, or individuals) need to understand that if they use space systems to target, exploit, or attack US citizens or resources, the United States will
respond. In addition to taking political or economic actions, this country could attack ground assets, communication links, or, if necessary, space assets as well. But this does not mean that negotiations leading to either informal understanding or formal agreements cannot prove beneficial to both the United States and the international community. Opportunities exist to further define the commons of space, the legal framework for operating in space, and the conditions that would allow a nation to defend itself.

Achieve Space Superiority
Just as all military campaigns today rely on operational plans to achieve air superiority, so should they include plans to achieve space superiority. The nation’s political and military leaders must recognize that without space superiority, American forces will operate under greater risk in a theater of operations. Space-superiority plans should specify the appropriate application of both nonlethal and lethal force in the particular medium to ensure the availability of space for US and allied forces and to deny it to enemy forces.

Like air or maritime superiority, space superiority does not exist all the time. Rather, military forces must establish it during a specific conflict and maintain it only for the duration of that conflict. Space superiority differs from the air and maritime versions because of the unique
physical characteristics involved. In a conflict, one can achieve air and maritime superiority over the limited geographic area (e.g., air superiority over the Persian Gulf or maritime superiority in the Mediterranean Sea). Space presents a more complicated problem. Orbiting space systems have the potential to affect an enormous portion of the globe; therefore, one must evaluate space superiority from the perspective of all of space, not just a limited theater of operations.

Thus, in its efforts to achieve space superiority, even for the limited duration of some future conflict, the United States must consider the overall impact of its actions on the commons of space. If the United States impinges upon the commons, establishing superiority for the duration of a conflict, part of the exit strategy must include the return of full access to all nations. This requires two approaches: (1) development of a complete spectrum of military options (nonlethal to lethal) and (2) development of doctrine and concepts of operation employing the military option that best achieves the desired effect with minimum impact upon the commons.

**Develop Capabilities for Space Control**
As history has demonstrated, concentrating on political means without properly preparing to use military force often results in failure. For that reason, the United States should aggressively pursue development of and test programs for
capabilities that will give future decision makers options to deny, disrupt, degrade, and, if necessary, destroy space systems that could threaten US interests in the twenty-first century. For the time being, this country can achieve space superiority without deploying weapons in space and without the use of weapons that create permanent effects on the commons of space.

In 1999 Dr. John J. Hamre, then the deputy secretary of defense, testified before Congress that DOD initiatives for space control emphasized the temporary denial of space to an enemy rather than the destruction of space systems: “We want our space jamming capabilities to be localized and temporary. . . . For example, we would want to jam a global positioning system signal around an air base that might be under attack, but we would not want to shut down the whole system.” He acknowledged, however, that a great deal of research and development remained before we could field such a capability.27 That year, however, the Air Force began pursuing space-control technology efforts and just recently initiated acquisition programs to develop capabilities for countercommunications as well as countersurveillance and counterreconnaissance with temporary/reversible effects.

One may handle future threats in space by means of a progressive pattern of responses that focus on denial and disruption but do not
degrade or destroy. However, if peaceful negotiations fail and military planners cannot develop terrestrial means to ensure space superiority, the only alternative may entail the deployment of some types of space-based weapons. The United States must be ready to respond to this scenario.

The United States needs a full spectrum of capabilities to give decision makers options for resolving conflict at the lowest level possible. Full preparation requires developing and testing the critical systems and technologies necessary to field such capabilities. Failure to do so could leave the United States vulnerable to surprises from other nations. On many occasions, Gen John L. Piotrowski, former commander of United States Space Command, has observed that the United States can’t afford to find itself in second place in terms of space weapons.28

The military also needs to develop more fully the doctrine necessary to operate and use space-control capabilities. Because the concept of space superiority is still relatively new to military planners, significant work still needs to be done on effectively and efficiently achieving it. Understandable concepts and doctrine will allow military leaders to give political leaders sound advice on how to achieve space control across the spectrum of conflict.

We also need to pursue better methods for characterizing potential attacks and defending current space assets—for example, improved
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situational-awareness capabilities for space to ensure better knowledge of future activities there. We also need better ways of confirming disruptions to or attacks upon satellites. An anomalous event that affects a satellite can have many causes: the harsh space environment, onboard system problems, or hostile action. The correct response depends upon knowing the specific cause. Today’s satellites are relatively incapable of confirming an attack; to maintain our advantage in space control, we must remedy that deficiency.

The United States should use space-based weapons only as a last resort but should not consider it an unthinkable option. American leaders have long believed this and have used military force when the situation demanded. Certainly, one would prefer to control the future through peaceful agreements that are in the mutual interests of the parties involved. At the same time, the United States must prepare itself to deal with a wide spectrum of potential conflicts in space by developing and testing a number of military capabilities—up to and including space-based weapons, preferably those with temporary/ reversible effects.

**Fund the Military Space Program**

In November 1998, Senator Smith noted that in their rhetoric, both the Department of Defense and the Air Force have
acknowledged the importance and promise of spacepower. In his 1998 report to Congress, Secretary [of Defense] Cohen stated that “spacepower has become as important to the nation as land, sea, and air power.” In 1995, the Air Force made clear in *Global Engagement* that: “The medium of space is one which cannot be ceded to our nation’s adversaries. The Air Force must plan to prevail in the use of space.” . . . Compared to the magnitude of the technical challenges involved—and these programs’ potential military value—the investments being made by the Air Force in these areas are paltry.29

This criticism is based on Senator Smith’s perception of Air Force budget decisions on space in the mid-1990s. He and others in Congress believe that the space threat is growing and that DOD should respond accordingly. A study by the Air Force Scientific Advisory Board in 1998 indirectly explained the very reasons why this perception developed and proposed an aggressive increase in Air Force space funding for the coming decade. Interestingly, it also showed the actual Air Force space budget for the previous five years (fig. 1). Note that actual Air Force expenditures on space declined slightly or stayed fairly level during the period—the data to which Senator Smith referred in his criticism of
the Air Force’s investment in space. The senator believed that the Air Force had ample opportunity to step up to the future but failed to meet this obligation.


In April 2002, the Congressional Research Service completed an analysis of the nation’s space program, pointing out that tracking DOD’s space budget proved very difficult since it is not reported as a single line item in the budget. Interestingly, the Congressional Research Service quotes the trade press as saying that DOD’s budget request for unclassified space activities is $7.8 billion. Since the Air Force executes a significant portion of the unclassified space budget (an average of 83 percent, according to the General Accounting Office), it appears that the Air Force budget request for 2003 is somewhere around $6.5 billion.
billion. A comparison with the Air Force budget included in the Scientific Advisory Board report of 1998 (less than $5 billion) suggests that the Air Force has stepped up to an increased level of support for space, at least to some extent. However, further analysis at the program level provides additional insight.

In early 1999, the Air Force was under fire for deciding to delay for about two years both the high and low portions of the Space-Based Infrared System (SBIRS), the new missile-warning satellite programs. It did so for a number of reasons—technical, programmatic, and funding. Many members of Congress interpreted this action as another instance of the Air Force’s failure to support space. The publication *Inside the Air Force* reported that key members of Congress were “concerned about the Air Force’s practice of using the SBIRS program . . . to pay its bills.”33 Sen. John Warner (R-Va.), chairman of the Senate Armed Services Committee, called on Defense Secretary William Cohen to cease making any changes to the SBIRS programs until Congress had an opportunity to consider them.34

Less than four years later, the Air Force again finds itself facing criticism about SBIRS—but now from a number of sources. Because of technical and programmatic problems, Congress, in the Defense Appropriations Act of 2002, denied all $94 million requested for procurement of the “high” element of SBIRS but increased
funding for research, development, test, and evaluation from the requested $405 million to $445 million. In the 2003 budget, the president requested $815 million for SBIRS-High, an 83 percent increase over the 2002 request.\textsuperscript{35} For a variety of reasons, ranging from earlier delays to technical and programmatic concerns, the SBIRS program is experiencing serious problems.

In the spring of 2002, due to budget overruns in excess of 25 percent, the SBIRS-High program breached the limits put in place by legislation known as the Nunn-McCurdy Amendment, thereby placing the future of the entire program at risk. In late April, Edward C. “Pete” Aldridge, undersecretary of defense for acquisition, technology, and logistics, recertified the SBIRS-High program as essential for national security and still the best technical approach for meeting the mission. Consequently, however, DOD’s independent cost estimates judged the Air Force budget too low, so the service agreed to fund the program at a much higher level—another significant increase.\textsuperscript{36}

Essentially, a comparison of the Air Force budget over the last few years to the budgets of the mid-1990s reveals a slight increase overall, but most of it went to pay for a few expensive programs that have run into trouble. Even though little has changed in its overall space portfolio in the last decade, the Air Force has stepped up to a leadership role by
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supporting a number of broken programs essential to national security—such as SBIRS-High. However, if the Air Force is truly to be the executive agent for space and if space really is a vital national interest of the United States, then the Air Force must support space at a level beyond its current programs. Space can help lead the transformation of DOD—but not unless the budget transforms as well.

Senator Smith and others have proposed a separate space force or space corps to adequately support DOD’s space efforts. A strong push for such an organization will continue unless the Air Force, as executive agent in conjunction with the other services and agencies, can meet both the actual and perceived need to be a good steward of military space. The Air Force must take the lead and help transform DOD’s efforts in space, an initiative that will require an ever-increasing commitment—not only in terms of rhetoric but also a greater share of the overall DOD budget. It must also reestablish credibility with Congress concerning a number of space programs, including SBIRS-High, and increase its commitments to transformational initiatives (e.g., space-based radar and space control). If the Air Force and DOD fail to meet this challenge, Congress could legislate the creation of a space service well before its time and well before many of the critical policy and doctrine questions have even been addressed.
Structure Laws and Regulations Governing the Commercial Use of Space
All space industries are global in nature. Navigation, weather, imagery, and communications from space—all of these capabilities were developed in the United States. The US space industry, once a free-world monopoly, now faces increasing competition from around the world. Complicating matters even further, nearly every one of these commercial developments has significant military implications. Commercial navigation, weather, imagery, and communications can help a potential enemy close the gap with the information-dominant United States.

Any US government action that prevents US companies from competing in international markets represents a threat to national security. If those companies are industry leaders and the world comes to them for a particular space service, the country at least maintains some insight and control over this service in times of conflict or crisis.

At the same time, any attempt by US companies to transfer critical technologies overseas also represents a threat to national security. Even if the technology is “only” for communications satellites, that technology still advances the state of the art overseas and allows international companies to provide improved capabilities in competition with those of the...
United States. In a global economy, however, no nation can isolate itself and remain competitive. The United States must trade overseas with space services; therefore, industry deserves some leeway in the exchange of technical information.

In March 1999, the State Department, in order to comply with the National Defense Authorization Act of 1999, assumed responsibility for satellite-export controls. However, according to John Holum, then the acting undersecretary of state for arms control and international affairs, the department found it extremely difficult to staff this critical function: “Congress mandated new staff . . . but there wasn’t any money provided for that.”37 International customers responded negatively. Indeed, as reported by Space News, “three large satellite operators from Canada, Europe, and Asia said new U.S. technology-transfer regulations will make it difficult, and perhaps impossible, for them to purchase U.S. satellites.”38 The clear implication was that these operators, previously American customers, would go to other international markets to obtain these services. Evidently, these policies have not changed during the Bush administration.

Given these circumstances, the new national space policy should allow US industry to maintain a leadership role in the space marketplace. The United States cannot afford to miss out on international opportunities because of government bureaucracy. An integrated
national strategy should make such difficult and controversial issues as remote sensing and imagery resolution easier to resolve. Furthermore, the United States should be able to capture the majority of space commerce in the twenty-first century—a prospect that is good for both business and national security.

Conclusion

*Space science, like nuclear science and all technology, has no conscience of its own. Whether it will become a force for good or ill depends on man, and only if the United States occupies a position of pre-eminence can we help decide whether this new ocean will be a sea of peace or a new, terrifying theater of war.*

—President John F. Kennedy, 1962

The United States has an opportunity to implement a vision that will help shape the world in the twenty-first century. Space is only one of many places where this opportunity presents itself, but it is unique in many ways. Enveloping Earth and reaching to the stars, space has the ability to affect, in some way, the life of every person on this planet. Without a peer competitor, the United States has the opportunity now to take advantage of the unique attributes of
space, but the nation has not yet stepped up to the challenge.

Conflict in space is inevitable. No frontier exploited or occupied by humans has ever been free from strife, but the United States has a chance to mold and shape the resolution of such conflict in the future. Opportunities exist through both formal and informal negotiations to define the commons of space and the rules of the road.

At the same time, the United States cannot afford to be caught off guard in the future—and cannot afford to allow another country to deploy a space-based weapon first. To ensure that this doesn’t happen, it must develop a robust program for an entire spectrum of space-control capabilities—deferring the decision to deploy operational, space-based weapons until a clear requirement exists.

If the United States remains strong; if space truly is a vital national interest; if we negotiate openly with the nations of the world; if we allow our industry to exploit space fully and become the unquestioned leader of the information age; and if we develop the means and methods to deal effectively with inevitable conflicts in space, perhaps the new ocean to which President Kennedy referred could remain a “sea of peace.” If, however, the United States continues without an integrated national strategy; if we fail to define a vision of space for the future; if we decide to develop space-control
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capabilities in a vacuum, apart from the rest of the space community; if we refuse to negotiate with other nations; or if we fail to fully establish a comprehensive, commercial space policy, then the ocean will undoubtedly become “a new, terrifying theater of war.”

The opportunity exists now but won’t last forever. It requires vision and decisions, national effort and debate on the issues (neither the Air Force nor any other military service can go it alone), understanding of a wide variety of very complex issues, and, most importantly, integrated national strategy. In order to fully exploit the tremendous riches and opportunities in space, the United States must be willing to effectively combine all the instruments of national power in a concerted effort towards the realization of a future vision. If the nation prepares now, this vision has no limits. If we fail to prepare, others will define that vision—and not likely in a way the United States would prefer.

Notes


2 In addition to conducting a survey of major newspapers, magazines, and the Internet during the course of this research, the author found that the Air Force Space Command Office of the Legislative Liaison (Headquarters AFSPC/XPPL), Peterson AFB, Colo., performs an ongoing, detailed search for
anything of interest to military space. This office, which publishes such articles every week in its “Legislative Update,” found no media response by the mainstream press either.


6 Ibid., 25.

7 Ibid., 24.


10 For example, during January 1996, the United Nations International Telecommunications Union supported the Pacific Telecommunications Conference, which addressed both geostationary crowding and frequency allocations and developed a number of suggestions to alleviate these problems. Only a few months later, as reported by the United Nations itself, severe crowding in the geostationary orbital slots over Asia “led to the jamming of a communication satellite by PT Pasifik Satellite Nusantara (PSN) of Jakarta, Indonesia, in defence of an orbital position claimed by Indonesia. This incident focused global attention on a worsening
problem of orbital crowding and caused the matter to be brought before the October–November 1997 World Radiocommunication Conference (WRC) of the 187 member-nation [International Telecommunications Union] in Geneva.” United Nations, Highlights in Space: Progress in Space Science, Technology, Applications, International Cooperation and Space Law, 1996 (Vienna: United Nations, 1997), 38; and idem, Highlights in Space: Progress in Space Science, Technology, Applications, International Cooperation and Space Law, 1997 (Vienna: United Nations, 1998), 51. After nearly six weeks, the conference made only minor modifications to the procedures for reserving orbital slots and offered no resolution to the Indonesian jamming incident. When contacted by the author in September 1998 about the incident, Rhea McGraw, spokesperson for PSN, provided the following amplifying information: “There was (and continues to be) some confusion over 'ownership' of the slot at 134 degrees East. . . . Both PSN and APSTAR IA [China] claim ownership of that position. PSN did carry out testing that may have resulted in the temporary suspension of broadcasting for APSTAR; however, this was in no way intentional, was halted immediately, and has not occurred since. The [International Telecommunications Union] did not get involved in the dispute settlement process, claiming bilateral negotiations were appropriate. The discussions are ongoing, with no clear resolution in sight.” She later indicated that the PSN (Indonesian) satellite project was halted due to the monetary crisis in Asia. Indonesia, therefore, felt no immediate urgency to resolve the dilemma.

11 The frequency-crowding problem is so severe that the United States government has had to consider methods for sharing critical frequencies originally reserved for military operations. The government has
done this with both the Global Positioning System (GPS, the military navigation satellite) and the Defense Meteorological Satellite Program (DMSP, the military weather satellite). For more information, see Office of Spectrum Management, National Telecommunications and Information Administration, *A Preliminary Analysis to Determine Interference Effects to GPS from Other Radio Services*. For a report on GPS issues concerning interference, see [http://gps.losangeles.af.mil/interference](http://gps.losangeles.af.mil/interference). For a description of the DMSP problem, see *In the Matter of the Application of LEO ONE USA CORPORATION*, file no. 57-DDS-P/LA-94(48) (Washington, D.C.: Federal Communications Commission, 13 February 1998).


14 According to Ambassador Robert T. Grey Jr., US permanent representative to the UN Conference on Disarmament, “We’ve got an agreement that bans the emplacement of weapons of mass destruction in outer space. We think that’s enough; we don’t anticipate any other problems.” “U.S. Interests and Priorities at the CD: An Interview with U.S. Ambassador Robert T. Grey,” *Arms Control Today*, October 1998, 3–8.

15 Briefing, Kenneth Bacon, Pentagon spokesman, 24 October 1997.

16 Ibid.

17 Briefings, Kenneth Bacon, Pentagon spokesman, 4, 11, 18, and 25 September 1997, and 2, 9, 16, 23, and 30 October 1997; press release, Sen. Tom Harkin (D-Iowa), subject: ASAT Policy and the MIRACL Test,
Col. John E. Hyten


20 Joanna Glasner, “U.S. Ends Afghan Image Contract,” Wired News, 2002, on-line, Internet, 29 May 2002, available from http://www.spaceimaging.com/newsroom/news/wirednews_1-18-02.htm. According to Glasner, “NIMA [National Imagery and Mapping Agency] had renewed the contract once in November but let it expire on Dec. 5. Over the past several weeks, the agency and Space Imaging discussed the possibility of extending an agreement but ultimately rejected such a plan. ‘NIMA did not renew it simply because after several months the situation had changed, and we re-evaluated,’ said Joan Mears, a spokeswoman for the agency. With a contract no longer in effect, the bulk of images shot for the Pentagon and NIMA will now be available for sale to the public, said Mark Brender, Space Imaging’s director of government affairs. However, he said the company is still negotiating with the government for rights to a small portion of the satellite data. Part of the government’s decision to end the imaging contract was probably financially motivated, said Tim Brown, an analyst at the military think tank GlobalSecurity.org. ‘It’s $2
million a month, and I believe that for the most part it was something of an experiment,’ he said. ‘The Defense Department’s not immune to wasting money.’ ”


22 Ibid., 82–86.


28 The author heard General Piotrowski make these kinds of remarks on numerous occasions in the 1990s. In most instances, the general was specifically referring to a space-based laser.
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29 Smith, “The Challenge of Spacepower.”
30 Marcia S. Smith, Congressional Research Service, *U.S. Space Programs: Civil, Military, and Commercial*, 9 April 2002, 8, CRS order code IB92011. Institution of the virtual major-force program for space should resolve this difficulty.
31 Ibid., 1, 8.
35 Smith, *U.S. Space Programs*, 10–11.
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