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MAHAN'S LEGACY : HOW WILL A NEW GENERATION OF WEAPONS FIT INTO COMPETING VISIONS OF OUTER SPACE?

John W. Heath, Jr.*
Georgetown Law Center, Washington, DC, USA

ABSTRACT

This paper looks at proposals for conventional space based weapons and contemplates the problems those weapons might cause for future commercial space activity.

INTRODUCTION

"[We] start from the fundamental truth," wrote Captain Alfred Thayer Mahan of the United States Navy, "warranted by history, that the control of the seas, and especially along the great lines drawn by . . .commerce, is chief among the merely material elements in the power and prosperity of nations."[1] Mahan, a force behind the turn-of-the-century American naval buildup, rose to prominence by articulating a link between commerce and naval power in his book, *The Influence of Seapower Upon History, 1660-1783* (1890). Canvassing historical examples, Mahan argued that in addition to exploiting the seas for commerce, transportation and new markets, successful nations floated large navies to protect national interests and free navigation. In his view, success required strength; commercial and military expansion upon the high seas had to proceed concurrently, "hand-in-glove."[2]

Mahan's basic vision is alive and well today in a new arena: space. The US military establishment has transplanted Mahan's ideas into its current thinking about space exploitation in this century. The Air Force sees its coming role in space in similar terms to Mahan's hopes for the Navy:

> [s]pace forces will emerge to protect military and commercial national interests and investments in the space medium. . .the US may evolve into the guardian of space commerce-similar to the historical examples of navies protective sea commerce.[3]

Jim Oberg, author of *Space Power Theory*, has documented this appropriation of Mahan's ideas by current Air Force strategic thinkers:

> These space power proponents cite the influence of the theories of Mahan as the impetus . . .for the acquisition of navies by several nations at the beginning of the 20th Century. At a historical crossroads,

 The views expressed in this paper are solely those of the author and do not reflect the official policy of any branch of the United States Government.

> many argue spacefaring nations find themselves in need of a similar overarching theory against which to plan their national programs. . . [4]

Space power advocates in the military hope that a latter-day version of Mahan's ideas will prompt the acquisition of weapons for space.

In the rush to develop this framework, few have questioned the underlying assumption that military expansion will complement commercial expansion. Will a new generation of space weapons facilitate or hinder the current track of space commercialization? Part one of this paper will survey some current proposals for the deployment of conventional space based weaponry. And part two will examine some potential problems that might be caused by such plans .

Before beginning a discussion of space weapons, let me say a word about sources and intentions. To the best of my knowledge, neither the Air Force nor the US government has formally adopted nor undertaken steps to deploy any of the systems I will describe.[5] Instead, I have tried to suggest the types of weapons the United States might adopt based on unclassified official policy statements, civilian commentary and graduate papers from the military professional schools. Secondly, I have intentionally avoided a discussion of the propriety of these weapon systems under public international law as beyond the scope of this paper. My purpose is not to rehash the old, treaty-centered debates but instead to critically -and hopefully, freshly - examine the relationship of weapons to commerce in space.

I. "The New Look" of Weapons in Space

The Department of Defense Directive on "Space Policy" outlines very broadly the projected future missions and responsibilities of the U.S. military in outer space.[6] In particular, section 4.6.1.8 of this Directive tasks the Armed Forces to "[p]rovide space control capabilities consistent with Presidential policy as well as U.S. and applicable international law."[7] Likewise, section 4.6.1.10 requires the defense establishment to "[e]xplore force application concepts, doctrine and technologies consistent with Presidential policy as well as U.S. and applicable international law."[8] Space control involves "[c]ombat and combat support operations to ensure freedom of action in space for the United States and its allies. . . [including] negation of space systems and services used for purposes hostile to U.S. national security interests"[9]; force application simply means, "[c]ombat operations in, through and from space to influence the course and outcome of conflict."[10]

These mission requirements then suggest a possible direction for future American weapons deployments beyond ballistic missile defense. "Combat operations" aimed at the "negation of space systems and services" (i.e. space control) squarely indicates a renewed interest in anti-satellite weapons (ASAT). "Combat operations. . . through and from space" designed to influence a conflict (presumably, in part, on earth) points to the development of precision ground attack weapons, capable of engaging and destroying targets on the earth's surface or atmosphere.[11] For the purposes of this paper, I will limit my discussion to proposals for space-based weapons systems stemming from these two missions.

A. Anti-Satellite Weapons

Anti-Satellite (or ASAT) weapons cleave easily into two categories: directed energy weapons or impact weapons. These weapons can permanently disable or completely destroy a target satellite (known as a "hard-kill")or temporarily disable, blind or degrade the function of the target satellite (alternately, a "soft-kill").[12] Many of the proposed weapons can be applied in either a hard-kill or soft-kill capacity.[13] However, let us examine each proposal in turn.

1. Directed Energy Weapons

The Space Based Laser (SBL) concept has interested the military as an ASAT weapon.[14] Traveling at the speed of light, a laser will impact its target almost instantaneously reducing the need to compensate while aiming at a moving object.[15] Because neither gravity nor the earth's atmosphere will distort its path through space, a laser will be able to hit anything in a direct "line of sight" with minimal adjustment.[16] And a space-based laser would certainly have a better chance than land-based or aircraft-based ASAT's of intercepting enemy satellite in higher orbits.[17]

Presumably the SBL could be employed as a soft-kill weapon as well. For example, a lower powered beam could be used to temporarily blind the sensors on a reconnaissance satellite. Alternately, assuming the weapon could be focused with the requisite precision, a high powered, SBL could target a certain piece of hardware on the target satellite- thereby crippling a specific service function but otherwise leaving the satellite intact. A similar directed energy weapon proposal involves radio frequency (RF). Like the SBL concept, a radio frequency weapon could be deployed into a high orbit and use a massive antenna to bombard target satellite with high energy radio waves.[18] The intense radio waves would overload and short out the fragile electronics on board a satellite, making it unable to be controlled or to perform its intended function.[19]

2. Impact Weapons

In contrast to the complex functioning of the directed energy weapons, impact ASAT weapons are quite simple by comparison. A space-based kinetic energy (KE) weapon relies on the relative speed of the target satellite for its destructive power. A KE ASAT interceptor would lie dormant in orbit until employed. Once activated, boosters on the interceptor would change the orbit of the weapon to intersect with the target satellite. Although the interceptor would not be traveling very fast at all, the force of the target slamming into the interceptor at extremely high velocity would obliterate both vehicles.[20] Because of the precision needed to intercept bodies traveling at such high speeds, some proposals have advanced a warhead that would release a cluster of smaller objects into the path of the target rather than focus on a single interceptor.[21]

A variation on the kinetic energy type interceptor is the co-orbital ASAT weapon. However, the co-orbital interceptor does not collide with the target; instead the co-orbital weapon "chases" the target and destroys it with an explosive charge when within close range.[22] The "space mine" is similar in concept to the co-orbital ASAT except that the mine is planted unobserved next to a specific target satellite long before the need to use it.[23] Once activated, the space mine closes with the target and destroys it with an explosive charge.

B. Precision Ground Attack Weapons

Unlike ASAT weapons, proposals for ground attack weapons do not cleave nicely into set general categories. Nevertheless, many of the same weapons that perform BMD or ASAT functions could also perform a ground attack application. The Space-Based Laser system could be used to attack either fixed, hardened ground targets or aircraft in flight.[24]

Kinetic Energy impact-type weapons offer similar promise for development as a precision ground attack weapon. Unlike the ASAT variant, the KE weapon in the ground attack role relies on the velocity of its projectile rather than the velocity of the target to destroy the target. Once activated, the KE weapon would hurl a projectile from orbit to impact a target on the earth's surface; on its way toward the target, the projectile accelerates to enormous speeds.[25] The actual destructive force depends on the type of projectile employed.

The basic projectile would consist of simply a thin, metallic rod approximately one to two meters long.[26] As the rod hurtles through the earth's atmosphere, the leading edge of the rod generates tremendous pressure. When the lead edge of the rod contacts the target, the target's surface in proximity to the tip liquifies as well, thereby allowing the rod to penetrate the target until the rod is completely worn away.[27] Another related approach involves the use of a hardened penetrating projectile that contained an explosive charge.[28] This projectile would remain intact while puncturing the target's surface; once well inside the target, the explosive charge would detonate at a preset depth or time(or upon reaching an open space) for maximum destructive effect.[29]

Even an attempt to hit a fixed target would require extreme accuracy and precision in employing this type of KE weapon. Currently, the accuracy achieved for guiding a comparable weapon (i.e. from space to the earth) such as an ICBM is not precise enough to guide a KE weapon on target in the kind of mission envisioned.[30] Because of the extreme rate of speed that a KE projectile must obtain, customary means of course correction and in-flight guidance based on data from radar, optic, and laser systems would likely prove ineffective.[31] Launching a cluster of extremely high velocity projectiles to bombard an area without any means to abort or control these weapons will certainly be dangerous. In response to these challenges, the commom aero vehicle (CAV) concept has been proposed. CAV involves the use of a secondary re-entry vehicle. Rather than shooting the projectile from space, a CAV vehicle could be deployed from an orbital platform.[32] While slowing down to sub-orbital speeds for reentry, the CAV vehicle would have aerodynamic controls and the ability to receive guidance and make in flight corrections.[33] Once over the target, the CAV would then release its submuntions with extreme precision in much the same way as a conventional aircraft.[34] While the weapon lacks for velocity and power, the CAV offers exceptional control and precise guidance.

II. Space Weapons and Commercialization

As business expands to develop new markets in outer space, commercial interests will increasingly come into conflict with these planned US military activities. Ironically, it is the US government that is propelling both the military and industry into inadvertent competition. Historically, because of the long-term, high risk nature of space systems development, the Government rather than business conducted research and provided services to the civilian markets.[35] With the Challenger disaster in 1986, the American government reassessed its role and began to privatize and deregulate. By 1995, the American commercial space industry was worth over $7.5 billion.[36]

Major plans exist to push out further into the fields of remote sensing, navigation, telecommunications, transportation, manufacturing and even tourism.[37] The United States government supports this expansion.[38] However, if the government were to develop and field the weapons systems discussed, government would be forcing the commercial interests into potential conflict with the military over spectrum allocation, orbital slots, and service continuity. Weapons in space could cause industry more problems in procuring insurance and licenses from the government. Let us examine each potential new hazard in kind.

A)Spectrum Allocation

Radio frequency spectrum is widely recognized as a limited and scarce natural resource.[39] The spectrum represents all the useable frequencies in which electronic transmissions may be sent and received; as the number of applications utilizing spectrum increases, the total amount of spectrum does not change. By treaty, the United States coordinates within the International Telecommunication Union (ITU) and accepts to be bound by the ITU's allocation of the spectrum. America's coordinated share of the spectrum extends from 9 kHz to 300 GHz and incorporates over 450 bands within the allocated segment.[40] At present the Federal Government exclusively controls 27.1% of the allocated spectrum and shares another 41.3% of the total; the remaining 31.6% is exclusively controlled by non-Federal entities.[41]

The Defense Department is concerned about the current trend towards the reallocation of spectrum away from the military.[42] These fears are not without some foundation, either. Some elements in the private sector have accused Defense of hoarding spectrum and have lobbied for a reallocation.[43] In Title IV of the Omnibus Budget Reconciliation Act of 1993, Congress removed bands in the 235 MHz range from the military.[44] The trend continues as the FCC plans to reallocate bands in the 200 MHz range for new commercial radiocommunications.[45] In virtually all spectrum ranges used by the military, an array of civilian commercial applications- including Fixed Satellite Services, Mobile Satellite Services, Personal Communication Systems and more- could compete for additional use.[46]

Any future plans to field weapon systems in space would further aggravate competition for spectrum resources. Launching and controlling a complex assortment of space based weapons as discussed would require a reversal of the trend towards reallocation away from the defense establishment. Perhaps, the armed services could realign their current systems to free up enough spectrum to deploy these weapons.[47] However, the costs in time and money to achieve such a move would likely be prohibitive. Quite simply, the military would likely be inclined to ask for more spectrum.

The commercial space industry's need for additional bandwidth to facilitate their increased activity would be increasing just as the military's ASAT and ground attack weapons became operational. As need and use of the spectrum escalated on both sides, military and commercial interests could find themselves competing in a zero-sum game for spectrum.

B) Orbital Slots

Like bands in the electromagnetic spectrum, "useful" slots in the geostationary (GEO) orbit are a scarce and finite resource as well.[48] A satellite in GEO, though moving at roughly 17,500 mph, will remain fixed over a certain point on the Earth.[49] Since satellites operating in the GEO orbit require some minimum buffer space to avoid interfering with the other satellite's functioning, there are a finite number of useful slots to be divided and distributed to member-states by the ITU.

Placing weapons in GEO orbit could be disruptive in a variety of ways. "Hard-kill" ASATs (beam, KE or high explosive) which completely destroy a target satellite run the risk of creating substantial amounts of space debris as a result. Residual space debris could make that portion of the GEO orbit uninhabitable for future satellites as the risk of a terminal collision with the small, fast moving, difficult-to-detect pieces would be too great. "Soft-kill" ASATs which merely try to temporarily disrupt or disable a targets functioning prove no better an alternative. While not leaving the GEO slot bombarded by wreckage, a "soft-kill" still runs the risk of destabilizing the target so that it tumbles out of orbit. An uncontrolled reentry or drastically decaying orbit is little better than the first option; the target has become a collision risk to other satellites in other orbits (or worse to people on the ground).

Barring these grim scenarios, the placing of any kind of weapon into GEO increases the pressure on industry. As mentioned earlier, the quest for useable slots is still a zero-sum game. Any slot given to the military is a slot taken from commercial interests. Arguably more slots could be created by narrowing the operating parameters of satellites in certain GEO regions. In other words, existing satellite operators would have less buffer for interference or maneuver and would be forced to take costly measures to upgrade the satellite's performance within more narrow limits.[50] Putting any such weapons in GEO will raise the cost of doing business for commercial operators.

Because of the limited space in orbit, some inquiry has focused on greater exploitation of low Earth orbits (LEO) under the GEO canopy. Unlike objects in GEO, satellites in LEO orbit travel much faster around the globe and do not remain over a fixed point for any extended period of time.[51] As such, assigning slots in LEO and monitoring them is a more difficult task. LEO poses a great risk to satellite operators as well since they must continually adjust the position of the spacecraft to compensate for increased atmospheric drag and stronger gravitational pull.[52] As the costs of putting satellites into LEO declines, space operators will have to facilitate traffic through low earth orbital to avoid damaging high speed collisions.

Space based weapons will make coordinating traffic through LEO more hazardous. To carry out their mission, ground attack weapons must pass a beam or KE projectile through the bands of LEO orbit to hit a target on Earth. As LEO fills up, coordinating a clear "window" through successive layers of orbits will be difficult to do without risk of some collateral damage. Improved monitoring and prediction of the path and location of commercial satellite constellations will be a necessity although not a guarantee of safety. Cheap commercial flights of reusable launch vehicles (RLVs) to and from LEO will further complicate monitoring because (as of now) these flights would not be coordinated by transparent international agreement.[53] Ground attack weapons utilizing a beam or submunitions carrier (e.g. the Common Aero Vehicle proposal) will offer more control in these instances while the KE variant will be uncontrollable once fired.

C) Disruption of Commercial Services

The next potential hurdle does not involve competition for a natural resource but for control over decision-making. As commercial entities become the major provider of space resources and services, the traditional power of state actors to control the flow of those goods and services wanes. When state enterprises exclusively provide communications, imagery and launch services, national security concerns dictate the authorized receivers and end users of the products. Commercial entities do not take into account national security concerns unless artificially forced to by a state regulatory power. Otherwise, nations will increasingly turn to private industry for space services, and commercial interests will be inclined to meet that demand no matter who the client state is. In other words, so called "rogue nations" like North Korea, Iraq and so forth which lack their own space-based assets will turn to the private sector to meet their needs.

Recognizing this pattern, the US military and government will increasingly put pressure on commercial providers to cease or disrupt potentially lucrative transactions with clients who pose a risk to American and allied national security. During the Gulf War, for example, American diplomats successfully put pressure on the French government to deny the Iraqis remote sensing imagery produced by SPOT.[54] After the Landsat Act was passed in 1992, the U.S. Secretary of Commerce had the authority to issue a "shutter-control order" to halt the picture taking activities of an American-controlled remote sensing satellite deemed to be a national security hazard.[55] Even Israel has demanded a similar "shutter-control" right with respect to images taken of its territory.[56]

What will happen in the future to commercial space service providers in the future who resist voluntary service disruptions? Certainly American owned or controlled ventures would likely face legal sanctions. Coercing foreign providers would be a more delicate matter. The question of whether the United States would intentionally try to disrupt or destroy satellite services being used by national enemies by using ASAT weapons is beyond the scope of this paper. However, in undertaking any coercive action, the United States would be hampered because of American reliance on foreign providers, the difficulty of determining use by an enemy, and the risk of escalating tensions by collaterally denying satellite use to third party nations.[57]

Conversely, what will happen to commercial interests who are currently forced to rely upon the military for services like global positioning system (GPS) navigation? Satellite navigation represents one of the few areas where industry has had to rely on the military for an essential service. American GPS has almost wholly supplied the demand for commercial navigation.

Nevertheless, commercial interests seem uncomfortable with the American military's control over such an essential service. The European Union approached the United States to explore the prospect of joint ownership and control of GPS functions; the US government flatly rejected this proposal citing the overarching military interest in GPS.[58] The American's stubborn rejection of joint ownership increased European suspicions that the Department of Defense could not be relied upon to provide open access to GPS whenever needed.[59] As such, the EU has pushed for the creation of a competitor system, Galileo, as insurance in case the US Defense Department begins to charge for access or makes GPS unavailable to commercial interests for security reasons.[60]

D)<u>Greater Risk: Insurance and Licensing</u>

The achievement of vast commercial enterprise in outer space requires as a condition precedent the systematic reduction of financial risk. Simply put, commercialization will not happen if the business community decides that the risks involved outweigh the potential profits.[61] Deploying these weapons would likely increase the risk of conducting business in space; this increased risk translates into increasing costs for insurance and licensing.

As commercial enterprises look to space, risk management becomes essential. Space tourism ventures, for example, must demonstrate to potential customers that facilities (e.g. "space hotels") are safe and that the "probability of damage from collisions with other space craft or debris will . . . be insignificant."[62] The Department of Transportation noted that safe, reliable reusable launch vehicles (RLV) would be necessary to attract investment in "satellite retrieval, package delivery and ultimately space tourism."[63] The American Institute of Aeronautics and Astronautics postulates that elements of risk must be defined and manageable before space commercialization can proceed.[64]

Space weapons present a marked increased in the risk of doing business in space. At some level, space weapons pose a safety risk for civilian enterprise. As previously mentioned, ASATs and ground attack weapons could cause unintended collateral damage to civilian spacecraft and satellites when used. These floating weapons also bring the risk of accident even when not in use. More than collateral damage or accident potential, these weapons are neither well-defined nor manageable elements as recommended by the AIAA. Military assets in space will rely on stealth and "invisibility" for protection.; the specific locations and activities of these weapons will likely be closely held information, unavailable for commercial interests. As such, the threat or even proximity of these weapons to commercial vehicles can not be predicted. Certainly industry cannot control these weapons and thereby "manage" the risk either. As a general precaution, industry could take measures to "harden" satellite/spacecraft hulls, electronics and so forth against accident or attack. However, industry officials have made clear that "protective measures are expensive and can make the difference between whether a satellite venture is profitable."[65]

The greater risk to commercial ventures posed by space weapons translates into higher prices for insurance and tougher licensing. As Collins and Ashford note in discussing space tourism, space services have to be demonstrably safe not only to potential customers but also to the insurance companies that underwrite such activities.[66]

The existence of space based weapons could drive up the price of obtaining commercial insurance or decrease the number of willing underwriters. Having to bear more of the financial risk or to be a self-insurer could foreclose possible initiatives in space. In some cases, the availability of insurance could affect the issuance of a commercial license in the United States. If insurance were more expensive or difficult to secure generally, meeting the statutory liability requirements would either substantially raise the cost of the operation to secure the necessary license or prohibit even applying for the license in the first place.

III. Conclusion

Traditionally, industry has benefited by the military's interest in space through government contracts and spin-off technology. And the Armed Forces have relied on the commercial sector as a supplementary or even primary service provider. However, in an era of weapons deployment in near earth space, that mutual symbiotic relationship shifts dramatically as the military competes with industry for certain scare resources and, military operations have the potential to disrupt commercial services and raise the risk and cost of performing valuable services in space. "[I]n space, our national security, foreign policy, and economic security are inexorably linked," wrote Keith Calhoun-Senghor, Director for Air&Space Commercialization at the US Department of Commerce, "We cannot neglect one without sacrificing the others. Nor should we treat them as competing." [67] And yet by putting these mighty projects of commercialization and militarization on track simultaneously, the government has forced competition and sacrifice at some inevitable date.

Should the interests of industry and the military be pitted against each other in this fashion? Mr. Calhoun-Senghor's statements offer the right answer: clearly not. At this stage in the development of space, I think additional treaty language or legislation is premature. Rather, policy makers should reexamine the "linkage" between "national and economic security." In his time, Alfred Thayer Mahan believed national success required linking military power to vast merchant fleets. Mahan's formula for success may not be readily translatable from the oceans to space.

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[1] ALFRED THAYER MAHAN, THE INTEREST OF AMERICA IN SEA POWER, PRESENT AND FUTURE 52 (1897).

[2] *See generally* WILLIAM D. PULESTON, MAHAN: THE LIFE AND WORK OF CAPTAIN ALFRED THAYER MAHAN at 129-131 (1939). (describing how much of Mahan's writings aimed at pushing American national policy toward expansion overseas for coaling stations, modernizing the decrepit American navy and building the Panama canal).

[3] United States Space Command, *Vision for 2020* (1998) <http://www.spacecom.af.mil>

[4] JIM OBERG, SPACE POWER THEORY 120-121 (1998) <http://www.peterson.af.mil /usspace/SPT/new-CHAPTERSw_figs.pdf>.

[5] *See* United States Space Command, *Long Range Plan: Executive Summary* 8 (1998) <http://www.spacecom.af.mil/usspace/x-sum1-10.pdf> ("At present, the notion of weapons in space is not consistent with US national policy. Planning for this possibility is the purpose of this plan should our civilian leadership later decide that the application of force from space is in our national interest.")

[6] *See* Department of Defense Directive 3100.10, *Space Policy* (July 9, 1999). [hereinafter DODD]

[7] *Id* at § 4.6.1.8.
[8] *Id* at § 4.6.1.10.
[9] *Id* at § E2.1.3.
[10] *Id* at § E2.1.1.
[11] For the purposes of this paper, I will refer to these weapons as "precision ground attack weapons" so as to distinguish its limited tactical role from other possible functions such as ballistic missile defense or offensive strategic weapons (e.g. nuclear weapons), designed to sow more widespread and indiscriminate destruction. By "ground attack" I do not mean to preclude the possibility of striking ships at sea or aircraft operating in the atmosphere.
[12] *See* LTC Jamie Varni et al., Air Force 2025, *Space Operations: Through The Looking Glass (Global Area Strike System* 21 (August 1996) <http://research.au.af.mil> (discussing hard versus soft kills with respect to the Space Based Laser); *see also* LTC Robert H. Zielinski et al., Air Force 2025, *Star Tek-Exploiting the Final Frontier:Counterspace Operations in 2025* 26 <http://research.au.af.mil> (discussing hard versus soft kills using an EMP ASAT).
[13] *See* Varni et al., *supra* note 12 at 21; *see* Zielinski et al., *supra* note 12, at 26. Many of these weapons can also be used in the ground-attack of BMD role as well.
[14] *See* Varni et al., *supra* note 12 at 21.
[15] See LTC William H. Possel, Air War College, Air University, *Laser Weapons In Space: A Critical Assessment* 21,24 (April 1998) <http://research.au.af.mil> (discussing the distorting effects of the atmosphere and earth's gravity on a laser beam).
[16] MAJ William L. Spacy, College of Aerospace Doctrine, Research, and Education, Air University, *Does the United States Need Space-Based Weapons ?* 11 (September 1999) <http://research.au.af.mil>.
[17] Despite these characteristics making the SBL a potential effective ASAT, lasers still have some inherent deficiencies. The most promising proposals for the ASAT role have been chemical lasers. To generate a sufficiently powerful beam, chemical lasers require tremendous quantities of reactive chemicals. *See* Varni et al, *supra* note 12,.at 23. As such, the added weight of the laser's "ammunition" makes merely lifting the SBL in orbit prohibitive, not to mention further attempts to replenish the laser after use against a target. *Id.* Finally, any SBL system would have to overcome the massive ranges of outer space *Id.*.
[18] Spacy, *supra* note 16, at 21.
[19] Varni et al, *supra* note 12, at 40.
[20] Spacy ,*supra* note 16, at 23. Satellite speed is determined by the height of the orbit. For example, a satellite in LEO travels at approximately 17,500 miles per hour (7.8 km/sec). *Id.*
[21] This is the so-called "shotgun" approach- for example, releasing a cloud of steel pellets in the path of an orbital. Spacy, *supra* note 16, at 24.
[22] Id at 24.
[23] Spacy, *supra* note 16, at 25.
[24] Varni, et al, *supra* note 12, at 21-22.
[25] Spacy, *supra* note 16, at 26.
[26] *Id.*.
[27] *Id.*
[28] Varni, et al, *supra* note 12, at 38.
[29] *Id.* As such the technology for creating a superhard metal that would withstand such an impact and allow for a deep penetration and explosive charge has not been found yet. *See* Spacy, *supra* note 16, at 27.
[30] Spacy, *supra* note 16, at 28.
[31] Spacy, *supra* note 16, at 28.
[32] *Id* at 29.
[33] *Id.*
[34] *Id.*
[35] American Institute of Aeronautics and Astronautics, *Space Commercialization: An AIAA Position Paper* 4 (January 1996) <http://www.aiaa.org/policy/papers/space-comm.html> [hereinafter Space Commercialization]; DAVID GONZALES, THE CHANGING ROLE OF THE U.S. MILITARY IN SPACE 1 (1999).
[36] Keith Calhoun-Senghor, Office of Air &Space Commercialization, US Dept. of Commerce, *Trends in Commercial Space 1996*, 2 <http://www.ta.doc.gov/oasc/tics/intro.htm>.
[37] *See generally Id.*
[38] *See* Commercial Space Act of 1998, § 101, 42 U.S.C. 14711(a) (1999)(mentioning that Congress backs the free market development of Earth orbital space).
[39] *See e.g.* Article 44, Instrument amending the Convention of the International Telecommunication Union (Geneva 1992) as amended by the Plenipotentiary Conference (Kyoto 1994) published in Final Acts of the Plenipotentiary Conference (Minneapolis, 1998) ITU 1999 p 22 (hereinafter ITU Convention).
[40] Norbert Schroeder, US Department of Commerce, Background Paper, *Radio Frequency Spectrum Allocations in the United States* <http://www.ntia.doc.gov/osmhome/chart_99.htm>.

[41] Joint Spectrum Center, US Department of Defense, *Electromagnetic Spectrum Allocation Chart* <http://www.jsc.mil/images/speccht.jpg>.
[42] Emmett Paige, Jr., prepared remarks, *Electromagnetic Spectrum: Key to Success in Future Conflicts* (July 10, 1996) <http://www.defenselink.mil/speeches/1996/s19960710-paige.html>; John Harbach, *Mission Statement, Joint Spectrum Center* 1999 <http://www.jsc.mil/mission.asp>.
[43] Paige, *supra* note 42.
[44] *Id.*; *see also Testimony on National Security Space Programs and Policies, in review of the Defense Authorization Request for Fiscal Year 2000 and the Future Years Defense Program Before the Subcomm. On Strategic Forces of the Senate Armed Services Comm* 106th Cong. (March 22,1999) (Statement of Gen. Richard B. Myers, USCINCSPACE) (discussing the effects of losing 235 MHz spectrum under the Omnibus Budget Resolution Act of 1993).
[45] Federal Communications Commission Report ET 99-6, *FCC Issues Guiding Principles for Spectrum Management* (November 18,1999) <http://www.fcc.gov/Bureaus/Engineering_Technology/News_Releases/1999/nret9007.html>.
[46] *See e.g.,* Communications Daily, *Mexico-U.S. Talks Heat Up On Wireless Interference Concerns*, April 21, 2000 <www.warren-news.com>.
[47] Paige, *supra* note 42.
[48] ITU Convention, art. 44, *supra* note 39, at 22.
[49] *See generally*, Dr. Patrick Collins, *Legal Considerations for Traffic Systems in Near-Earth Space* 2, <http://www.spacefuture.com /archive/legal_considerations_for_traffic_systems_in_near_earth_space.shtml>.
[50] *Id.*
[51] *Id.*
[52] *Id.*
[53] At some point in the future, routine RLV traffic would become so saturated as to require channeling into specific flight paths by international agreement or more specialized traffic control by an international organization. Such measures would make monitoring and finding an open window to earth much easier.
[54] GONZALES, *supra* note 35, at 35, FN 17.; John Mintz, *US Agencies at Odds: For Whom Can the Eye Spy?* WASH. POST, November 17, 1993, at G1*available in* 1993 WL 2088124.
[55] Leonard David, *US Officials See Pros and Cons in New Imaging Satellites* SPACE NEWS April 17,2000 <http://www.spacenews.com/stemp/crossroads/crossroads_1.html>.
[56] *Israel Wants Imagery Ban* SPACE NEWS, June 17-23,1996, at 1.
[57] INTELSAT provides a classic example of this problem. During the Gulf War, the Iraqis, the United States and many third party nations relied on INTELSAT for broadcast and communication services. The United States government did not risk its own user rights nor creating tensions with other users in an effort to deny the Iraqis service. GONZALES, *supra* note 35, at 35.
[58] *See* Statement of Neil Kinnock, Member of the European Commission for Transportation and Trans-European Networks, *European Strategy for GNSS* GNSS 98 SYMPOSIUM October, 20 1998 <http://europa.eu.int /en/comm /dg07 /speech/sp981020_en.thm>.
[59] *GPS Concerns Spur European Support for Galileo Program*, SPACE NEWS, Dec. 20, 1999 at 22.
[60] *Id.*
[61] Space Commercialization, *supra* note 35.
[62] P.Q. Collins, et al., *Potential Economic Implications of the Development of Space Tourism* 13 <http://www.spacefuture.com /archive/potential_economic_implications_of_the_development_of_space_tourism.shtml>.
[63] Federal Aviation Administration, US Department of Transportation, Notice of Proposed Rulemaking, *Commercial Space Transportation Reusable Launch Vehicle and Reentry Licensing* 21 April 1999. <http://ast.faa.gov/pdf/nprm4_20_99.pdf>.
[64] Space Commercialization, *supra* note 35,at 2.
[65] Jeremy Singer, *Industry Seeks Guidance on Threats* SPACE NEWS, 6 March 2000 at 17.
[66] Collins, *supra* note 62, at 13.
[67] *Testimony on Commercial Space Legislation Before the Subcomm. On Science, Technology and Space of the Senate Comm on Commerce, Science, and Transportation* 105th Cong. (March 5,1998) (Statement of Keith Calhoun-Senghor, Director, Office of Air &Space Commercialization, US Dept of Commerce) <http://www.prospace.org/issues/SpaceCommerce/030598deptofspacecommerce.htm>.