SPACE

ABSTRACT: The U.S. space industry faces significant challenges in the 21st century. Although the U.S. dominates space in terms of investment and capabilities, commercial competition from Europe is formidable and growing. The satellite manufacturing and launch services sectors have significant overcapacity as commercial satellite demand was slashed following several high profile bankruptcies. Although revolutionary breakthroughs are required for significant cost reductions in accessing space, government and industry are on evolutionary paths. Finally, government decision-makers continue to struggle to define the proper balance between commercial interests, and traditional national security concerns.

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PLACES VISITED

Domestic

45th Space Wing, Patrick AFB, FL
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Air Force Research Lab, Edwards AFB, CA
Boeing Delta IV Factory at Decatur, AL and Launch Site at Cape Canaveral AFS, FL
Boeing Satellite Services, El Segundo, CA
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Lockheed Martin Atlas V Launch Site at Cape Canaveral AFS, FL
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NASA, Dryden Flight Research Center, Edwards AFB, CA
NASA, Kennedy Space Flight Center, FL
NASA, Marshall Space Flight Center, Huntsville, AL
National Imagery and Mapping Agency, Washington D.C.
National Reconnaissance Office, Chantilly, VA
National Security Council, Washington D.C.
Office of Science and Technology Policy, Washington D.C.
Sea Launch, Long Beach, CA
Space Imaging, Denver, CO
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INTRODUCTION

This essay summarizes the results of a five-month study of the global space industry, focusing on the health of the US industry, its role in a global context, and its ability to meet national security requirements in the near-to midterm.

Space-based capabilities have become an essential element of American national power, providing an asymmetrical advantage to the US in nearly every sphere of our political, military, economic, and social activity. We rely on space for a wide range of applications, and have integrated space into our national "toolkit" so thoroughly that sometimes we are unaware of our reliance on space.

America's global leadership in space capabilities reflects decades of investment several times that of any competitor. In 1999, for example, the US government spent a total of $31B on space, in the civil, intelligence, and military sectors; Europe, by contrast spent about $6.4B across all multinational and national programs. While this difference in investment is significant, it does not ensure a proportionate advantage in capabilities. Continued leadership in space capabilities rests as much on the effectiveness of government policies, as on the sheer scope of investment.

This study occurred during a period of major adjustment for the industry. The boom in space commerce projected during the mid-1990s has largely failed to materialize, as a series of low earth orbit (LEO) systems, most famously Iridium, have either failed to achieve market success, or have failed to find necessary financing. This wave of failures has had a damaging impact on the industry, and is forcing a reconsideration of government policies and acquisition decisions made during the period when expectations for a commercial boom were still widely accepted.

This was not the first such period of excessive optimism for the space industry. As in earlier cases, this retrenchment reflects to a large degree the nature of the space environment. Operations in space offer unparalleled advantages in overlook and freedom of overflight. These advantages, if capitalized upon, can lead to highly successful commercial ventures. However, the space environment is extremely harsh—hard to reach and hard to operate in. Barriers to entry are high, capital investments are high, and risks are high. These conditions create a tendency for space systems to slip in time to market, often yielding a significant advantage to terrestrial competitors.

Despite these obstacles, the space industry demonstrated growth over the past year and projects continued growth in the years ahead. This growth will occur primarily in the telecommunications area, as satellite systems participate in the expansion of the global information infrastructure. The pace of this growth will depend on the ability of space-based solutions to compete with terrestrial rivals on price, availability, and customer satisfaction. The success of these applications will define the prospects for the satellite manufacture and the launch sectors of the industry. The romance often associated with space has little role in the commercial industry; its health will be defined by the ability of space-based solutions to find a market in the face of vigorous competition from other technical solutions—cable, fiber, and cellular telecommunications being the most prominent.

It is noteworthy that the space industry is a tremendous enabler of economic activity, but is not in itself a comparatively large endeavor. The revenues generated from space applications in 2000 were $39.5B.[i] These revenues feed into a much larger market ($900B) that includes terrestrial telecommunications and remote sensing systems. The revenues generated from the sales of commercial and government satellites reached $15.8B[ii] while launch service revenues totaled $8.2B.

Space activity is conventionally divided into four sectors: the civil sector, primarily NASA; the military sector, led by the Air Force; the intelligence sector, in which the dominant actor is the NRO; and the commercial sector. The American space industry feeds capabilities into each of these sectors, which in turn feed its growth. In 2000, for example, the intel and military sectors combined to launch sixteen satellites, all built and launched by American firms. These satellites and launch vehicles provide a solid baseline for American firms which is not available to Europeans, with a much less developed national security space capability. [iii]

HEALTH AND STRUCTURE OF THE INDUSTRY

The expense and risks inherent in space technology have encouraged widespread partnering at the national and commercial levels, and led to significant consolidations in the industrial sector since the end of the Cold War. Even more than before, the space industry is now very "lumpy," with few buyers and few sellers, and with the government playing a key role as purchaser and in building the playing field for the industry. These consolidations and partnering arrangements continued over the past year. As a key example, the European space industry has largely consolidated over the past year with the creation of European Aerospace Defense and Space (EADS), a global-scale competitor to the American leaders, Boeing and Lockheed-Martin.

This trans-European consolidation continues to mature. Over this first year, the emphasis has been largely on creating effective working relationships across the Franco-German cultural divide. As these relationships become more routine, EADS will move to realize management efficiencies and find synergies across the various components of the firm.

The near future will also define the relationships between the American and European space industries. At its inception, EADS was viewed as a means of creating an effective European counterpart to the American industry, capable of meeting its American competitors on equal terms and to partner on an equal basis with US companies. The export control climate (see the separate essay in Section II) has chilled those hopes, and increased the likelihood that EADS will form the European basis for an industry largely divided into European and American markets.

The market pressures of the past three years have had a Darwinian effect on many small firms, which had hoped to gain entry into the space marketplace. In particular, the series of innovative launch ventures formed to service a projected rise in LEO constellations has largely dissipated. That has left the field to long-standing suppliers, primarily Boeing and Lockheed-Martin, with Orbital Sciences sustaining its capabilities for small payloads.

That decrease in projected payloads also played a role in NASA's redirection of its efforts to find a successor to the Space Shuttle. Since the mid-1990s, NASA had pursued a strategy of partnering with the commercial sector to develop and field next-generation launch technologies. This strategy was embodied in the X-33 and X-34 flight vehicles, designed to test the technologies necessary for a single stage to orbit, reuseable launch vehicle. Once the X-33 and X-34 encountered cost and technical problems, the original contract structure of the government-industry partnership became untenable since there was no market justification for L-M and Orbital to invest further to bring the projects to completion. NASA's Space Launch

Initiative represents a “back to Square One” approach, and seems unlikely to yield a next-generation launch vehicle or a successor to the Shuttle for decades to come. That, in turn, will eliminate any prospect for new commercial opportunities to be opened by a significant decrease in launch costs over the foreseeable future.

There remains some prospect that research conducted on the International Space Station (ISS) will yield commercial opportunities beyond the applications now viable. However, the cutback on research facilities and funding recently announced by NASA, with the slow buildup of commercial activity on ISS, give scant grounds for optimism on that score.

It appears that the consolidation among the major contractors is nearing its end, and that further movement will primarily occur at the subtier level. Supply chain management has become a recurring concern among program managers in all segments of the space industry, as the domestic industrial base continues to contract, the industry becomes more global, and export control issues complicate the provision of even low-technology components. The major prime contractors have all focused attention on this issue, executing a range of strategies to ensure the stability of their supply chain.

The problem of securing and retaining personnel was another issue that recurred from firm to firm, and across the government-industry divide. In all sectors, the shortage of trained engineers and operators threatened the growth of future capabilities. The shortage in the space industry reflects a broader trend across the United States, as technically trained personnel fall short of requirements in nearly every industry sector. In the space industry, the acute crisis that appeared on the near horizon last year has apparently subsided, as returnees from the “dot-com” world have returned to the space industry. This temporary relief, however, will not solve the larger-scale issue. Across all the various sectors of the space industry, the manpower distribution is largely bimodal, with a large peak of experienced personnel, recruited during the Apollo era, now nearing retirement. No adequate source of replacements is now visible as the nation nears the loss of this vast pool of experience.

The drawdown in defense spending over the past decade, combined with the overcapacity still evident in this industry, have caused the normal competitiveness of major contract awards to increase to an unusual level. That competition, while not unnatural, has forced firms to divert research and development (R&D) funding into near-term engineering solutions for ongoing projects, reducing or eliminating the development of capabilities necessary to sustain American lead in space capabilities in the future. Several studies have called attention to this alarming trend, and recent action by the Department of Defense has begun to address this issue.

Concern over the vector of the national security space effort led over the past year to the creation of the so-called Rumsfeld Commission—more formally, the Commission to Assess United States National Security Space Management and Organization. This commission recommended a sharper focus on the funding and acquisition of space systems. Its recommendations on reorganizing the management of these assets have been largely accepted for implementation. While these actions may well strengthen the military capabilities of American space systems, their impact on the industry itself remains unclear.

APPLICATIONS AND SUPPORT SERVICES

Space systems generally compete with terrestrial systems for market share and investment (e.g., satellite vs. cable television). This competition has significant impact on the commercial segment of the space industry since terrestrial systems are generally far cheaper to install and operate than space-based systems.[iv]

Many within the industry predict that broadband services will be a primary driver for space market demand in 2001 and beyond. Satellites offer an efficient point-to-multipoint architecture for two-way data flow, high-speed Internet access, and a converged telecommunications, multicast, and multimedia environment. Virtually all industry experts predict that satellites will provide the primary global internet "backbone," generating otherwise unavailable access for rural subscribers, and playing an increasing role in delivering high-speed internet access. And to further capitalize on this segment, powerful marketing relationships are emerging as satellite-based broadband service providers join with major Internet service providers and electronics retailers.

Satellite service providers are also poised to provide several new or expanded services that will impact and enhance the daily lives of people in the more developed regions of the world. For example, Digital Audio Radio Service (DARS) providers plan to offer up to 100 radio channels via satellite to mobile vehicle and handset receivers. Beginning service in 2001, this promises to be one of the strongest niche markets for satellite service providers. Further, although Direct Broadcast Satellite (DBS) has been around for a while with limited success, analysts expect four broad categories of new DBS services to roll out in 2001. These include (1) personalized TV that "learns" and automatically records preferred types of programming; (2) enhanced TV that allows customers to order pizza and access sports statistics and other data using interactive and internet-enabled services; (3) on-line TV that turns the television into a personal computer; and (4) broadband services that allows customers to attach personal computers to satellite dishes for faster internet access. In addition, analysts predict that Global Positioning System (GPS) technologies will continue to grow and integrate with other data sources to meet increasing demands in multiple markets, including engineering, construction, agriculture, asset management, automotive, recreation, and transportation. A number of satellite providers are also providing Internet, web, and e-mail content to commercial airline travelers and private aircraft operators.

The second major commercial application for space technology, remote sensing, has continued to mature over the past year. As with telecommunications, the blossoming of this application has been much more modest than forecast a few years ago. Reports indicate that the only high-resolution (1m) commercial system now flying, Space Imaging's Ikonos, is yielding enough revenue to cover current operating expenses, but not enough to invest in successor systems. Firms engaged in this activity have voiced steady complaints about government activity in several areas, notably in regulatory environment and in the failure to purchase imagery to the extent promised (see the separate essay in Section II).

Just as the telecommunications applications face competition from fiber and cable, the imagery firms face rivalry from airborne systems, which typically are cheaper and more responsive, with equal or better resolution than space-based systems. The space solutions offer the advantage of global coverage and data bases extending back into time, permitting analysis of changes over years in many cases. It appears that the profit in this application area will arise in value-added analysis, rather than in the images themselves.

From a regional perspective, the Asian-Pacific financial recovery will have a significant impact on the space industry since the area will have over 40 million subscribers to satellite-delivered services by 2010. Overall, Internet applications and telephony are the largest projected growth areas in Asia, the Middle East, Africa, Russia, and Latin America as these regions look to satellite-based services as either an enabler or substitute for expensive traditional terrestrial infrastructure. Demand for DBS will also increase, as will broadcast radio, and unique GPS applications. A key challenge for many regions is the uneven wealth distribution and tight government regulations that leave many potential consumers unable to afford space-based services. Further, some experts are concerned that Latin America will face overcapacity in satellite telecommunications in 2001 and beyond.

In the past, the principal customers for satellite telecommunications services were large communications carriers and medium to large sized businesses. This trend is changing rapidly into a market dominated by the needs of the end-consumers; individuals located in homes and small businesses, often in competition with established communications and cable TV carriers. For example, the handheld terminals (i.e., small antennas) attached to facilities are manufactured in large quantities to satisfy these many users achieving significant economies of scale. The terminal business, especially in new multimedia, high data rate networks, has the potential to exceed the size of the satellite manufacturing and launch services sectors combined. Mobile communications, access to Internet data, and television and entertainment programming that satellites provide will drive much of the consumer electronics market.

While there are growth opportunities for space applications as detailed above, the space industry must guard against over-optimism based on rapid near-term growth projected by some analysts. For example, the underdeveloped regions of the world have the highest potential for demand and benefit but are least able to afford space services. Serious business case analyses must consider these realities in order to fully appreciate the risk of high capital investments in space.

SATELLITE MANUFACTURING

The commercial satellite manufacturing industry has significant overcapacity and more than adequate competition. U.S. companies have traditionally led the global manufacture of large commercial communications satellites. However, the competitive landscape has changed with Europe’s Astrium and Alcatel Space emerging as stiff competitors to the big U.S. satellite manufacturing companies (Boeing Satellite Systems, TRW, Lockheed-Martin, and Space Systems/Loral). The satellite manufacturing sector also comprises numerous smaller companies located all over the world who apply their expertise and focus on the development, manufacture, and delivery of specific components and/or sub-systems for the prime satellite manufacturers. These niche players are quite successful and supply prime satellite manufacturers with many products and systems that go into a satellite.

There are two opposing trends appearing in satellite manufacturing. GEO satellites are growing in size and capability while LEO and MEO satellites are becoming smaller with less power to support a constellation of many satellites. GEO satellites are still uniquely manufactured to meet application requirements but use common bus designs such as the Boeing 601 and 702 series, Loral’s 1300 series, and Alcatel's Spacebus 3000 and 4000 series. GEO satellites continue to go through extensive testing and retesting to ensure reliability. LEO and MEO satellites are now mostly constructed on assembly lines and contain many off-the-shelf components and sub-assemblies manufactured by subcontractors. Complete testing is done on only a few satellites to verify design concepts, while sample testing is done on the rest to assure quality control processes are intact. Overall, the satellite-manufacturing sector has implemented multiple process improvements to reduce satellite delivery times to 18 months or less—a major improvement over the typical three-year delivery time of five years ago. Nonetheless, the U.S. commercial satellite-manufacturing sector faces several hurdles that threaten its future reliability and vitality:

- Recent commercial failures and setbacks in the once burgeoning mobile communications market tremendously reduced anticipated satellite-manufacturing requirements.
- Existing satellites are lasting longer than expected and the new generation of satellites has increased capability, capacity, and life spans. These conditions also slowed previously forecasted demand, particularly for replacement satellite systems.
- Export control restrictions and lengthy Department of State (DoS) licensing requirements have cost U.S. firms directly in sales (see essay in Section II), and have probably contributed to an erosion of American market share in satellite manufacture over the past four years.
- Like other technology sectors, the satellite manufacturing industry faces an erosion of key human resources capability. The industry is not replacing an aging workforce fast enough with technically qualified and experienced entry and mid-level professionals, especially engineers, scientists, and computer specialists.
- Finally, commercial companies are not investing in innovative research and development where benefits are uncertain, technologies are risky, and costs are high. In addition, government programs cut back significantly on truly innovative research and development to leverage commercial innovation. As a result, technology development is on a slow, evolutionary path. This pace of development allows international competitors to achieve parity and compete successfully while investing less significantly in research and development.

These challenges did not go unnoticed by the financial community. Most of the major U.S. satellite manufacturing companies had relatively flat revenue growth over the past five years. Though some, such as Boeing and TRW, increased their revenue streams through acquisitions, the large number of leveraged acquisitions over the past few years left many others in the industry with high debt to equity ratios. Failures in the satellite applications sector, flat revenue growth, and high debt to equity ratios created uncertainty in the satellite-manufacturing sector and chilled investors.

With the grow-out of fiber, space-based telecommunications have migrated to other market niches, away from the long-haul communications that had been the forte of the industry since the 1960s. The most significant change will come with the deployment of $50B to $80B worth of new multimedia, high data rate satellites early in the next decade. These new satellites, which will operate at the very high Ka and V-band frequencies, will provide services using very small micro-terminals or ultra-small aperture terminals. Unlike today's very small aperture terminals (VSATs), these terminals will provide a "universal service" for fixed or mobile customers requiring wide or narrow band services and connect home and business users at relatively low cost.

Other satellite technology advances include on-board data processing and switching. Satellites now have millions of lines of software code onboard to serve as mini switchboards in space. Shaped reflector antennas are now in common use and eliminate considerable heavy microwave hardware to relay data. Regional mobile communications satellites use large, 12-meter wide antennas.

Satellite technology advances such as on-board data processing, re-configurable antennas, robotics, and laser communications drive the need for increased on-board satellite power. Additionally, higher power satellites enable the end user to use smaller, lower cost ground terminals. Satellite manufacturers are achieving higher power without increasing the weight and cost of a satellite through innovative, large area solar cell arrays and deployable heat radiators. Unfortunately, progress in new battery technology is slow, with the high-pressure nickel-hydrogen batteries continuing to be the preferred source of direct current power. Satellite manufacturers are using electric ion propulsion engines for satellite station keeping and working to improve engine efficiency.

LAUNCH SERVICES

The three U.S. launch companies, Boeing, Lockheed Martin, and Orbital Sciences had near perfect launch records in 2000—a significant improvement over the disastrous record of 1999. The rapid improvement in the reliability of the "legacy" systems combined with the progress marked by new launchers enroute to market, to brighten the picture for the launch segment of the industry.

While the national launch capability remains sufficient to meet identified demands, there are a series of issues that threaten future capabilities.

- From a global perspective, launch capacity is vastly oversubscribed in all market niches. As has been the case for several decades, the European Space Agency/CNES/Arianespace partnership supporting the Ariane rockets dominates the commercially competable market, and the Europeans continue to upgrade the Ariane V to ensure that they continue to do so. Russian systems such as the Proton and Soyuz offer price advantages over comparable American systems and have gained increasing presence in western markets. The Chinese are marketing the Long March once again, the Japanese are re-entering the market with the H-2A, and India's GSLV is now maturing. Highly capable and inventive systems such as Boeing's Sea Launch are struggling to build a business base. The Boeing and Lockheed-Martin Evolved Expendable Launch Vehicles (EELV) systems now under development will face very sharp commercial competition as they seek to enter this market and establish their credentials for reliability.
- The U.S. is using expensive, less efficient legacy launch systems from two major national launch sites to support all national security requirements.
- Although Boeing and Lockheed Martin will replace legacy systems with the new, more efficient EELV systems, there is no clear transition or backup plan to cope with potential delays or problems with the unproven EELVs.
- Complicating matters, the eastern (Cape Canaveral AFS) and western ranges (Vandenberg AFB) are obsolete and undergoing expensive upgrades that will not be completed before 2006.

The nation's current domestic launch structure is diagramed in Appendix A, Domestic Launch Capabilities: Current and Proposed[v] and Appendix B, Eastern and Western Missile Launch Ranges.[vi] Reductions in the satellite market forced a DoD decision to reduce heavy lift responsibility to only Boeing's Delta IV EELV heavy-lifter. Additionally, resource and manufacturing consolidation over the past five years produced a rather narrow industrial base. With global launch capacity far exceeding current global demand, cutthroat and minimum profit margin pricing for launch services is common. The high debt burden, lower launch demand projections, and waning investor confidence has driven aerospace stock values down to almost the junk bond category on Wall Street.[vii] These conditions pose a threat to vehicle availability if EELV development falters or market pressures and high debt cause commercial enterprises to collapse. As pointed out by the GAO in their 1997 letter to the Chairman of the Subcommittee on National Security, "An unsuccessful test flight, coupled with the expiration of existing vehicle contracts, could create a void in the government's launch capability."[viii] That concern remains today. With the contractors so heavily leveraged in the development and production of new launch vehicle families, a severe failure would have a tremendous negative impact on investor confidence and corporate values. Potential loss of one or both of the launch contractors would make competitiveness in a robust launch market and governmental plans for leveraged savings impossible.

Another challenge is the range support for launch services. Several studies of launch support reconfirm that aging range systems reduce efficient and effective space lift operations. In a robust space market, demands for the broad spectrum of commercial, civil, and national security launches can quickly exceed the aging range systems' capacity. Studies show that antiquated tracking radars and obsolete telemetry and communication systems threaten range safety management, reduce responsiveness, and dramatically increase maintenance and user costs. The $1B, multi-phased range modernization and standardization program (RSA) has a completion date in 2006 if current schedules hold.[ix]

On the positive side, spaceport authorities are strengthening and beginning to complement the federal government's launch commercialization effort. The Florida Spaceport at Cape Canaveral, Virginia Spaceport on Wallops Island, California Spaceport at Vandenberg AFB, and Alaska Spaceport on Kodiak Island, have federally leased property rights and FAA licenses to conduct commercial expendable vehicle launches (Appendix A). In Florida, the Spaceport Florida Authority (SFA) supported EELV development with private sector financing of nearly $500M in new infrastructure to include launch pads, hangars, payload facilities, control centers, storage facilities, and even tourism facilities.[x] As shown in Appendix A, there are seven other spaceport agencies seeking authority for expendable or reusable space vehicle operational licenses. In the distant future, these proposed sites may become trans-space centers for reusable vehicles.

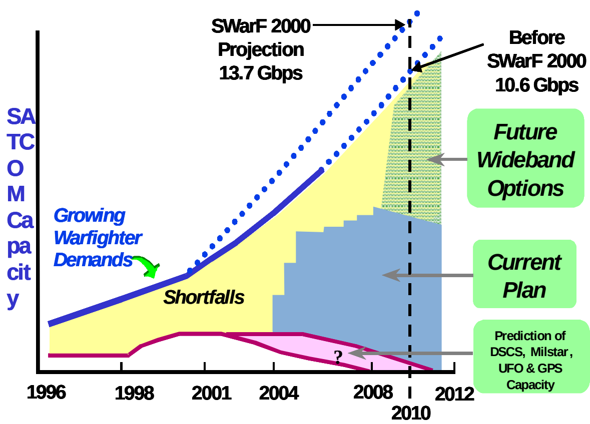
To span the tenuous period between legacy launch vehicles and EELVs, the nation must streamline launch requirements and provide some insurance if the new generation of launch vehicles are delayed. The RSA program will improve reliability and profitability and the government should expedite completion by fully funding requirements as quickly as possible. Additionally, national policy makers, as an insurance policy, should consider establishing international support agreements to provide reciprocal launch support from foreign sources when needed. The government should support formation of spaceport authorities like those in Florida and Alaska that add to U.S. launch site capabilities and sources of investment capital. Because DoD chose to rely on commercial services for national security requirements, the government must become and remain full partners with commercial businesses. Understanding businesses' need for financial stability, the government must provide unwavering support for the health of the industry by modernizing outmoded methods, rules, and regulations that are inconsistent with good business sense. In the long run, superior, visionary leadership and a solid national space policy is the key to reliable, predictable, and cost-effective access to space.

MAJOR ISSUE ESSAYS

Military Surge and Mobilizations Requirements

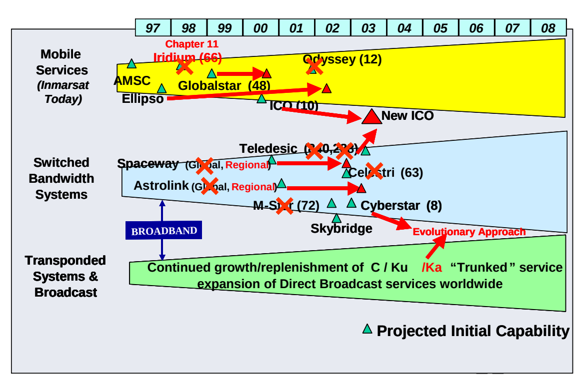
The U.S. Military Satellite Communications (MILSATCOM) architecture is the primary backbone of our force projection communications capability. Unfortunately, MILSATCOM is beginning to strain under the rapidly growing demands placed on it by dispersed forces, increasing data requirements, reduced force structure, and a growing demand for protected communications. The 1997 SATCOM Senior War fighter Forum (SWarF) acknowledged that increased OPTEMPO forced DoD to become ever more dependant upon commercial satellite capacity requirements of 10.6 gigabits per second (gbps) to meet emerging DoD requirements.[xi] This requirement increased to 13.7 gbps during the 2000 SWarF, a 30 percent rise in slightly over three years.[xii]

DoD's current and proposed MILSATCOM capabilities consists of DSCS (SLEP), Global Broadcast Service (GBS), and Wideband Gap filler in the wideband range; MILSTAR II and Advanced Extremely-high Frequency (EHF) in the protected range; and UHF (DAMA) and Advanced Narrowband System or Mobile User Objective System (MUOS) in the narrowband range. These systems are not sufficient to meet DoD operational mission requirements as currently structured.[xiii] DoD's strategy is to compensate for MILSATCOM bandwidth and coverage shortfalls by leveraging commercial SATCOM.



Although commercial SATCOM capability has grown at an explosive rate during the 1990s, it does not satisfy all of the unique requirements of our deployed forces. Critical issues include geographic coverage gaps, lack of protection against jamming and nuclear detonation, guaranteed access and control, and negotiated landing rights. Many commercial SATCOM systems are suffering major delays, reduced service areas, restructuring, mergers, high debt due to leveraged consolidations, and bankruptcy (see chart below). The deteriorating financial health of many commercial SATCOM companies might ultimately translate into the "right" SATCOM system not being available for DoD requirements. Additionally, overcapacity in satellite manufacturing and launch services, export control restrictions, unexpected increased satellite life spans, an aging workforce, and decreasing governmental incentives for commercial research and development are contributing to a weakened commercial SATCOM industry.

These challenges have not gone un-noticed by the financial community. Many of the major US companies within the satellite industry had generally flat revenue growth over the past five years. Additionally, the large number of leveraged acquisitions left some in the industry with a high debt to equity ratio making them highly vulnerable to market swings. Though temporarily afloat due to DoD usage, Iridium, a global mobile telecommunications satellite operator, remains a very high risk for DoD. Many other commercial SATCOM companies are experiencing



similar challenges such as; receiving regulatory approval, securing uninterrupted financing, and broken contracts. These significant challenges in the market resulted in uncertainty and chilled investors. Even though the current slow-down in the dot-com technology sector may revitalize interest in the commercial SATCOM market, it is still volatile and unpredictable.

Military forces cannot accept the uncertainty of commercial SATCOM systems. Since market forces drive the availability of commercial SATCOM systems, it would be difficult for emerging systems to demonstrate a capability to reliably satisfy DoD requirements. DoD SATCOM architects should not expect huge changes anytime soon. It is risky to assume commercial systems are able to adequately meet the ever growing demand for SATCOM support required by deployed and mobile users, never mind be able to meet additional surge requirements during times of crises.

There exists a severe requirement and capabilities mismatch when it comes to our current and future SATCOM architecture. Though the current MILSATCOM architecture is greatly enhanced through the addition of DSCS (SLEP), Wide Band Gap filler, Global Broadcast System, MILSTAR II, and Advanced EHF, we still fall short in meeting the anticipated bandwidth requirements projected for the force of 2010 and beyond.

Commercial satellite systems present a viable supplement to MILSATCOM systems but are not a panacea. There are many applications where commercial SATCOM capability is available to provide supplemental support (fixed station locations, CONUS bases, traditional developed regions, etc.). However, that support is extremely expensive, unprotected, and not always available. The traditional approach of pre-purchasing capacity in anticipation of operations (leasing) is unaffordable and unresponsive to rapidly changing environments. DoD needs a surge capacity that maximizes both military and commercial SATCOM assets appropriately, but without the long-term fixed cost of reserving commercial standby capacity. Recommend DoD accomplish the following:

1. Review and validate the war fighter's requirement for protected wideband support. Some serious sole searching may identify that the majority of DoD's bandwidth shortage does not require the protection and stringent anti-jam capability provided only by EHF systems.
2. Consider the right mix of MILSATCOM and commercial SATCOM to ensure deployed forces are not at risk. Some <u>limited</u> anti-jamming capability for commercial SATCOM such as good antenna discrimination, side-lobe rejection, and compatibility with ground-based frequency hopping modems are desirable.
3. Continue to leverage innovation within the commercial SATCOM industry. However, this does not replace the need for a vigorous and strongly funded research and development program focusing on next generation data compression algorithms, transponder technology, and more efficient bandwidth utilization.
4. Develop a multi-mode terminal providing an interoperable solution across a range of military and commercial frequency bands and interoperability with both military and commercial SATCOM legacy systems.
5. Use DAMA to permit sharing of available frequency spectrum and increase the probability of access.
6. Consider a satellite civil reserve air fleet (CRAF) type arrangement to reserve commercial SATCOM capacity to meet surge requirements. Evaluate the costs, restrictions, and benefits of entering into long-term CRAF contracts. However, A CRAF like program must include a cascading plan to maximize the unique capabilities of both military and commercial

SATCOM systems and ensure that tactical users who need protected, mobile, and regionally available SATCOM bandwidth have access to it.

Commercial SATCOM is essential for the war fighter and provides an alternative means of satisfying communications requirements that cannot be satisfied using MILSATCOM. However, deployed U.S. forces cannot accept the uncertainty of market driven commercial SATCOM. The commercial SATCOM industry is a "for profit" business and not designed to meet the rapidly evolving and robust requirements of crises reaction forces. DoD should review its long term MILSATCOM requirements, recognize the existing shortfalls in capability, and develop a viable strategy to increase current MILSATCOM capability and/or search for innovative cooperative ventures with commercial industry that will "guarantee" the availability of dedicated, reliable SATCOM support wherever our forces require. The transformation of our forces to a more agile, rapidly deployable and lethal force depends upon it.

Lieutenant Colonel Brian Hurley, U.S. Army

Satellite Export Control - Just How Bad Is It?

In 1998, in response to allegations of illegal transfers of launch technology to the Chinese, Congress moved all authority for export licensing of U.S. commercial satellites from the Department of Commerce (DoC) to the Department of State (DoS). Recently, space industry experts produced alarming statistics attributing a dramatic negative impact on the commercial satellite industry because of the DoS export control process. Government officials run the gauntlet of opinion -- tighter controls were necessary, U.S. industry's loss of market share was attributable to other factors -- but most agree revision of the current process is required. Some at either ends of the spectrum frame this issue as "greed" vs. "national security." In reality, it is a delicate and complex balance between narrow national security interests (protecting sensitive technology from potential adversaries) and broader national security interests (maintaining U.S. industry dominance, U.S. military reliance on a robust commercial satellite sector, cooperation and interoperability with our allies, and recognition of the global marketplace). With this balance of national interests as a framework, this section briefly outlines the history of export controls, discusses the impacts of the current export control regime, analyzes the recent improvements to the process, and proposes changes for the future.

In 1986, the Reagan administration approved launching U.S. commercial satellites on Chinese rockets because of a shortage of U.S. launch capacity. Twenty-one launches of U.S. made satellites took place on Chinese rockets between 1992 and 1999.[xiv] Before 1992, DoS generally had responsibility for export control of satellites. In 1992, based on a number of factors including the collapse of the Soviet Union and increased international competition, the administration facilitated U.S. business opportunities by transferring responsibility for licensing some aspects of commercial satellites from DoS to DoC. During this period, the federal government encouraged U.S. companies to engage with other nations (including China and the former Soviet Union) in cooperative space projects. In 1996, with commercial launches exceeding government launches, licensing authority for nearly all commercial satellites passed to DoC. (Note: Control of other potentially commercial space technologies such as *launch* technology and *remote sensing* technology remained at DoS.)[xv] During 1998, a select congressional committee, the Cox Committee, held hearings and concluded that U.S. satellite companies improperly transferred technical information to the Chinese after a series of Chinese launch failures.[xvi] In response to these allegations, Congress passed the FY99 Defense Authorization Bill, the *Strom Thurmond National Defense Act,*[xvii] which transferred licensing of commercial satellite exports back to DoS, essentially treating all commercial satellites and satellite components as munitions under the International Traffic in Arms Regulations (ITARs).

For the past two years, representatives of the commercial space industry have asserted that the transfer of licensing authority back to DoS has had a devastating impact on the U.S. commercial satellite industry, claiming that the DoS process is ambiguous and cumbersome, resulting in gross delays or in fact cancellation of commercial sales. They also cite examples of items controlled by the ITARs that in fact are widely available on the commercial market, so-called "Radio Shack" technology. [xviii]

A recently released seven-month study by the Satellite Industry Association (SIA) noted that since the transfer of export controls to DoS, U.S. companies lost over half the public competitions, dropping to 45 percent of the market share, after a 10 year period of garnering at least 75 percent of the market.[xix] SIA also contends that California based satellite manufacturers lost $1.2B in business and over 1,000 jobs in 2000 because of stiff export controls and increased competition from Europe.[xx] Some recent examples illustrate industry's concern:

- Eutelsat Atlantic Bird 1: An Italian satellite company, Alenia Spazio, has a launch contract with China. However, in building their satellite, Alenia used some U.S. manufactured components and has run into significant delays obtaining an export license from the U.S. In June 2000, Alenia's Chief, Giuseppe Viriglio, stated, "Our approach is now to minimize U.S. content and adopt non-U.S. options."[xxi]

- Chinasat-8: Loral completed a telecommunications satellite for China and has waited since December 1998 for a license to ship the satellite to China. Potential loss is $174M.[xxii]

- Radarsat 2: Orbital Sciences Corporation was to build the Radarsat 2 "bus" for Canada. Orbital could not assure Canada that it could get the export license because of Canada's lax retransfer regime. Canada dropped Orbital from the competition. Analysts estimate the loss between $51M[xxiii] and $75M.[xxiv]

Some of the above losses are clearly attributed to the transfer of export controls to DoS. But government officials, industry analysts, and foreign competitors disagree over the significance the export licensing process has had on the *industry-wide* loss of market share and point to a number of other more significant factors: (1) better competition from European manufacturers;[xxv] (2) emergence of a *Fortress Europe* mentality that European countries need to bolster their own industrial base and simply "buy European;"[xxvi] (3) weakness of the euro against the dollar;[xxvii] and (4) technical problems by U.S. companies.[xxviii] Admittedly, most industry experts recognize these other factors, but still point to export licensing as the most significant factor.[xxix]

Industry's complaints of extreme delays on individual projects are valid; however, the average processing times appear to be improving. For example, according to the Defense Threat Reduction Agency (DTRA), during the period from January 1993 to March 1998, DoC averaged 177 days to process the 12 commercial communication satellite (COMSAT) licenses.[xxx] On the other hand, DoS reported for the period between March 1999 and June 1999, 900 satellite export license applications requiring interagency review averaged about 80 calendar days and an additional 300 applications requiring internal review only took 25 days.[xxxi] For the second quarter of 2000, DoS improved their processing average to 41 days for satellite licenses requiring multiple agency review and only 14 days for licenses handled solely in DoS.[xxxii] As to actual denial of licenses, the DTRA Space Division (responsible for reviewing space related license applications for DoS) has processed 5,000 licenses since its creation in 1999 through Spring 2000 and has disapproved only ten licenses.[xxxiii]

Although the degree or significance of tightened export controls on the commercial satellite industry may be disputed, both industry and government officials agree the current export regime has contributed to the loss of market share for the U.S. commercial satellite industry. The system must be improved to protect truly sensitive technology without undermining U.S. commercial competitiveness worldwide.

During the past year, both Congress and the Executive Branch took steps to improve the export licensing process. The FY 2000 Foreign Relations Authorization Act called on DoS to establish a regulatory regime for expeditious export licensing of commercial satellites, satellite technologies, and their components to NATO allies and major non-NATO allies.

In May 2000, the administration introduced 17 export control reforms aimed at improving the process with our NATO allies and Japan. These reforms, the Defense Trade Security Initiatives (DTSI), attempt to expedite the licensing process. Among the proposed reforms was the possibility of "bulk" licenses to bundle export of commercial satellite technologies, components, and systems into one license.[xxxiv]

In another initiative, after significant negotiation, Secretary of State Madeline Albright agreed to an " exemption process" under the ITARs for Canada, Great Britain, and Australia as long as they had similar export regimes preventing the retransfer of certain technologies.[xxxv] Other allies hope to gain a similar exemption status with six countries (Britain, France, Germany, Italy, Spain, and Sweden) signing an agreement in July 2000 (Framework Agreement) in hopes of being treated as one entity when dealing with the U.S. on export controls.

One of the key DTSI proposals was a periodic review of the ITAR *Munitions List* (quarter of the list every year) to ensure the list contains only important technologies. Another DTSI initiative provided for automating the licensing process. In January 2001, DoD kicked off a $30M program labeled "USXparts" that electronically transfers technical documents between federal agencies engaged in export licensing.[xxxvi] The system should streamline the process and give applicants visibility to the status of their license applications. Generally, however, the DTSI initiatives have met mixed reviews among industry and allies alike.

Industry representatives, government committees, and Congress continue to look for ways to improve the export control process. Clearly, the Munitions List requires periodic reviews. For example, the list includes commercially available off-the-shelf technology (so-called "Radio Shack" technology) when it is "modified" to fit in a satellite. The government should only subject such items to export control if the modification is sensitive technology.[xxxvii]

At least two legislative efforts were initiated. Senators Phil Gramm and Mike Enzi introduced legislation to revitalize the Export Administration Act, the legislative authority for DoC's control of *dual-use* technologies. This act removes controls on items widely available in the U.S. or sold overseas.[xxxviii] It bolsters DoC as a controller of national security interests and calls for "end-user" controls of technology, review of items on the National Security Control List, flexible tiering of countries to streamline exports, criminal penalties for violations, and raising the criminal standard from a "knowing" transfer to a "willful" transfer. The legislation was recently "voted out of committee" by a vote of 19-1.

In the House of Representatives, Congressman Howard Berman filed legislation to transfer export-licensing jurisdiction for commercial satellites from DoS back to DoC.[xxxix] Such a reversion is highly unlikely given the political firestorm associated with the real and perceived lack of controls at DoC.[xl]

Although industry is working hard and committing resources to comply with the current processes, and various government agencies are working hard to improve the process, it is time to step back and take a fresh look at the entire export control process that was originally designed during the Cold War. Last fall, the head of DTRA commented that although Congress is looking to make some "very important incremental improvements" this year, what really is needed is a "blank sheet of paper approach to national security export reform."[xli] The two current lead agencies have a particular focus: DoC emphasizes support for U.S. business. DoS focuses on foreign policy. Perhaps it is time for a new organization whose focus should be managing export controls to enhance "national security interests" in its broadest context (i.e., including the importance of economic development and the industrial base to national security) and attempting to "better control critical technologies, while boosting the competitiveness of American companies."[xlii][xliii]

One proposal would be to create a joint presidential/congressional commission to study the entire export control regime. The first step for the commission would be to scrub the *Munitions List* and determine what technologies are truly "*critical*" and capable of protection. With the ever-expanding growth of technology worldwide, "many of the things that are subject to review from years past are so widely available on the marketplace it's impossible to control them."[xliv] The commission would pass this *critical* technology list on to the newly created export control agency. Congress should grant such an agency the authority and resources (e.g., sufficient technical experts) to professionally monitor and protect those few technologies *critical* to national defense. Such protection should be stratified depending on alliances. However, the list of *critical* technologies must be small to minimize the impact on U.S. commercial industry competing in the global market place.

Other technologies could be covered by umbrella agreements and subject to a brief (e.g., 5 day), streamlined, automated, and transparent process. The DoS, DoC, and DoD, as well as other agencies could review applications within the 5-day period, but the presumption would be to grant the license. In addition, the new agency could grant a license to a group of countries such as NATO to allow free exchange of foreign national workers between projects without having to obtain a license each time.[xlv] Finally, Congress should eliminate the need for most Congressional notices, especially when the transactions involve our NATO allies, as well as Japan, Australia, and New Zealand.

Although there are risks inherent in any system to protect technology proliferation, the above reforms balance the risk to U.S. national security and commercial satellite development. The above methodology provides enhanced protection for critical technologies necessary to maintain the technological edge. At the same time, the streamlined approach for remaining technologies should allow expedited processing and predictability for U.S. satellite manufacturers. Export control licensing of U.S. commercial satellites might finally make sense.

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Remote Sensing Regulatory Environment

Observation of the earth from space, formerly the exclusive purview of a few powerful nations, has become the province of many. Nations and commercial enterprises not usually considered part of the information age revolution are placing remote imaging satellites into orbit. The imagery produced is of a very detailed quality and appropriate for many uses. Consortiums of businesses and states threaten the complete control of space imagery previously reserved for a few select nations. Additionally, sophisticated analysis is available for interpretation of imagery. As the world increasingly becomes transparent, states are attempting to satisfy both security and commercial requirements.

Approximately two-dozen civil observation satellites are currently on orbit[xlvi] and providing remote sensing data. Most operate in the visible light range while a few are able to gather radar data. All are providing imagery to commercial enterprises, most of which are outside the borders and control of the U.S. government. The satellites are positioned in geosynchronous or sunsysnchronous orbit to observe selected areas of the earth or move to variable orbits allowing them to position and reposition to observe objects of interest. The images available from commercial enterprises range in the amount of detail, but are routinely available to one meter of resolution. The key to the value of commercial imagery is the interpretation services for photos. Professional services provide information of value to the customer based on detailed analysis of the imagery. Several commercial enterprises have full service packages available. In some cases, they may commission the manufacture of a satellite, contract with a launch provider, provide the downlink and signals handling, and interpret the images through in-house subject matter experts.

There are numerous regulations and restrictions on the commercial sale and dissemination of remote sensing imagery. A United Nations resolution[xlvii] outlines generally accepted international conventions. Domestically, a presidential decision directive (PDD-23) and implementing guidance,[xlviii] a White House Fact Sheet,[xlix]the National Oceanic and Atmospheric Administration (NOAA), and the Department of Commerce[l] all place varying constraints on the industry. The regulations generally require the licensing of all space systems, impose time and resolution limits on imagery, and restrict sales to non-U.S. customers when it involves national security. Probably the most onerous regulatory measure from a commercial perspective is shutter control. The current one-meter shutter control option, while not exercised to date, has a deleterious effect on potential customers who may not be willing to hazard a capricious U.S. government decision on availability.

There are essentially two issues concerning national security in the remote sensing environment. First, potential adversaries could use imagery against U.S. forces or interests, and, second, foreign access to technology. Both are valid concerns and any policy affecting this market must consider them. Much of the resistance to unfettered sale of remote sensing imagery lies in national governments' resistance to visibility. The U.S. and its allies are among the most cautious. As an example, U.S. law prohibits photographs of Israel at resolutions more detailed than two meters. Despite these restrictions and efforts to stem the tide, the commercial market is breaking through. To date, there have been numerous releases of satellite imagery that have crossed the boundary from commercial to defense related. The release of these photos, clearly in the realm of national interest to those countries, lends some support to the argument that the "transparency genie" is truly out of the bottle.

The friction between government and commercial interests will continue without changes to the current system of regulations and its real or perceived dampening of commercial development. Without some modification to the current system, the U.S. commercial imagery industry will flounder. This is due to aggressive foreign competitors who operate without the same restrictions placed on domestic companies. Foreign customers looking for images and data view U.S. commercial imagery providers as potentially unreliable. This is due in large part to the deliberate (read tardy) nature of the export control approval process and the hard to define shutter control threat to business. The current export control licensing procedures are not responsive to industry needs. The following are areas for consideration:

1. Development of a Commercial Imagery Strategy. Allocation of funds and support of the federal government are critical to the continued viability of the domestic imagery industry. The U.S. must move toward a commercial imagery strategy that meets the security needs of the nation while simultaneously supporting the growth and world competitiveness of U.S. commercial imagery companies. In 1999, then Secretary of the Defense William S. Cohen guaranteed an 800 percent increase in government spending to purchase imagery from commercial sources.[li] Although commercial enterprises developed business plans based on anticipated government contracts, this funding never materialized.

2. Ground Obscuration Procedures. It is time to acknowledge that remote sensing devices not under U.S. control will observe the U.S. We should redouble our efforts to produce techniques and measures to mask and/or mislead overhead imaging satellites. When it comes to national security/military unit posture and movements, we should immediately assume that someone is looking and take appropriate measures to control the impact.

3. Resolution Controls. The U.S. should not subject commercial imagery at resolutions of one meter or greater to regulatory restrictions. A prudent trade policy that assumes pre-approval for these products should be adopted. This change would expedite sales by allowing a guaranteed level of service that commercial enterprises could provide in a speedy and market sensitive fashion.

4. Timing Release Controls. Twenty-four hour notification is generally required prior to the sale of any imagery. The U.S. should eliminate the current pre-sale timelines and allow immediate release of imagery that is not prescribed in advance due to issues of national security.

5. Mandate the Use of Commercial Images for Certain Government Requirements. Government agencies (NIMA, DoC, DoD, CIA, etc.) should purchase all imagery requirements of one meter or greater from commercial sources. The NRO should focus on imagery with resolutions of less than one meter. This measure will ensure the viability of U.S. commercial enterprises, cut the cost of imagery, increase efficiency, and allow the NRO to concentrate it's efforts on detailed imagery directly related to national security.

6. Shutter Control Vested in the NSC. The potential for invoking shutter control negatively impacts commercial businesses. Removal of specific shutter controls will aid the industry in developing a robust customer base. This does not remove the power of the national leadership in time of emergency. Former CIA Director James Woolsey supports this approach and believes shutter control should rest in the hands of the President of the U.S.[lii]

A massive and significant change to the administration of the commercial remote sensing industry is in order. The U.S. should lift all restrictions beyond those associated with mainstream trade practices. The current regulatory restrictions do not recognize that this industry is beyond control. Continued impediments to the development of the U.S. domestic industry will simply cause customers to seek imagery outside the U.S. This will put U.S. leadership in imagery technology at risk for no apparent reason. The capability to provide detailed imagery, without market restrictions, already lies in uncontrolled commercial enterprises overseas. The U.S. needs to make fundamental psychological adjustments to recognize that total visibility is a fact. If we embrace this truth and take prudent measures to work within a transparent world, the U.S. can continue to lead in technology development while simultaneously protecting national interests and security.

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CONCLUSIONS

The U.S. relies on space more than any other nation in the world to achieve its diplomatic, economic, and national security goals. A diverse group of industries, businesses, and government agencies covering transportation, health care, finance, agriculture, education, energy, and national security, to name a few, rely on space systems to achieve global competitive advantage. Space is vital to our economic, diplomatic, information, and military power.

Although the U.S. remains the global leader in space with capabilities far exceeding the nearest competitor, the U.S. industry is losing commercial market share to foreign enterprises. In order to maintain our competitive advantage in space, government agencies must implement policies that promote efficient regulation of the space industry without undue loss of commercial competitiveness. In the near term, the government should take actions to eliminate the disincentives to sustaining excess capacity, and encourage robust research and development to yield revolutionary advances in technology and maintain U.S. technological dominance across the industry. In the midterm, fundamental review of the technology control regime is urgently necessary, not just for the space industry but for the high-tech components of American industry as a whole.

The Rumsfeld Commission fell short of recommending the establishment of a National Space Council as had been done in earlier administrations. While the commission acknowledged the problems of the past few years in reconciling the demands of the various space sectors, it called for less structured mechanisms to handle these issues. Time will tell if this is a sufficient response to the problems that have developed in balancing national security with commercial interests. Overall, however, that central issue will dominate policy deliberations for this largely dual use industry in the future, as it has for the past decade. The decisions made to reconcile these interests will in large measure define the health of the industry in the years ahead.

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[i] Satellite Industry Association Briefing, Industrial College of Armed Forces, ?? Jan 01.

[ii] European Space Directory 2000, page 67.

[iii] "Structure of the Space Market – Public and Private Space Efforts." 2001. The Space Transportation Association. p. 7.

[iv] During the Space Industry Study, several leading experts mentioned that terrestrial systems are an order of magnitude (10X) cheaper than satellite systems.

[v] References for the drawing

[vi] Report of the Interagency Working Group February 8, 2000, *The Future Management and Use of the U.S. Space Launch Bases and Ranges*, pg 7

[vii] BOOZ Allen & Hamilton, *Final Report, Space Technology Industrial Base Assessment*, December 2000, pg 12

[viii] Report to the Chairman, Subcommittee on National Security, Committee on Appropriations, House of Representatives, June 1997, *Access to Space – Issues Associated With DoD's Evolved Expendable Launch Vehicle Program*, GAO/NSIAD-97-130, Access to Space, (707131)

[ix] Range Modernization, Parts 1 and 2, Joint Hearings before the Subcommittee on Space and Aeronautics of the Committee on Science and the Subcommittee on Military Research and Development and Subcommittee on Military Procurement of the Committee on Armed Services House of Representatives, First Session, March 24 and June 29, 1999, pp 77-78

[x] Spaceport Florida Authority fact sheet, pg 3, http://www.spaceportflorida.com/

[xi] Gbps refers to gigabit per second or 1x10(9) bits per second

[xii] Office of Deputy Assistant Secretary of Defense (C3ISR & Space)/C3, briefing slide, Washington D.C., Department of Defense, December 2000. Data derived from the Emerging Requirements Data Base (ERDB).

[xiii] TRADOC Systems Manager for Satellite Communications, The Army Satellite Communications (SATCOM) Architecture Book (Fort Gordon, GA: TRADOC), April 2000. 1-1.
[xiv] Edward Alden, "Curbs Bring U.S. Satellite Industry Down to Earth," *The Financial Times Limited*, 10 Oct 2000, p. 14.
[xv] Interview of Lt Col Rob DeSilva, State Dept, Mar 2001.
[xvi] *House Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China (the Cox Committee) Report*, Available: http://www.access.gpo.gov/congress/house/hr105851-html/appbod.html.
[xvii] *Strom Thurmond National Defense Authorization Act for Fiscal Year 1999*, Pub. L. No. 105-261 sec 1513(a), 112 Stat. 1920, 2174 (1998).
[xviii] Ann Roosevelt, "AIA Offers Initiatives to Streamline Export Controls," *Defense Week*, Vol 22, No. 11, 12 Mar 2001, p. 1.
[xix] "U.S. Satellite Export Controls Said to Cost $2.1 Billion, 1,000 Jobs," *Aerospace Daily*, 7 Feb 2001, Vol 197, No. 24, p. 201.
[xx] *Ibid.*
[xxi] "Preserving Options," *Aviation Week & Space Technology*, 5 Jun 2000, p. 35.
[xxii] Joan Johnson-Freese, "Becoming Chinese? Or—How the U.S. Satellite Export Licensing Process threatens National Security," *Space Times*, Jan-Feb 2001, p. 4.
[xxiii] Freese, "Becoming Chinese?" p. 6.
[xxiv] "Orbital Sciences Loses Radarsat 2 Contract," *Armed Forces Newswire Service*, 20 Dec 1999, p. 1.
[xxv] Some European manufacturers dispute that the U.S. loss of market share is attributable to the export control process: "I don't think we can credit U.S. export controls with winning any contracts . . . the contracts won in 2000 were not due to export licenses issues, but (because we met the requirements)." Jean Michel Aubertin quoted in an article by Rob Fernandez, "Issues and Opportunities," *Via Satellite*, October 2000, pp. 19-20.
[xxvi] Gordon Adams, "The Transatlantic Defence Market and 'Fortress America': Obstacles and Opportunities," in *Between Cooperation and Competition: The Transatlantic Defence Market*, Chaillot Paper 44, Paris, Institute for Security Studies of the Western European Union, Jan 2001, pp. 3-49.
[xxvii] "What's Ahead in Aerospace," *Aerospace Daily*, 18 Sep 2000, p. 413.
[xxviii] Peter Pae, "Satellite Export Curbs Hurting U.S. Makers," *Los Angeles Times*, 6 Feb 2001, Part C, p. 1.
[xxix] *Ibid.* Statement by Clayton Mowry, SIA – "While it is impossible to attribute all of the lost revenue and market share to new export controls . . .."
[xxx] Defense Threat Reduction Agency (DTRA) briefing to National Space Foundation, 2000.
[xxxi] Tam Harbert, "Beaming Business Abroad, *Electronic Business*, June 2000, p. 6.
[xxxii] Statement of Dave Garner, in "Export Control Commission Urged to Draft Clear Regulations," *Aerospace Daily*, Vol 195, No. 55, 20 Sept 2000, p. 433.
[xxxiii] Interview of Dave Garner, DTRA, Mar 2001.
[xxxiv] Vago Muradian, "State Dept to Implement Export control Reforms over Coming Weeks," *Defense Daily International*, Vol 1, Issue 9, 2 Jun 2000, p. 1.
[xxxv] Canada, the only previous country granted special exemption, had the exemption suspended in 1999 because it retransferred certain technology to China and Iran (Greg Schneider, "U.S. Will Relax Arms-Sale Curbs; Allies to Gain Greater Access," *Washington Post*, 24 May 2000, Section E, p. 1; *see also* William McGlone and Michael Burton, "Economic Sanctions and Export Controls," *The International Lawyer*, Vol 34, p. 383). At the end of June 2000, Canadian Foreign Affairs Minister Lloyd Axworthy and Secretary of State Albright reached an agreement on export controls that will re-instate about 80% of the pre-April 1999 Canadian exemptions (Sharon Hobson, "Canada, USA Close the Export Gap," *Jane's Defence Weekly*, Vol 33, No. 26, 28 Jun 2000). As to Britain, Secretary Cohen and the British Secretary of State signed a "Declaration of Principles for Defence Equipment and Industrial Cooperation" laying out a roadmap for negotiations in Feb 2000 (Gordon Adams, "The Transatlantic Defence Market and 'Fortress America': Obstacles and Opportunities," pp. 3-49). As to Australia, the U.S. signed an agreement to lower defense trade barriers in Jul 2000, but much work remains before the "exemption" provision may be applied to Australia (Neil Baumgardner, "United States, Australia Sign Agreement to Lower Defense Trade Barriers," *Defense Daily*, 18 Jul 2000, p.1).
[xxxvi] George I. Seffers, "DoD to Streamline Export Licensing," *FCW*, 18 Jan 2001, p. 1.
[xxxvii] Joel Johnson, Aerospace Industries Association proposed a similar suggestion in article by Douglas Barrie and Amy Svitak, "European, U.S. Trade Barriers under Siege; Aerospace Industry Eyes Joint Projects," *Defense News*, Vol 16, No. 13, 2 Apr 2001, p. 1.

[xxxviii] Marc Selinger, "Sen. Gramm Unveils Export Control Bill," *Aerospace Daily,* Vol 197, No. 16, 24 Jan 2001, p. 124.

[xxxix] Ann Roosevelt, "AIA Offers Initiatives to Streamline Export Controls," *Defense Week,* Vol 22, No. 11, 12 Mar 2001, p. 2.

[xl] When Congressman Berman proposed the legislation last April, the timing was horrible, as the DoS had just filed allegations against Lockheed Martin for passing rocket motor information to the Chinese before the AsiaSat 2 launch on a Long March rocket. James Asker, "Collateral Damage," *Aviation Week and Space Technology,* April 2000. (Note: Loral, Hughes, and Boeing have previously faced allegations of export control violations. "Lockheed Martin Denies Technology Transfer to China," *Armed Forces Newswire Service,* 10 Apr 2000, p. 1.) Lockheed Martin agreed to pay a $13 million fine in June 2000. "Lockheed Martin to Pay $13 Million to End U.S. Government Export Case," *Armed Forces Newswire Service,* 19 Jun 2000, available at http://web.lexis.com/universe/document.

[xli] Dave Garner quoted in *Aerospace Daily,* 20 Sep 2000, p. 433.

[xlii] Jay Farrar quoted in article by Vago Muradian, "DTSI 'Doesn't Work,' Fundamental Export Control Reform Needed, CSIS Says," *Defense Daily International,* 16 Mar 2001, p. 1.

[xliii] CSIS recommendations for export reform sent to the President on 1 May 01 included a proposal to "initiate a senior-level review to determine whether to assign responsibility for the administrative tasks for all licenses – State, Commerce, Treasury – to a single agency." "Technology and Security in the 21st Century: U.S. Military Export Control Reform," Center for Strategic and International Studies Report, executive summary available at: http://www.csis.org/export/execsum.htm

[xliv] Frank Cevasco, CSIS study member quoted in article by Vago Muradian, "DTSI 'Doesn't Work,' Fundamental Export Control Reform Needed, CSIS Says," *Defense Daily International,* 16 Mar 2001, p. 2.

[xlv] The Stimson Center is currently analyzing how to strengthen multilateral export control regimes with a report due out in late April 2001. Vago Muradian, "DTSI 'Doesn't Work,' Fundamental Export Control Reform Needed, CSIS Says," *Defense Daily International,* Vol 2, No. 11, 16 Mar 2001, p. 1.

[xlvi] Outlook/Specification Spacecraft, Aviation Week and Space Technology, 15 January 2001.

[xlvii] United Nations General Assembly, Principles Relating to Remote Sensing of Earth from Outer Space, 1986.

[xlviii] White House, National Security Council, PDD-23, 18 March 1998.

[xlix] White House, Office of Science and Technology Policy, National Security Council, Memorandum of Understanding Concerning the Licensing of Private Land Remote Sensing Satellite Systems, 2 February2000.

[l] Department of Commerce, Licensing of Private Land Remote Sensing Space Systems, Interim Final Rule, Federal Register, 31 July 2000.

[li] Opening Ceremonies of theNational Space Symposium, Colorado Springs, Colorado, 5 April 1999.

[lii] Aviation Week and Space Technology, Shutter Controls, How Far Will Uncle Same Go?, 31 January 2000.