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SPACE

ABSTRACT: The space industry plays a central role in American security, foreign policy, prosperity and prestige. Today, American space capabilities surpass those of any other nation and U.S. technology continues to set the standard for global competitors. However, the space industry throughout the world has entered an economic depression without precedent in its history. Financially and demographically, the sector bears a closer resemblance to moribund industries like shipbuilding than it does to the infant, high technology business it is.[1] Massive over-capacity exists in both launch services and spacecraft manufacturing, and once-growing companies are downsizing and/or merging to survive. Additionally, the U.S. space industry is more reliant on the government as an anchor tenant than at any time in the last decade. The Space Commission Report highlights the danger: "The U.S. Government, as a consumer, a regulator or an investor, is currently not a good partner to the national security space industry."[2] Unless a greater government commitment and clarity of vision emerges, the overall industry will struggle through adolescence and the commercial sector may never reach maturity.

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INTRODUCTION

A nation's security and economic strength depends on more than its people and resources -- it requires the ability to innovate and respond to a rapidly changing global environment. For the United States, the quest to explore space and put a man on the moon is a shining example of national strength derived from such innovation and agility. America enjoys space preeminence today thanks to a potent industrial base buoyed by substantial government support.

Sovereign access to space and unfettered operations in space are critical to U.S. national security. However, preeminence today does not guarantee supremacy in the future. This study occurred during a period of major adjustment for the industry . . . the space industrial base is clearly at a crossroads and its underlying health is suspect. Adding to this uncertainty are the recent failures of the Ariane 5 and the Shuttle *Columbia*, as well as the continued stagnation of the commercial sector. ***The U.S. Government continues to be the space industry's anchor tenant as increased investment for national security and movement toward network-centric warfare provide the critical lifeline and underscores the importance of finding correct industry-government relations.***

The commercial sector will not rebound in the near future. To accelerate recovery, the entire range of assumptions, policies and strategies governing the relationship between the commercial and government sectors requires review. Technology transfer restrictions must be reexamined and long-term/consistent partnerships established. Until a new strategy is vetted and implemented, the American taxpayer will continue to bear the burden for sustaining this industry.

This treatise analyzes the space industry by sector and is an executive summary versus a detailed roadmap through the industry. It is the culmination of numerous visits to commercial companies, civil organizations and government agencies in the United States, United Kingdom, Germany and The Netherlands. Numerous industry leaders provided valuable insights through seminar discussions, site visits and personal interaction. Host companies consisted of launch vehicle manufacturers, satellite manufacturers, component manufacturers, underwriters and ground facilities.

THE INDUSTRY DEFINED

The space industry is a classic example of the industrial underpinnings of national power as advocated by Bernard Baruch. The industry is comprised of satellite manufacturing and booster manufacturing/launch services that sustain three sectors of space activity: civil, commercial and national security.[3] These three sectors are not mutually exclusive, rather inextricably linked by the inherent dual-use aspects of many space systems . . . events in one part of the space industry directly impact other segments.

<u>Civil Sector</u>. The civil sector has a scientific mission and conducts research and development for non-military applications. This sector also provides the basis for multinational cooperation in space. The National Aeronautics and Space Administration (NASA) is the lead agency for U.S. civil space activities. By far, the largest and most competitive international competitor and partner is the European Space Agency (ESA), which is comprised of members from 15 different European countries. The three largest

organizations within ESA are France's Centre National d'Etudes Spatiales (CNES), the Italian Space Agency and the German Space Agency. Other major foreign civil space agencies are much smaller in scope and are almost exclusively national programs. They include the Canadian Space Agency, Japan's National Space Development Agency, Russia's Rosviakosmos and India's Space Research Organization. Additionally, it appears The People's Republic of China is close to becoming the third nation to independently undertake manned space missions.[4] Hallmarks of the manned program are the Space Transportation System (STS) or Space Shuttle, the *Soyuz* and the International Space Station (ISS). The unmanned program features robotic spacecraft and probes that have circled Jupiter, rendezvoused with comets and prowled the surface of Mars.

Commercial Sector. Mobility and multimedia are key themes of the networked economy in the twenty-first century. Commercial space activities generate economic benefits for the Nation and provide the government with an increasing range of space goods and services. During the twilight of the space era, government exclusively drove technology activities; subsequent assumptions assumed the commercial sector would drive future advances in technology. These assumptions have not been borne out by the market. With flat revenue growth, cautious investors, high insurance premiums and few contracts, companies do not have the margins to aggressively invest in research and development programs. To stimulate private sector investment, ownership and operation of space assets, the government also facilitates commercial sector access to government-owned hardware, facilities and data.

National Security Sector. This sector encompasses both military and intelligence activities. It provides national leaders with asymmetric advantages in implementing foreign policy and when employing the military instrument of national power. This sector is experiencing a series of reorganizations at all levels. Air Force Space Command (AFSPC) is the major command responsible for organizing, training and equipping space forces. United States Strategic Command (USSTRATCOM) is the unified command responsible for execution functions during hostilities. Secure communications, navigation/timing, photoreconnaissance, missile warning and signals intelligence are the major functions performed by the national security sector. America's military is dominant, thanks in large part, to the integration of space-based assets with air, land and sea forces. The National Reconnaissance Office (NRO) purchases and operates intelligence-gathering satellites; the National Security Agency (NSA) and National Imagery Mapping Agency (NIMA) are the primary customers for this intelligence information. Other space-fairing nations, most notably Russia and China, also have intelligence organizations to leverage capabilities derived from space-based assets.

CURRENT CONDITION

In 2002, the space industry continued its metamorphosis into an aggregation of a few large vertically-integrated companies that absorbed smaller niche companies. Currently, the six-largest satellite manufacturers in the world are Alcatel, Boeing Satellite Systems, EADS Astrium, Lockheed Martin's Space Systems, Loral Space and Communications and Northrup Grumman Space Electronics (formerly TRW). The U.S. launch service providers are the Boeing Company, Lockheed Martin Corporation and, to a lesser degree, Orbital Sciences. Internationally, Arianespace, Boeing Launch Services and International Launch Services are the major launch providers.[5]

The U.S. space industrial base is vital to national security; therefore, the industry is heavily regulated. Normal market forces are fettered by technology transfer restrictions imposed by the Department of State; therefore, values of imports/exports are not accurate measures of industry health. As a result, the line of demarcation between commercial entities and government is oftentimes blurred. To keep the industry solvent, the U.S. government provides substantial support to maintain sovereign access to space.

U.S. leadership in space culminates from decades of investment several times that of its closest competitor. In 2002, the U.S. institutional investment across all space sectors was approximately $35.5 billion (civil: $15.5 billion; military: $12 billion; NRO: $8 billion).[6] At the same time, European institutional investment in space is estimated at $4.8 billion (civil: $3.8 billion; military: $1 billion).[7] While this difference is significant, it does not necessarily guarantee a proportionate advantage in capabilities. Continued preeminence in space depends as much on efficient policies as the sheer scope of monetary investment.

The space industry is an oligopoly/oligopsony economic structure. Only a limited number of suppliers and buyers have the need to place payloads into orbit. For example, in the 1997 Census, the U.S. Census Bureau listed the concentration ratio for the four largest firms as 71 percent of the market. In 2002, this number trended higher as mergers and acquisitions continued.[8] Commercial revenues from space-based services failed to reach predicted levels. Worldwide, revenue from commercial satellite services was approximately $52 billion in 2002.[9]

Primary business segments include satellite manufacturing, rocket manufacturing and launch services. This industry transcends several classification codes within the North American Industry Classification System (NAICS). The NAICS code 336414 (Guided Missile Space Vehicle Manufacturing) is most indicative of the overall industry and is used as a baseline.[10] The sum of the market shares of the top firms in an industry is C = w1 + w2 + w3 + w4. The Herfindahl Hirshman Index (HHI) is the sum of the market shares squared for firms in a given industry, multiplied by 10,000: HHI = 10000[6]. The Herfindahl Hirshman Index for NAICS 336414 is approximately 1570. This number indicates more mergers are likely and will be unopposed by government.[11] However, considerations other than economic may override the trend toward continued consolidation as the U.S. Government faces a major decision point on what size and shape this critical industrial base is to assume. Reliance on a single spacecraft manufacturer or launch service provider is not in the best interest of national security.

Barriers to entry and exit remain high. Excess capacity in the industry is the biggest market force preventing entry. Additionally, high capital investment costs, infrastructure, marginal profits and insurance costs deter competition. Other detriments to entry include specialized labor requirements, a small network of suppliers, stringent legal requirements, tough environmental standards and government subsidies to incumbents. Barriers to exit are also high. Stringent environmental concerns coupled with substantial specialty assets such as booster production plants, transportation systems and launch infrastructure represent significant sunk costs with limited alternative use.

CHALLENGES: DEFINING EVENTS OF THE PAST YEAR

Civil Sector

In terms of budget and scope, the International Space Station (ISS) is the largest international cooperative program in the world. The ISS provides a permanent human presence in space over the next 10-15 years. Unlike a conventional satellite, which orbits the earth pointing in the same direction (unless commanded otherwise), the Station orbits like an airplane, keeping its main axis parallel to the local horizon. This is a distinct advantage for both all-sky investigations and Earth observations because an instrument can automatically scan most of the sky during the 90-minute ISS orbit.[12]

Progress on the ISS grabbed many headlines during the past year; however, the tragic loss of seven astronauts and *Columbia* due to thermal incursion during atmospheric reentry stalled forward inertia of international manned space programs. The fate of manned space flight and the ISS program remains in the balance. The *Columbia* Accident Investigation Board, formed by the NASA Administrator, is conducting a thorough review of NASA's shuttle procedures. It has yet to reach a firm conclusion on the exact cause, but has uncovered some overarching systemic and cultural problems.

ISS construction is significantly slowed by the *Columbia* loss. With the Shuttle fleet grounded, the ISS assembly sequence is on hold. Additionally, the Space Shuttle is a crucial logistics carrier for resupplying the Station. Two major decisions were taken within this context. The first was to use the Russian *Soyuz* for crew exchanges. The *Soyuz* mission on 26 April 2003 carried two new crewmembers to the Station and the incumbent crew of three returned to earth via the *Soyuz* docked at the Station. Reducing the permanent crew to two means necessary supplies can be furnished by revising the schedule of the Russian Progress spacecraft, which has been increased from three to four missions in 2003. Furthermore, the loss of the Shuttle has implications for an increased role of ESA's Automatic Transfer Vehicle (discussed in detail below).

The ISS is both protected and hindered by its international composition -- its budget and viability are relatively secure, yet political wrangling impedes progress. The *Columbia* accident will compound cost and schedule woes; nevertheless, completion of the core station is likely, due to political influences and substantial sunk costs. NASA's budget for the ISS is approximately $2.1 billion per year. Current cost projections are estimated at $30 billion to complete the core elements. Life cycle costs through 2012 are estimated at $96 billion. This cost dramatically exceeds the 1998 estimate of $25 billion.[13]

With access to space estimated at approximately $10,000 per pound,[14] NASA sponsored several studies in a search for lower cost options. The most recent was the Space Launch Initiative (SLI), with reusable launch vehicle design, single stage to orbit and new propulsion systems touted as possible solutions.[15] However, the SLI program is now on hold and finding cheaper access to space through transformational technologies is decades in the future. With more money needed to return the Shuttle to safe flight, future launch concepts are not likely to receive adequate funding. Funding priorities among manned missions and the ISS could portend trouble for unmanned missions.

In comparison with the United States, the Canadian, European, Japanese and Russian civil space programs are modest in scope and marked more by international cooperation than competition. European civil space is explored in greater detail below.

Commercial Sector

Satellite Manufacture. Commercial satellite manufacturing is oversubscribed and competition for major contracts is intense. This trend led to a commercial sector marked by fewer prime contractors and sub-contractors,[16] while the national security sector has also consolidated with the merger of TRW and Northrop Grumman.[17]

Supply chain management is a recurring theme within the industry as the number of domestic subtier suppliers continues to dwindle and import/export control issues dampen international free market forces. The major U.S. manufactures still dominate the large commercial communications satellite market, although this may change as Europe's Alcatel and Astrium are considering a merger, despite Alcatel's historical reluctance.[18]

There were only six new orders for commercial satellites in 2002, a number even lower than mid-year predictions.[19] Requests for new satellites are not expected to recover until 2005, when optimistic forecasts predict 15 to 20 new orders.[20] With an estimated capacity of 50 satellites per year, the commercial satellite sector is in desperate need of rationalization. From the buyers' perspective, it's hard to justify replacement satellites during an economic downturn, especially when there is unused capacity on orbit. To further exacerbate the situation, most satellites exceed life expectancy, significantly decreasing demands for replacement spacecraft.

Broadband. The primary cause of the downturn in commercial satellite manufacturing is the slump in the telecommunications industry . . . a slump that will deepen due to fading prospects of the broadband segment. In the telecommunications market, space platforms face stiff competition from terrestrial-based systems such as fiber and cable. Currently, only government programs require new satellites. Hughes was forced to shut down its broadband operation in February 2002,[21] and Teledesic put its broadband endeavor on hold and halted construction of new satellites. These actions are typical of broadband providers around the world who are forced to take severe cost-cutting measures and/or declare bankruptcy.[22] In hindsight, satellite-based broadband could not reduce costs fast enough to capitalize on a vanishing opportunity; meanwhile, terrestrial providers stepped in and established themselves as incumbents.

Insurance Woes. From 1997 through 2002, the space insurance business experienced a complete market cycle.[23] Profitability ushered in new capacity, leading to historically low rates and liberal terms only to have mounting losses reverse the trend. At one time, insurance was based on random launch and on-orbit failures. Recently, launch failures coupled with endemic design flaws in satellite buses (the advent of "generic faults") emptied the coffers of underwriters; claims and losses are at an all time high.[24] The number of underwriters continues to shrink; currently, there are only 22-25 space insurers worldwide. All members of the commercial space industry are adversely impacted: premiums are higher, contracts are increasingly restrictive with shorter policy periods and satellite replacement costs often exceed insurance premiums.

No one is affected more than satellite manufacturers. GEO satellites continue to grow in size, power and capability. These "super birds" employ common bus designs such as Lockheed Martin's A2100 and Boeing's 601 and 702 series. Common-use bus designs bring both efficiencies and challenges. On one hand, common bus designs cut production costs and reduce satellite delivery times to less than 18 months. However, they also gave rise to the "birth of the generic fault."

A "generic fault" can be defined as a recurrent technical problem rooted in either the design or manufacturing process of the satellite and related to specific components or subsystems.[25] A major problem over the past years is the design flaw in certain common buses, most notably, Boeing's 601 and 702 platforms. Resulting on-orbit anomalies had devastating effects on the space insurance market and caused Boeing to lose some credibility as a satellite manufacturer.[26] Boeing claims the problems are resolved, but with fewer satellite launches, it will be challenging to establish platform reliability.

Commercial Remote Sensing. In reality, *commercial* remote sensing is a myth; it doesn't exist without the government as the anchor tenant. Both the United States and Europe attempted to establish remote sensing on a commercial basis and were largely unsuccessful; the market simply does not exist. The U.S. has three companies that offer high-resolution satellite imagery: EarthWatch, ORBIMAGE and Space Imaging. International competition is provided by SPOT Image in France. Commercial imagery companies also face competition from airborne systems, which are cheaper and offer equal or better resolution; however, space-based systems have the advantage of overflight and global coverage.

Remote sensing has many uses. Applications include urban planning, environmental monitoring, homeland defense and military intelligence. This said, the government remains the primary user and anchor tenant for this industry segment. Companies engaged in this activity voice concerns over excessive government regulation and lack of long-term government commitment. The government's dilemma is determining how much latitude to give commercial ventures in light of dual-use technology. (See separate essay in Section II).

Demographically-Challenged. Industry demographics are a cause for concern. As space businesses consolidate, employment in the industry continues to shrivel and hourly wages remain almost flat.[27] The workforce is also aging with few qualified replacements anxious to join the industry as new opportunities in fields like biotechnology are siphoning the pool of new talent. This is indicative of the aerospace industry as a whole, and is an ominous trend given that 26 percent of the workforce is eligible to retire in 2008.[28] The industry is in the uncomfortable position of needing to bring in new engineers ahead of the mass retirement later this decade, while layoffs roll across the industry.

National Security Sector

New Roles and Relationships. In 2002, the national security sector of the space industry underwent several large-scale organizational changes. The first of these was the implementation of the Rumsfeld Commission's findings with the consequent consolidation of the "black" and "white" space communities under the Under Secretary of the Air Force. Sole authority over both sides of the national security sector will result in increased efficiency, less duplication of effort and sharing best practices.

In 2002, USSTRATCOM subsumed U.S. Space Command (USSPACECOM). The merger attempts to eliminate redundancies and streamline the decision-making process, but the repercussions are yet to be felt.[29] STRATCOM's historical roots are deeply embedded in the nuclear strike mission of Strategic Air Command and may portend a shift in focus and culture. This shift may give military space a new and more martial vision, garnering increased funding for SPACECOM's heretofore-unsuccessful initiatives to develop space-based weapons.

Another organizational move is the consolidation of AF space acquisition into an operational command with the new alignment of the Space and Missile Center (SMC) under Air Force Space Command. Of particular concern, from an industry standpoint, is the potential impact on the AF space acquisition community. The intent was to infuse an operational focus into the acquisition corps,[30] but it may have unintended negative effects on career progression for AF space acquisition personnel, and ultimately the ability of the SMC to attract high-caliber people.

Finally, DoD addressed the most troubled space acquisition programs (Space-Based Infrared System, Evolved Expendable Launch Vehicle, Advanced Extreme High Frequency, etc.) through the simple expedients of adding cash and program management changes.[31] The government's experiment with the Total System Performance Requirement concept caused loss of program management insight and costs spiraled out of control. Changing the acquisition management of these programs to a more traditional approach will help to keep these programs on track, although more cash infusions will be needed. Additionally, one of the NRO's highest profile programs, the Future Imagery Architecture (FIA) imaging satellite being developed by Boeing, is facing significant cost overruns and scheduling delays. There is significant pressure from senior DoD leadership to get this program under control, if not, it could accelerate the migration from space-based assets to terrestrial-based systems.

Trends in Military Space. The recent wars in Afghanistan and Iraq re-emphasize the utility of space systems, and highlight future trends in the military use of space. Operations *ENDURING FREEDOM* and *IRAQI FREEDOM* made extensive use of GPS-guided precision munitions. They also relied heavily on space-based assets to provide intelligence, reconnaissance and surveillance (ISR). While "national assets," in the form of reconnaissance and surveillance satellites, were more integrated into daily operations than ever, they still suffered from inherent problems with persistence and timeliness. As a result, coalition forces turned to terrestrial assets such as JSTARS, Rivet Joint, U-2 and Global Hawk to augment or supplant orbital systems. However, the bandwidth needed to transmit this information increased by several orders of magnitude over previous conflicts, and space-based assets provided this vital communication link.

This may be the beginning of a trend to make terrestrial assets the primary source of responsive, persistent ISR capabilities. These assets rely on space-based capabilities to relay information. Their ever-increasing need for omnipresent bandwidth increases the importance of communications satellites, bringing them into parity with other orbital collection assets, at least while a conflict is in progress. This shift could have the effect of relegating orbital ISR assets to what was once their exclusive role, namely collecting information from denied areas during peacetime. Furthermore, network-centric warfare's increasing need for information may dictate more military spending for developing (or leasing) space-based communication assets.

Impact of Missile Defense. In January 2002, the SecDef established the Missile Defense Agency (MDA) in order to "establish a single program to develop an integrated ballistic missile defense system" (BMDS).[32] To develop the system, the MDA uses two new concepts: a "national team" approach to integrate the numerous systems that comprise the BMDS, and a "capability-based" acquisition process. These initiatives have the potential to affect the space industry in two broad ways. If successful, the national team approach could inhibit further industry consolidation by making formal mergers unnecessary. Capability-based acquisition may benefit industry by establishing a process that reduces risk while providing a mechanism to rapidly incorporate new technology. More significantly, the MDA has a programmed budget of almost $50 billion over the FY04-09 Future Years Defense Plan (FYDP).[33]

The MDA's programs will impact all segments of the space industry. System integrators (Boeing and Lockheed Martin) stand to receive revenue in excess of $4.5 billion over the FYDP, while military satellite manufacturers should garner between 20 and 40 satellite orders during the same period. In turn, these satellites will provide launch providers with more robust manifests.[34]

The MDA will also significantly impact the firm selected to provide the boosters for the system's ground based midcourse (GMD) intercept segment. In March 2002, Orbital won a five-year, $425 million contract to develop an alternative to a troubled GMD booster being developed by Lockheed Martin,[35] and subsequently received $50 million in incremental contract modifications to pay for demonstration and test flights. If Orbital wins, the production contract includes a $535 million option to purchase 50 interceptor boosters between 2004 and 2009.[36] The total value of this project is similar if Lockheed Martin's booster is chosen, although it comprises a significantly smaller percentage of that firm's business.

Access to Space: Space Launch

The spacelift industry amortizes expenses assuming a large number of launches. In the mid-to-late 1990s, prospects were high as the inundation of demand for cellular phones and satellite television fueled a massive surge in launch orders. The DoD, Boeing and Lockheed Martin invested heavily in two new launch vehicles -- the Evolved Expendable Launch Vehicle (EELV) program -- to leverage off this runaway commercial market. Much like the gold rush in California, prospects stalled when the "gold" ran out, in this case with the sudden bankruptcy of two promising young telecommunications companies, Iridium World Communications and Globalstar. This injected a measure of sobriety into a rambunctious industry. Since then, the promise of space Internet has vanished, the space telecommunications sector became anemic and tough international competition prevailed. Instead of a surge in launch orders, launch manifests were sharply curtailed. Only 83 satellites were launched worldwide in 2002, this is 35-45 percent lower when compared to 1999-2000.[37]

The EELV program broke new ground in the U.S. spacelift industry with a new government/commercial relationship. In this unique partnership, the government is an investor in the program. In exchange for pursuing a new partnership with the USAF, launch providers benefit from guaranteed military business and a valuable competitive edge in the commercial market. On 21 August 2002, Lockheed Martin successfully launched the maiden flight of the Atlas V with a commercial payload; subsequently, Boeing placed two satellites into orbit with two successful flights of its Delta IV. This demonstration of new capability is critical since the USAF contracted for 22 launches with the Delta IV and seven with the Atlas V; the launch contracts are worth $1.5 billion and $500 million respectively.[38] Through the year 2020, the USAF estimates the EELV program will save the DoD $10 billion in launch costs -- a 50 percent savings.[39]

These savings are overly optimistic. Launch cost estimates were based on larger manifests and benefits derived from economies of scale. For Lockheed Martin, costs were originally spread across 19 Atlas V launches per year, rather than a total of seven currently on the books. In a similar scenario, Boeing expected a launch rate of between 36 and 50 per year, but new market models predict only 17 to 23 per year.[40] As a stopgap measure, the U.S. Government will likely provide an additional $100-$200 million per year until the market regains its strength.[41]

The two U.S. launch providers are taking divergent approaches. Lockheed Martin is catering to the commercial market; it chose to "write off" sunk costs and to price future launches based on recurring costs. This strategy may allow them to price future launches more competitively than Boeing who has secured the majority of military payloads through 2005, but is pricing future launches to recoup one-time costs (R&D, infrastructure etc.).[42]

Boeing's situation is complicated by allegations the company improperly obtained and used proprietary Lockheed Martin documents to win the majority of the initial EELV launch contracts. If the allegations prove true, the Air Force could exact penalties on other Boeing contracts, or perhaps reallocate some of Boeing's launches to Lockheed Martin. However, Boeing's monopoly on heavy lift launches into polar orbits along with the Air Force's commitment to two independent launch vehicles may complicate any penalties. The outcome of these allegations will not be known for years.[43]

International Scene

Transatlantic Stress. Europe's space industry is a case study in the difficulties associated with 15 diverse nations attempting to forge a common vision for space. The vision often runs headfirst into competing economic, political and national security goals among the member countries. Europe's space power simply does not match its space ambitions. Europe continues to sort through relationship challenges at all levels. Lines of communication between commercial industries spread across member nations are convoluted and awkward, often leading to less than optimal industry investments. (See separate essay in next section).

Several forces in the geopolitical arena are forming a chasm between Europe and the United States, with some ramifications for the space industry. Ongoing disparities between the United States and its European allies concerning American policies toward Iraq, the Administration's pullout from the Anti-Ballistic Missile Treaty, its embrace of preemptive military action as a foreign policy doctrine and the U.S. refusal to participate in the Kyoto Protocols are symptomatic of fundamental ideological rifts.

The fissure widens with the EU's plans to field a rival navigation and timing constellation called Galileo. The EU wants to its place alongside the U.S. as a true global space power. Europe fears falling farther behind the United States technologically; furthermore, since GPS is not under European control, they are concerned that U.S. national security concerns could trump EU's access to GPS. The U.S. is concerned

Galileo will hurt the U.S. industrial base, disrupt NATO unity and interoperability, prevent free market forces from operating and degrade GPS signals.

Civil. Europe views international commitments to the ISS as a treaty obligation; the U.S. does not view it in this light. Subsequently, the ESA "hitched" a significant portion of the space program to the ISS "star." ISS program setbacks have dramatic effects on their industries. For example, the *Columbus* module continues to shrink in size and scope and deployment faces delay. One of ESA's most ambitious contributions to the ISS is the Automatic Transfer Vehicle (ATV), scheduled to be ready for use in mid-2004. Launched by the Ariane 5, the ATV will perform automatic rendezvous and docking with the ISS. The ATV can deliver up to 9 tons of supplies, payloads, crew items and propellant.[44] During its 6-month stay, the ATV will also provide reboost and attitude control for the ISS. On departure, the ATV will take up to 5.5 tons of waste for destructive reentry into the atmosphere.[45]

Launch. International competition is strong for commercial, and to some extent, civil customers. In 1996, the Clinton Administration mandated that all DoD spacecraft must be launched on U.S.-manufactured rockets; therefore, there is no international competition for U.S. military payloads. With two launch service providers, the U.S. has a competitive advantage extending from inter-firm cooperation, rivalry and government anchor tenancy.

Arianespace is the leading commercial launch provider, but is critically dependent on the commercial market since it lacks the flow of military launches enjoyed by its U.S. and Russian counterparts. To stay competitive in a slumping commercial satellite market, the ESA radically cut launch prices below cost in hopes that better times lie ahead. Arianespace plans to cut its number of supplying contractors, reduce the model lineup and ask government to help offset the costs of its launch site. The company reported a loss of $177 million for FY01 on sales of nearly $800 million; these losses are attributed to a slowdown in demand and the seven-month grounding of Ariane 5 that resulted after a launch failure in July 2001.[46]

The Ariane 5 suffered another catastrophic launch failure on 11 December 2002 when the main-stage engine nozzle cracked during the maiden flight of the new Vulcain 2 engine. The Ariane 5 likely will be grounded until late 2003, and the flight will feature a customer with deep faith in Ariane or will be a demonstration flight with no active payload.[47] The post-mortem indicates inadequate pre-flight testing, demonstrating the harsh dynamics of the launch industry: price pressures are leading to emphasis on analysis versus testing and producibility versus reliability. This failure cast light on serious management deficiencies that are forcing major shifts in the relationship among ESA, CNES and Arianespace.

In the face of shrinking demand, lower prices and stiffer competition, a complete overhaul is needed to help reach the break even point by 2003.[48] The governments of Europe also view space launch as a strategic industry and will need to provide financial support to counter the federal contracts that U.S. launch service providers receive.

OUTLOOK

Civil. Three decades ago, space conquest was a source of national pride and a symbol of national power. Today, the *Columbia* accident and mounting costs associated with the ISS put manned space exploration in jeopardy. To ensure a viable future, NASA and the international civil sector at large must reenergize support for manned space flight. A first step along this path is to create a vision for the future and better inform the public about the benefits of space exploration.

Commercial. It is tough to make a good business case for the space industry. With the exception of GEO-based communications, no segment of the industry has been successful without extensive government support. What's more, the long-sought "Holy Grail" of lower launch costs is unlikely to make a significant difference. The industry has no elasticity of demand with respect to the price of launch. Even though launch costs have dropped 20 – 30 percent in recent years, the number of launches continues to decline.[49] Looking ahead, commercial demand for satellites and launch services is projected to remain flat through 2005, and only begin to increase after 2006.[50] Similarly, DoD purchases of satellites and launch services should remain constant over the next five years.[51] The challenge for the industry is to survive this cyclical downturn. Overcoming this challenge entails more government support, and the future health of the space industry hinges on how respective governments provide this support.

National Security. The space industry has a very limited capability to surge. The process of maintaining the constellations of satellites needed for national security is an ongoing one that does not and cannot change significantly as the Nation transitions from peace to conflict. Consequently, extensive government support is required to keep the industry postured to support national security requirements.

GOVERNMENT: THE DRIVING FORCE

Government support is the foundation upon which the space industry is built. More significantly, the actions of the United States Government define the nature of the industry, not only within the United States, but around the world as well.

Export/Import Controls. U.S. technology transfer laws are extremely stringent. There is constant tension between economic benefit and national security. Rather than enhancing high-technology businesses in the U.S., national security concerns are stifling industry's ability to effectively compete internationally. Most importantly, satellite export licensing protocols do not differentiate between friend and foe, forcing other countries to "grow" an indigenous industrial base.

Regardless of where they are manufactured, most satellites contain some U.S. components. However, current export control laws tend to "engineer" U.S. companies out of the world market -- forcing other countries to duplicate the U.S. industrial base and "grow" indigenous technology. Additionally, several laws and agencies govern export control including the Department of Commerce, the Department of State, the Defense Threat Reduction Agency, the Arms Export Control Act, the International Traffic in Arms Regulations, the Export Administration Act and the Trading with the Enemy Act. These laws are not always in harmony and divide power among several agencies.[52]

The U.S. is attempting to cover the external world with a techno-impervious blanket; however, instead of keeping the world at bay, it's freezing out U.S. industry. Much of the technology the U.S. is trying to protect is available elsewhere. A more prudent tactic is to provide high-tech solutions to other countries' needs. This net effect will "counter mobilize" the competition by discouraging investment in separate research and development and keep them from competing directly with U.S. companies.

Policy Recommendations

As a result of the industry study, the space seminar offers the following recommendations to enhance U.S. national security, and the industrial base as a whole:

- Technology Transfer:
  - Revise current satellite export laws -- transform technology export control into a living process. Examine relative U.S. and foreign technology levels and delineate U.S.-unique technologies that require special protection.
  - Ensure decisions are made on a country-by-country basis rather than imposing carte blanche restrictions. This permits U.S. companies to lead rather than react and maintain critical skills within U.S. borders.
  - Consolidate and eliminate redundant policies. Fuse *all* export control authority under DoS purview. This mandates an increase in DoS manpower.
- Commercial Industry:
  - Establish a stable, long-term government-commercial relationship rather than the on-again/off-again crisis response relationship currently in place.[53] Given new strategic requirements (homeland security), it is especially important to establish this relationship with commercial remote sensing providers. Short-term commitments increase government costs, and destabilize the industry.
- National Security/Acquisition:
  - Provide industry a vision of requirements through joint DoD-commercial requirement planning sessions.
  - Ensure the acquisition community understands the impact of policies and financial practices on the industry as a whole.
    - Avoid optimizing on a program-by-program basis to the overall detriment of the industry.
    - Ensure program managers understand provider's financial incentives.
- Civil Space:
  - The U.S. should lead an international steering committee to determine a viable roadmap for the future of the ISS (i.e., whether to continue Station build out for additional scientific return and value).
- Space Launch:
  - Maintain two launch service providers, at least until both systems have established record of reliability (e.g., ten successful launches).

MAJOR ISSUES ESSAYS

EUROPEAN SPACE CHALLENGES

INTRODUCTION

The European space industry is faces continued consolidation and restructuring due to weak commercial demand following the downturn in the global telecommunication sector while simultaneously struggling to recover from recent technical issues and overcoming political challenges in Europe. Additionally, unlike in the United States, the European civil and military sectors are not being bolstered to offset the low commercial demand since the European nations are reducing their discretionary spending to meet their fiduciary commitments to the European Union.

DISCUSSION

The European space industry is composed of a single launch service provider and a small number of satellite and launch vehicle manufacturers. Europe's launch service provider is Arianespace, a quasi-commercial entity established in 1981. Its two major shareholders are the French Space Agency (CNES[54]) and the European Aeronautic, Defense and Space Company (EADS) -- Europe's largest aerospace company with major operations in Germany, France, Great Britain and Spain. EADS is also the main builder of the Ariane family of launch vehicles, and through its Astrium subsidiary, earth observation and telecommunications satellites. The other major satellite provider is Alcatel Space, who is jointly developing with Astrium the new Alphabus satellite specifically designed for dual launch compatibility with the Ariane V.

The European Space Agency (ESA) is the primary civil customer in the European space market. Its 15 member states each contribute to the organization's vision, planning and financing. Not all of the members are part of the European Union (EU), so the long-term relationship between ESA and the EU is still being defined. ESA's largest contributors are France's CNES, and the space agencies of Germany and Italy, each having their own priorities and national interests. ESA's annual budget for the last few years has been around € 2 B.[55]

After years of consolidation, the customer/supplier relationships in Europe today are especially complex, as illustrated by Arianespace's shareholders structure: CNES (holding 33% of Arianespace), is also a principal customer; EADS (27%), is also the supplier of Ariane launchers and Astrium satellites; SNECMA (8%), is also provider of the Vulcain-2 engine; and Fiat Avio (6%), also the prospective supplier of a small lift vehicle called Vega, that might be a trade-off in upcoming budget cuts.

In general, the space business has detracted from the financial health of the companies. For instance, in 2002 EADS's space business generated losses of € 268 M on € 2.21 B in sales, a loss leader for the company, prompting them to reduce their space work force by 30% in an attempt to achieve profitability by 2004.[56] And Arianespace, with annual sales now around one billion euros, has generated annual losses of around 25% in 2000 and 2001, with 2002 already in the red (negative 6%) prior to adjustments for the failed Ariane 5 launch last December.[57] Both customers and suppliers are facing financial pressures.

Ariane 5 Failure

Reacting to increasing competitive pressure from the American EELV program, the European collective selected as its sole heavy launch vehicle an upgraded version of the Ariane 5. This new launcher is capable of placing two heavy satellites into GEO transfer orbit. Arianespace, under cost and schedule pressure, employed a design process that emphasized analysis over comprehensive testing, and relied on computer analysis to verify the design of a new engine nozzle built using a new and less expensive manufacturing processes[58]. The Vulcain-2 engine nozzle produced by these processes failed catastrophically during its maiden launch on 12 December 2002, resulting in the loss of the Hot Bird 7 and Stentor satellites, valued at $635M, and put into question the future of the Ariane 5 program.[59]

This failure magnified the already difficult impacts of reduced market demand, increased competition from the American Delta IV and Atlas V, and financial pressures on individual national space agencies and ESA. It raised doubts about the future of Arianespace and the composition of the European space launch infrastructure.

In order to restore customer confidence in the Ariane 5, Arianespace is redesigning the Vulcain-2 main engine and planning at least one demonstration flight to regain the confidence of the commercial market. Arianespace estimates this cost around € 300M to € 450 M. The cost will be borne by ESA or its primary backers, as France's CNES has traditionally covered approximately 50% of the Ariane V funding.[60] But, given the interrelationships of Arianespace's shareholders, customers, and suppliers, the sources of funds are essentially the same entities that comprise Arianespace itself.

Arianespace reveals an interesting web of government and industrial relationships that will become strained as the conglomeration attempts to return the upgraded Ariane 5 to commercial service. Even before the December failure, Arianespace faced financial challenges and announced that it would be seeking € 150 M in new investments from its shareholders next year.[61] This problem is compounded by the cost of operating the basic Ariane 5 in single-satellite configuration to meet existing commitments until the dual-satellite heavy lifter is back in service.[62]

Galileo

As if the financial pressures were not enough, the divergent political interests of the European nations, ESA's members, and the EU itself also challenge the European space industry. This is clearly shown by the Galileo project, Europe's alternative to the U.S. Global Positioning System (GPS). Galileo has experienced delays from a series of conflicting interests, illustrating how national priorities are politicizing the space market's decision-making processes. These conflicts include the failure of the German and Italian delegations to agree on project leadership and national work-share, ESA's attempt to match the work-share against the member nations' funding profiles to ensure just returns, and the prospective prime contractor's attempt to place work in the most effective location. These issues constitute a political dilemma where even the noble-sounding intentions of the prime contractor are suspect, since the company, Galileo Industries, is a newly formed joint venture of Astrium (of Germany and Britain), Alcatel Space (of France), and Alenia Spazio (of Italy) -- all with vested interests of their own.

To move forward, the European Commission has designated Galileo as a collective priority and has threatened to bypass ESA to break the negotiation logjam.[63] Since the major players advise both the EU and ESA, it is likely the same issues will persist: the national space agencies' budgets will decrease; priorities focused on work to be performed within their national boundaries; discretionary funding allocated to local industry; and they will still try to shift the common burden to other members in the union. At some point, ESA and the EU should consider aligning their memberships, or at least clearly define their roles and relationships for multinational space programs.

CONCLUSION

With abundant financial and political issues outstanding, the European space industry is facing a more difficult challenge than merely a market downturn. Arianespace is in the most precarious position, delicately balanced between being a private industry and a national asset. Its future is uncertain. Arianespace could be absorbed into a larger company to help shield it from future downturns, or conversely, elements of the company could be nationalized to cover fixed costs and provide assured access to space. Either way, Arianespace is not likely to emerge unscathed from the Ariane 5 failures.

The important hurdles are to weather the short-term financial losses, correct the problems with the upgraded Ariane 5 and perform successful demonstration launches as quickly as possible. Even if this process takes two years, the slow recovery of the primary commercial customer segment may actually be beneficial in that it should prevent the American competitors from pulling too far ahead. If the European industry is ready when the next launch boon happens, it can retain its position as a major player.

Even though the European space industry is facing a slow commercial market and political wrangling, it is bolstered by a collective will to ensure it succeeds. The primary satellite manufacturers and launch vehicle providers are all part of much larger aerospace companies that appear committed and able to weather the storm. It is also unlikely that the European nations would agree to be dependent on outside sources for either satellites or launchers. Consequently, it is likely that the cash burden will be borne first by the parent aerospace companies, to cover losses for at least another year. It is also likely that increased national support through the civil space agencies will allow Arianespace to demonstrate the corrected systems are safe and reliable. Given the political pressures to retain in-country work share, it appears that CNES and the French taxpayers will continue to bear the majority of the load.

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COMMERCIAL REMOTE SENSING

INTRODUCTION

Today, headlines expound on the limitless potential of high-resolution remote sensing satellite imagery. New applications include use of commercial imagery by the Federal Emergency Management Agency (FEMA) for disasters, NASA to search for shuttle debris, and the Department of Homeland Security (DHS) for border control. Despite commercial remote sensing's potential; the industry is still constrained by large entry costs and conflicting government policies. Resisting urging by Congress, the Central Intelligence Agency, and the Department of Defense, the National Imagery Mapping Agency (NIMA), the Federal Agency responsible for collection and distribution of imagery, has been reluctant to leverage commercial assets. The time is ripe for the public and private sectors to partner and harvest the global market for high-resolution satellite imagery.

DISCUSSION

History and Policies of Remote Sensing

Remote sensing imagery became available to the commercial world in 1972 with images available from the U.S. LANDSAT Satellite and the Earth Resources Technology Satellite (ERTS-1). Subsequently, the French launched SPOT-1, a commercial remote sensing satellite capable of ten-meter resolution, in 1986. One year later, the former Soviet Union began capturing and selling commercially high-resolution (2-meter) images. The possibility of foreign industry capturing the potential commercial remote sensing market prompted the U.S. Government to allow domestic commercial remote sensing industry to enter the market.

National and International Policies. In the 1990s, the U.S. Congress passed the Land Remote Sensing Act. While the Remote Sensing Act allowed private companies to enter the satellite remote sensing industry, obtaining a license from the Secretary of Commerce remained a daunting task due to National Security concerns. Limitations on operations, reporting and auditing requirements, constraints on foreign involvement and restrictions on what could be imaged were but a few of the myriad rules and regulations with which a nascent commercial imaging business had to comply.

During his tenure, President Clinton issued Presidential Decision Directive (PDD) 23, establishing guidelines for foreign access to remote sensing systems, technology and data. The PDD authorized U.S. commercial firms to collect and sell high-resolution images, although there are restrictions for export control of items and technology—commercial firms could now compete with foreign imaging providers.

Despite these restrictive rules and operating limitations, three commercial remote sensing companies operate in the U.S.: Space Imaging, ORBIMAGE (formally Orbital Sciences), and DigitalGlobe (formally EarthWatch). Space Imaging's Ikonos, and DigitalGlobe's QuickBird commercial satellites all provide 1-meter resolution images.

Public Organization's Roles and Culture

The primary organizations involved in the managing, processing, distributing and servicing of satellite imaging are the National Reconnaissance Office, NASA and NIMA. NRO's mission is to develop and operate unique and innovative space reconnaissance systems and conduct intelligence-related activities, while NIMA is the primary consumer of remote imaging.[64] The Departments of State and Commerce are key to enforcing laws and international policies on space usage, licensing and exporting.

NIMA's vision is to become a world-class imagery provider.[65] In late 1999, Congress requested the CIA and the Secretary of Defense form a commission to review NIMA (the agency was perceived as struggling to meet its objectives in the national security environment). The Commission identified a lack of resources to support intelligence, acquisition, research and development. It also identified a lack of trained officers, cultural and bureaucratic impediments to NIMA's use of contractors, and a dependence on outdated processes. The CIA, along with Congress, prodded NIMA to adopt e-business and commercial practices and to use commercial satellite imagery rather than relying exclusively on government satellites. This would free intelligence assets to perform the core functions of intelligence, surveillance, and reconnaissance while commercial industry handles unclassified business.

Market Forces-Foreign and Domestic.

Commercial providers of satellite imagery predict sales will grow, although there is some doubt whether the market can support the investment needed to get these firms up and running. Despite recent NIMA contracts with Space Imaging ($120 million for imagery) and DigitalGlobe ($72 million for data), funding for continued operations is strained. The NIMA contracts (known as the Clearview contracts) are the first attempt at a long-term contract (5 years) and are worth up to $500 million. These contracts are a step in the right direction but it will take more than one long-term contract to foster a healthy industrial base.

The commercial satellite remote sensing industry is increasingly important to the U.S. Government. For example, Space Imaging's Ikonos satellite was heavily used during the early phases of Operation Enduring Freedom. During this operation, the government decided against shutter control. Instead, it chose the more politically palatable option of buying all the precise images of Afghanistan available during the conflict.

Since the early 1990s, concerns over foreign competition have driven the U.S. government to push for higher resolution imagery. In turn, this opened the floodgates for higher resolution programs from foreign competition as India, France and Russia are contemplating development of next-generation imaging satellites. India is developing procedures to permit better than 5-meter imagery. France's SPOT-5 satellite has a "Supermode" capability for collecting 2.5-meter resolution imagery.

Opportunities -- Uses of Data. Most of the commercial remote sensing industry currently concentrates on providing services for NIMA. There are many other uses for this technology, however. Opportunities exist in agriculture, disaster recovery, nature conservancy and homeland security. For example, civil and commercial imagery played a key role in the recent Space Shuttle *Columbia* disaster. NASA's Landsat 7, SPOT and QuickBird satellites collected imagery information on the debris path locations before and after the disaster. By comparing the images, analysts were able to identify changes in foliage resulting from falling debris and teams could concentrate search patterns.

Perhaps the greatest application for satellite imagery will come from the DHS. Imagery can assist first responders by providing situational awareness during or after a disaster or terrorist attack. Imagery could provide information on alternate escape paths, routes for ambulances, or to show roads enforcement official might use following an incident. With all these opportunities, the industrial base and infrastructure for the remote sensing industry would seem healthy. Yet, according to Lt General James R. Clapper, USAF, the business is constrained by persistently low funding.[66]

Obstacles. Although government encouraged commercialization of remote imaging in the 1990s, private imagery industries cannot survive today without public funding. Impediments to profitability include technical, market and policy/regulatory risks. One technical risk is losing an expensive satellite during launch—all three commercial providers have lost one satellite during launch--DigitalGlobe lost two. Market risks include competition from aerial imagery and from government satellites. Risks are considerable, but another barrier are entry costs ranging from $97 million to $497 million,[67] with annual industry revenues of only $200 million.[68] Lastly, the government imposes stringent policy and regulatory constraints such as licensing and limits on operations when national security is involved.

Developing Partnerships Between Public and Private

On April 25, 2003, President Bush authorized a new national policy on commercial remote sensing. The new policy encourages maximum government reliance on U.S. commercial remote sensing capabilities, promotes the development of long-term relationships between the U.S. Government and the U.S. commercial remote sensing industry, and provides timely and responsive regulations for licensing and export control. These new policies should allow remote sensing firms to remain solvent while reducing costs to the government and ensuring national security.

To be successful, support to the commercial remote sensing industry must be through a mix of short and long-term contracts. Using procurement contracts for a one-time buy provides help to individual firms, but gives no assurance of future revenue. Long-term contracts, with yearly options, will save money and benefit industry. Finally, NIMA must focus on becoming a first-class provider of services and information. The organization needs to re-engineer its business processes, replace legacy hardware with e-business systems and change corporate culture.

While today an independent commercial remote sensing industry may not be commercially viable, an effective partnership between the government and the commercial sector will benefit both industry and government.

CONCLUSION

There are many policies, constraints, and restrictions affecting the commercial remote sensing industry. Traditionally, remote sensing was the domain of the U.S. Government, which collected and controlled high-resolution space-based information for national security purposes. The advent of commercial remote sensing, improvements in technology and competing foreign capabilities mean the U.S. Government and private industry must come to an agreement about future remote sensing policies. President Bush's new national policy along with new partnerships between the commercial sector and federal organizations are the first step in this direction. National policy needs to continue to encourage public-private partnerships and the government should develop a strategy that involves a long-term business base with funding for imagery and products.

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MILITARY USE OF COMMERCIAL SATELLITE COMMUNICATIONS

INTRODUCTION

The first commercial communication satellite, Intelsat I (Early Bird), began providing service on June 28, 1965.[69] Since then, the industry has grown considerably. The Intelsat fleet now consists of 25 communication satellites in geosynchronous earth orbit. In 2000, the Commerce Department reported that there were 425 satellites in orbit providing commercial communication services, and the industry reported revenue of $67 billion.[70] The commercial business began as consortia funded by international governments. Increasingly these entities have become true commercial companies. COMSAT, Intelsat and IMMARSAT are all privatized.

In the meantime, the U.S. military became increasingly dependent on satellite communications. In Desert Storm, Coalition forces used sixteen military and five commercial communication satellites, with a total available transmission rate of 200 million bits per second.[71] Most recently, the *Washington Post* reported that DoD was scrambling to acquire access to commercial satellites to support Operation *IRAQI FREEDOM*. DoD officials project military use will be ten times the satellite capacity it used in 1991. Unmanned Aerial Vehicle (UAV) systems like the Predator are huge consumers of bandwidth.[72] Increasingly, DoD will need to augment available military communication satellite capacity with either commercial or additional military assets.

DISCUSSION

State of the Industry

During the 1990s, projections indicated strong growth in the commercial satellite communications industry; however, another emerging technology and poor forecasting disrupted this vision.

First, fiber-optic technology came of age. An outgrowth of the "Internet Bubble" was a dramatic increase in worldwide fiber optic capacity. In 1988, comsats accounted for 98% of transoceanic message and data traffic. By 2001, fiber-optic networks carried 80% of this traffic.[73] Currently, there is a dramatic cost advantage of high speed and reliable terrestrial networks over space-based systems.

Second, market forecasting for global phone and paging systems was over-optimistic. The Iridium business plan assumed a subscription base of one million international travelers and nearly 100% market penetration. When delivered, the system was late and the phones were bulky and expensive.[74] At the same time, the cellular phone industry blossomed; it was cheaper to buy and discard a cellular phone in each region visited than purchase an Iridium phone. As a result, Iridium, Globalstar and Orbcomm all went bankrupt.

Presently, excess capacity exists in the commercial comsat market for DoD use; however, there is no guarantee this will continue. While the U.S. Government was able to get a "bargain basement sale price" on Iridium services, this will not happen often. The U.S. Government track record is remarkably bad at picking market winners. Therefore, continuing reliance on comsats requires improved market analysis capability.

Military Use

Military use of commercial comsats brings unique requirements. Security is a priority. Military comsats must be hardened against electromagnetic pulse (EMP) and equipped with some anti-jam (AJ) capability. Furthermore, the telemetry, tracking and control channels and the ground stations must be secure.

Studies by the Defense Threat Reduction Agency (DTRA) concluded that the detonation of a single 50-kiloton nuclear weapon at 120-250 kilometers would destroy billions of dollars of commercial satellites at LEO. The useful life of the satellites would become less than three months versus the expected service life of 4 – 10 years.[75] Nevertheless, the government has been unsuccessful in convincing U.S. industry to voluntarily harden their satellites. Anecdotal evidence suggests it would add about 6% to the cost of a satellite. In an industry with little or no margins, a voluntary effort is not likely. If the U.S. military is to rely on commercial comsats, it might consider co-investing with industry to harden some of these assets.

Anti-jam capability is also required for essential DOD communications. There may be ground-based techniques that allow some AJ capability without substantially driving up the cost of commercial comsats. In addition, lower priority communications such as medical or routine telephone traffic could be transmitted over commercial comsats freeing up dedicated military comsats for higher priority uses. Techniques as varied as transponder hopping or removal of the enemy jammer might be used to counter these threats.

Currently, industry does recognize the need for operational security. To remain viable, commercial comsat companies must maintain control of their satellites. Therefore, these signals are routinely encrypted yet remain vulnerable to jamming.[76] Some protection in the manner of redundant antennas and high power transmitters are used. The physical security of ground stations must also be considered. Commercial companies are increasingly aware of this vulnerability. Employing redundant ground stations is standard industry practice. The National Security Telecommunications and Information Systems Security Committee (NSTISSC) issued NSTISSP No. 12 National

Information Assurance (IA) Policy for U.S. Space Systems which addresses some of these needs.

This directive also specifies some IA requirements and the generation of a Cryptographic Security Plan (CSP). In discussions with industry, they supported this directive. They noted however, there is not sufficient industry input and would prefer policies that are "vetted" with industry.[77] This is a common problem with some government regulation. It is also important to note that the directive allows government departments and agencies to impose requirements that are more stringent. This may result in a myriad of implementing regulations that will further confuse industry.

Government-Industry Business Arrangements

Typical commercial arrangements with comsat providers are by lease. These can be short ad hoc or long term agreements. Long-term contracts may specify the priority of the user. The highest priority (and price) would be for a user that cannot be pre-empted. Users who are willing to accept preemption would pay a lesser rate with the lowest rate for the lowest priority and the shortest notice time for preemption. The price difference between ad hoc and long-term leases is striking. In the RAND study in 2000 on commercial satellite communications, they calculated the following data:

Duration of the Lease	Price (Gbps-Year)[78]
One Week	$274 million
Three months	$154 million
One Year	$ 77 million
Ten year	$ 58 million

This data indicates that with the ad hoc weekly service for more than 11 weeks one could buy a year of service under a ten-year lease. These prices all assume the needed capacity is available in orbit.

Government contracts also contain clauses that allow termination for convenience. That is, they can decide to terminate the contract and be liable only for incurred cost and some profit. The incurred cost on a lease does not include any allowance for the build and launch of the satellite. This has a dampening effect on companies' willingness to speculate on government business. The other problem, which makes it difficult for the government to make long-term commitments, is the appropriation process. Lease cost are funded with Operations and Maintenance money that is valid for one year. The Anti-Deficiency Act prevents the government from spending money that has not been appropriated. Therefore, in ordinary business, it cannot commit to a lease of greater than one fiscal year.

The U.S. Government needs to look at developing business arrangements that can accommodate the needs of both parties. At the recent Schriever II Space War Games, the concept of a Civil Reserve Air Fleet (CRAF) type business arrangement for military use of commercial comsat was discussed.[79] Some central activity such as DISA needs to be responsible for setting up this business arrangement. First, they need to scope the known and anticipated needs based on a consistent set of assumptions. The assumptions need to be shared with industry. Second, a dialogue must be established with industry on the

DOD assessment of the risks of the military using non-hardened satellites and consideration of co-investment as part of the overall strategy.

Multi-year service contracts can be used to develop long-term business arrangements. These contracts can cross multiple fiscal years. The cancellation ceiling or penalty is specified if the U.S. Government wishes to end the contract. The cancellation ceiling in the early years could be high enough to allow the provider protection for any up-front investment necessary to meet government needs. The maximum possible needs could be specified in the contract. The provider could sub-lease unused capacity. The U.S. Government would have the right to preempt any user but this revenue could offset its outlays. In discussion with industry, it appears there may be flexibility on locations. That is the contract would be for a given amount of service but not necessarily in a fixed location of the world. This requires some user restraint; this is potentially problematic since the military has an insatiable appetite for bandwidth.

CONCLUSION

There are significant complexities involved in mixed public/private financing. The military will continue to use commercial satellite communication to augment dedicated military capability. Currently, excess commercial comsat capability exists. This will not necessarily remain the case, however. To ensure it can continue to count on commercial comsats, the U.S. Government must communicate to industry its actual requirements in terms of capacity and security. Additionally, the government must establish a central activity to take advantage of its consumer power and to develop one set of regulations. The government should also develop flexible business arrangements to acquire comsat bandwidth to include the possibility of co-investing with industry to meet unique needs. These arrangements could be in the form of long-term multi-year contracts that allow payment over a number of years while still covering upfront investments. These measures will ensure a continued mix of dedicated military assets and commercial capability.

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SUMMARY

The race to space began with the Soviet Union’s launch of Sputnik in 1957. In response, the U.S. undertook a massive national effort to achieve parity, and surpass Soviet Union space capabilities. The U.S. space industry has maintained a national competitive advantage for over 40 years. Guaranteed government subsidies (some call economic bailout), new efficiencies, steady launch requests from a healthy military sector and domestic rivalry/cooperation guarantee U.S. preeminence for years.

The space industry is highly cyclical; when the satellite business is booming, the space launch industry is lucrative. Success necessitates “surviving” through the down times, then having ample capacity and reputation for reliability when customer demands are high. Current global demands cannot sustain the number of service providers in a free market; therefore, government subsidy is key. Companies able to find efficiencies

through common vehicle applications, consolidations, economies of scale, etc., will have a competitive advantage in the commercial market.

The competitive pressures and the number of new commercial orders are not enough to sustain and shape this critical industrial base. The U.S. Government will continue to inject itself into the process to inoculate this critical industry from collapse. In the immediate future, a major shift of international leadership is not likely.

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[1] Thompson, Loren B. "A Mirror of America's Decline?" City News Publishing Company, 15 November 2002. Equating the space industry to shipbuilding implies space sovereignty is critical to national security, yet the industry is stagnant, and requires substantial government subsidies to keep it solvent.

[2] *Commission to Assess National Security Space Management and Organization*, Washington, DC, 11 January 2001, p. 72.

[3] Some analysts subscribe to four sectors; however, the recent consolidation of intelligence and military space activities support a three-sector concept. Unifying and categorizing the intelligence and military segments as the "national security sector" accurately captures its essence and national leadership intent.

[4] Hays, Peter L. United States Military Space. Institute for National Securities Studies, Occasional Paper No. 42, September 2002, p. 6.

[5] Japan, India and China also have space launch capability, but on a smaller scale and are not generally competitive as international launch service providers.

[6] Gugliotta, G. and Pianin, E. "Spaceflight Debate Pits Man vs. Machine." Washington Post, 27 February 2003, p. A6.

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[8] US Census Bureau, 1997 Economic Census, URL www.census.gov/epcd/www/97EC31.HTM. As of date of this publication, figures for the 2002 Census were not available.

[9] Briefing to the Space Industry Seminar, ICAF, January 2003, Ft McNair, Washington, DC.

[10] US Census Bureau, "2002 NAICS Definitions." Retrieved 24 March 2003 from URL http://www.cennsus.gov/epcd/naics02/def/ND336414.HTM.

[11] The HHI is important from efficiency and merger standpoints. Higher HHIs indicate potential for greater efficiencies. Government is likely to challenge mergers when HHI exceeds 1800 and mergers increase HHI by more than 100. Based on this and projected demand, further mergers in the space industry are likely and will likely remain unopposed.

[12] Feustel-Buechl, Jorg. "ESA Plans for Future ISS External Payloads." On Station, December 2002, p. 6.

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[14] Estimated cost to GEO orbit.

[15] Friedman, L., "Hints of a Vision," SpaceNews, 17 March 2003, p.15.

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[18] Andy Pasztor, "Alcatel Signals It Will Discuss Consolidation With Astrium," The Wall Street Journal, 30 April 2003, B7.

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[20] Armand Musey. "Dollars and Sense: Cycle of Consolidation Rolls On," Via Satellite, 1 November 2002, p. 1.

[21] Sallie Hofmeister. "California; Hughes Loss Narrows as Revenue Climbs 10%" The Los Angeles Times, 15 April 2003, C2.

[22] "Futron examines profitability of three key satellite sectors," Satellite News, 7 October 2002, p. 1.

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[25] Ibid, p. 6.

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[27] US Department of Labor, Bureau of Labor Statistics, retrieved on 5 April 2003 from URL http://stats.bls.gov/ces/home.htm.336414.htm and www.ita.doc.gov/td/industry/otea/usito98/tables_naics/336414.htm.
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[31] Chris Mecray, "The FY04 Space Budget--Government Space to the Rescue," Via Satellite, 1 April 2003, p. 1.
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[33] Missile Defense Agency Fiscal Year (FY) 2004/FY 2005 Biennial Budget Estimates Submission, p. 22.
[34] Information compiled from the following sources: Missile Defense Agency Fiscal Year (FY) 2004/FY 2005 Biennial Budget Estimates Submission, 18. "Air Force Budget Request Bolsters Military Space Accounts Across The Board," Defense Daily, Potomac, 3 Feb 2003, p. 1. Missile Defense Agency Fact Sheet available at http://www.acq.osd.mil/bmdo/bmdolink/pdf/stss.pdf. The STSS constellation requires a minimum of 9 to 12 satellites to ensure satellite-to-satellite communication; 18 to 20 satellites would provide increased coverage for a key region, while 25 to 30 satellites are needed to provide worldwide stereo coverage.
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