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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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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. 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 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.

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.

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.