Vice President's
Space Policy Advisory Board

The Future of the U.S. Space Industrial Base

A Task Group Report

November 1992

VICE PRESIDENT'S
SPACE POLICY ADVISORY BOARD

THE FUTURE OF THE U.S. SPACE INDUSTRIAL BASE

A TASK GROUP REPORT

NOVEMBER 1992

Foreword

The United States is facing a broad array of interacting economic, geopolitical, and industrial challenges as it approaches the next century. Among these is the coincidence of a sluggish economy, large annual federal budget deficits, increased international competition, and a significant and sustained reduction in defense spending resulting from the end of the cold war. The objectives of national defense and civil space programs, as well as those of the commercial sector, are dependent on the maintenance of a healthy space industrial base. It is clearly in the national interest to take those actions which will assure that this base not be unnecessarily compromised by near term reactions to current challenges.

This Task Group of the Vice President's Space Policy Advisory Board was appointed to identify the important issues which will affect the ability of our space industrial base to respond to the defense, civil, and commercial space objectives, and to recommend government policies and actions which will address these matters. We believe the issues which the question raises are serious, but that proper government actions can mitigate adverse consequences and assure not only an adequate space industrial base but one that can grow in support of our nation's increasing space activities and ambitions.

We feel it important to point out that some of our recommendations have appeared in reports by other very able advisory committees which addressed various aspects of our national space program. Our repetition of them results from less-than-complete responses by the affected government agencies and also from the lack of systematic follow-up. We strongly recommend a periodic progress review by the National Space Council of the implementation status of the recommendations contained in this report.

Daniel J. Fink, Chairman

Joseph P. Allen	Alan M. Lovelace
Robert Anderson	Richard J. Messina
Philip Culbertson	John L. Piotrowski
Don Fuqua	Charles R. Trimble

Executive Summary

Our space industrial base has given the United States the capability to be the world's leading space-faring nation. We have exploited space to greatly advance our national security by using extraordinarily sophisticated reconnaissance space systems to guard against military surprise, and other spacecraft that support the pinpoint delivery of weapons. We have fulfilled the dreams of those visionary national leaders who enacted the first National Aeronautics and Space Act by advancing our scientific knowledge of the planet we occupy and the universe around us. And the advancements in technology engendered by the U.S. space program have had world-wide impact in fostering entire new industries. The industrial base is broad. It is not merely plant and equipment, but an entire infrastructure of skilled scientific and technical manpower backed up by superb government, private and academic facilities and institutions.

We anecdotally understand that this space industrial base is being threatened. Not a day goes by when we can't read about increasing defense drawdowns, new layoffs in the aerospace industry, and reduced engineering enrollments. But this isn't the first time that a severe down cycle has hit the aerospace world. We experienced it before and bounced back to even greater triumphs. The last major cycle occurred in the late sixties and early seventies when the Apollo drawdown and some defense budget reductions coincided. Between 1965 and 1971 employment on NASA programs dropped by over 300,000 people. Between 1970 and 1971, nearly 50,000 space-related jobs were eliminated. In the current drawdown, defense-related employment (only a portion of which is space-related) has fallen by over 100,000 jobs per year, and in one month (July, 1992) over 17,000 jobs were eliminated. The numbers from the two eras are not dissimilar. What then might make it different this time?

Several factors suggest there could be a significant difference in the effects on the space industrial base this time around. In 1971, well into the Apollo phase down, the NASA budget was two-thirds of the total U.S. space budget, with military space representing the other third. Two decades later, the positions are virtually equal, such that the space industrial base is more sensitive to the defense cutbacks. In 1971 industry was busy downsizing, investment was curtailed, and the immediate future was far from rosy. But few aerospace contractors contemplated leaving the field or merging, and they carefully held on to their key capabilities and facilities. The Soviet Union, with its massive military threat, was still present and, to government and industry observers, represented a solid "floor" on how low things might get. This time the Soviet "floor" has collapsed and no one is confident in predicting the extent of the slide. The downsizing is already more severe to most aerospace contractors. Those who have the opportunity for "dual use" technologies are avidly seeking the non-defense application; and suppliers who have the choice are turning elsewhere for their business. Finally, in 1971 the U.S. enjoyed virtual monopoly status as the West's provider of space launch services and communications satellites. Today there is intense international competition in both the launch vehicle and satellite markets, with non-market competition from Russia and China further complicating the scene. There is a relatively healthy U.S. commercial space industry with revenues of about $5 billion in 1992, a 14% increase over the previous year. It represents a growing fraction of the space industrial base.

Thus, the renewed interest in understanding the threats to this base, and in trying to assure that the impact of these threats do not compromise our national goals, is well founded. Space systems must continue to play an important role in our national security posture. The goals of our civil space program, as articulated by the Augustine Committee, are the reflection of our uninterrupted national ambition to benefit all through advances in science, technology, and exploration. Finally, there is increasing recognition that a space program that focuses only on government needs without regard to a healthy commercial sector is not complete, nor will it be competitive in the international marketplace.

Competency to Achieve National Objectives

The first important judgment this panel had to make is whether, despite the challenges to the space industrial base now occurring, the nation can maintain a capability to meet our future military, civil and commercial objectives. There is no quantitative analysis that we could make to answer this question. Our conclusion is based on considerable interaction with government and industry personnel tempered by a large dose of our own judgment. The panel concludes (with the important exception of commercial launch competitiveness discussed below) that the nation *can* meet present expectations, and with a base that can be sensibly expanded to meet stretched goals. This conclusion, however, is fragile in that it depends on two key assumptions: that adequate technology R&D is funded by the Defense Department and NASA, and that industry downsizing is done efficiently enough that key capabilities are not so diffused that they cannot be brought to bear on demanding problems.

The current DoD strategy is to maintain a strong technology base (techbase) to continue to have leverage over any potential enemy during a period when the procurement and other accounts are being significantly curtailed. Even if the DoD succeeds in maintaining its techbase funding, the industrial base that supports Defense may lose a considerable amount of systems engineering capability as new large programs become rarer. Systems engineering cannot be maintained by "make work" projects or studies. Maintenance of skills requires real programs. The DoD should recognize the potential of NASA programs as an additional base for maintaining systems engineering capability.

While current projections of the NASA budget do not show the suggested 10% annual growth of the Augustine Committee, NASA's programs have not been predicated on a Soviet threat since the Apollo era, and should be sustainable even through difficult budget years. We should not take great comfort, however, even with a maintained budget because a large portion is devoted to operations, which do not contribute markedly to an industrial base and, as stated by the Augustine Committee, "the technology base of NASA has now been starved for well over a decade and must be rebuilt..." **The investments that the DoD and NASA make**

in space technology are vital to maintaining a healthy space industrial base. The DoD must succeed in its goal to maintain its techbase, even in a drastically reduced defense budget environment, and NASA, which has started to respond to the Augustine technology recommendation with its Integrated Technology Plan, must be successful in holding down operations costs and greatly accelerating technology investment.

The U.S. aerospace industry understands well the current budget environment and the necessity to restructure and downsize. In their presentations to us, companies even used the more appropriate word: "rightsizing." In contrast to previous periods they are not waiting for the other fellow to go first. They know what they must do to remain competitive. Nevertheless, the process is not very efficient and the danger is that certain capabilities could be unacceptably reduced, "critical masses" dispersed, and capability so diffused that the industrial base would be irreparably damaged. The government cannot manage this "rightsizing"; it is industry's job. But many of our laws and regulations were promulgated in times of expansion and may seriously inhibit an orderly restructuring and downsizing process. For example, the antitrust laws designed to protect the public may be counterproductive by preventing companies from having sensible discussions on how to maintain national technical capabilities by aggregation and specialization. Similarly, various allowed tax treatments may slow the downsizing of facilities. **There should be prompt government review of the legal and regulatory impediments to "rightsizing" that would help maintain our space industrial base, and actions taken to remove these impediments.**

DoD/NASA Coordination

There are not two space industrial bases, one for defense and one for the civil space program; they both draw from the same well. Certainly the missions are different, their management styles are not the same, and security classification impinges heavily on much of the DoD program. Nevertheless, they largely use the same industry, require virtually identical technologies, share the human skills, often use common facilities and certainly draw new entrants from the same academic institutions. Preserving the base for one helps the other, and vice versa.

Despite this commonality of interest, we observe that the two agencies look at industrial base issues independently. The DoD has initiated a very systematic process for analyzing its industrial base. It looks at all pertinent sectors such as shipbuilding, aircraft, missiles, etc. One of these categories is *space*. By a survey process, unique technologies, skills, processes and facilities are identified, threatened areas are sought out, and actions are presumably recommended to preserve essential elements. The DoD appears to ignore NASA and its programs in this evaluation.

NASA, on the other hand, has no such process. Rather, it concentrates on single programs, such as the Space Shuttle, to assure that it has the industrial capability to support operations for the system's projected life.

Results of the DoD analysis are not yet available. But from industry presentations, it appears that certain key technologies may require special support, including such areas as large deployable structures (and optics), and stabilization and control of agile spacecraft. It is clear to us that industrial base issues should be coordinated between the DoD and NASA, with any responsibility for supporting critical technologies rationally assigned to the appropriate agency. **The DoD and NASA should address the space industrial base issues in a highly coordinated format. This should not be a one-time effort, but kept up to date to alert the system to any unacceptable loss in capability.** NASA should examine the well-defined DoD process for possible adoption, and DoD must recognize NASA's role in supporting the defense industrial base.

Another area that can best be accomplished jointly deals with the nation's unique space facilities such as large thermal-vacuum chambers and acoustic test chambers. We would include both government and private facilities in any assessment. At present there is a large amount of over capacity and many otherwise useful facilities will be shut down in the downsizing process. In the future more sharing of facilities may be required. Industry is in no mood to fund new facilities, although new programs may require them. Some years ago the DoD and NASA, through the auspices of the AACB (Aeronautics and Astronautics Coordinating Board), did a long-range plan for aeronautical facilities (wind tunnels, etc.) which successfully defined an evolutionary path for such facilities. **We need such a coordinated long-range plan for the unique space facilities that will be required in the new space environment.**

Individual Agency Measures

The procurement processes the government (both DoD and NASA) uses were designed largely during periods of rapid expansion. There was value in encouraging competition and increasing the number of organizations that could contribute to our nation's space programs. It should not be surprising, therefore, if the process is not optimal when the industrial base is shrinking. **The procurement process should not encourage unwarranted dilution of the space industrial base.** This translates to higher weightings for such criteria as past performance, current skills and facilities, and preservation (not dilution) of critical competencies.

Many past studies, e.g., several Defense Science Board reports and the Augustine Committee, have recommended improvements to the efficiency of and value received from DoD and NASA procurements. These include minimizing the use of special requirements in order to make greater use of commonality (including dual use between the DoD and NASA), greater use of commercial components, reliance on performance specifications rather than detailed design specifications, and greater use of commercial business practices. All of these recommendations help the industrial base by less reliance on special items which are expensive and difficult to obtain over a long period of time and/or by requiring less oversight and reduced paperwork. The latter permits a larger percentage of our financial resources to go into the end items, a *must* if we are serious about preserving our industrial base. The procuring agencies generally agree with these recommendations, but actions lag the good words. **It is time to actively implement the many past serious recommendations that have been made to increase the value received from government-procured goods and services.**

As the space program matures, more systems become operational and operations take a larger fraction of the budget. For example, it is now estimated that space operations take about one-third of the NASA budget. Unchecked, these funds, which contribute to a healthy budget but not as much to preparing the industrial base for future needs, will crowd out programs which do. It is, therefore, necessary that both the DoD and NASA minimize the cost of their space operations. Both organizations would like to accomplish this for space launch, and NASA has an aggressive program to reduce the cost of Shuttle operations through improvements in both the system and operating procedures. New systems should have an eye on the health of the future industrial base and be designed to minimize operational cost. The Space Station is a case in point. Operating cost should be a major design consideration. The system should be "technologically transparent" so that it can accept upgraded (hopefully commercial) components and subsystems and not be dependent on unique contractors for years to come. **In summary, operating costs should be vigilantly under pressure, and new systems should have low operating costs as a major design criterion.**

Finally, as the industrial base is "rightsized" so should be the government counterparts. Companies which restructure recognize that the corporate staffs who are paid to ask questions of their operating divisions not only consume overhead funds, but create overhead in operations. **The government agencies will have to make some of these same difficult decisions in downsizing and restructuring their staffs and the associated support contractors.** Similarly, they must guard against the natural tendency to bring work "in house" because an industry or academic institution is forced to relinquish a capability. This is not the way to maintain a space industrial base.

Space Launch

Advisory groups should be tiring of advising the government on steps to take to renew our nation's space launch capability. The basic facts haven't changed, except perhaps to worsen. We are dependent for the launch of our major payloads on the Space Shuttle and the ballistic-missile-derived Delta, Atlas and Titan launch vehicles. The latter are relatively reliable workhorses and could serve our government launch needs into the next century, albeit at increasingly uncompetitive prices, because now our international competitors will be improving the operating efficiency of their fleets. We will be paying more than we should for our own launches and will not be competitive for international commercial payloads. Complicating this will be pressure from non-market economy (NME) nations such as China and Russia.

Our response to this challenge must be threefold. No matter what else we do, the current stable of launch vehicles will be with us through this decade. **We should invest in upgrades to the current vehicles and supporting infrastructure to increase reliability and reduce operating costs. We should implement a fair trade agreement to provide interim insulation of the U.S. commercial launch industry from unrestricted access by NMEs, and define "rules-of-the-road" with other governments. Finally, we must develop and make operational a modern, low-cost launch system.**

The nation will get three benefits from implementing the last of these recommendations: (1) The cost of future government launches will be significantly lowered, (2) Our industry will have an internationally competitive launch capability, and (3) Lower-cost access to space will stimulate the use of space, benefiting all sectors. At the same time, such a program will preserve essential elements of the space industrial base.

Commercial Space

Today, the estimated $5 billion in commercial space-derived sales represents about 14% of U.S. total space expenditures. It could be argued that the commercial portion of the space industrial base does not contribute that much to the whole. We have already pointed out, however, that operations are taking an increasingly larger part of government expenditures. Operations play a smaller part in commercial programs. In addition, many studies have been done to show that government programs cost more than corresponding commercial programs (estimates range from 30% to factors of 2 to 3 or more). Finally, the government program, led by defense, is shrinking while the commercial programs continue to grow. Combining all these factors, a growing commercial contribution to our space industrial base is more significant than the 14% would imply.

There are a number of ways the government can help this nascent but growing industry. Again, many of these measures have been recommended in previous studies and are being implemented to various degrees. **The government has many opportunities to remove impediments and implement policies that promote industry growth.**

Export restrictions should be reviewed in light of the changed international environment. It is difficult to understand why communications satellites delivered on orbit are on the U.S. Munitions List. The Export-Import Bank should be allowed to provide increased financing support. Market-opening measures by the government should be encouraged. **The manner in which the government buys its goods and services can have a positive effect on the commercial space industry.** Examples (all of which have been used at some time by the government) include serving as an anchor tenant in privately funded projects, procuring data rather than the hardware which produces the data, and the funding of risk-shared technology demonstration programs.

Finally, for the same money a number of small programs contribute more to the space industrial base than does a single large one. More of the funds expended on small programs go into end items since less oversight is (or should be) required. Institutions, whether government or private, are willing to take more risk on a small program and innovation is encouraged. Development cycles are shorter; thus innovation is incorporated sooner. Defense conversion through diversification is difficult, but conversion from large defense programs to challenging smaller space programs is relatively easy and is highly useful in preserving the industrial base. **The government should recognize the particular value of multiple small programs in contributing to the space industrial base.**

Engineering Education

The panel did not have time to address this important issue in any depth. We know from past experience that young people react to market forces extremely rapidly in choosing their fields of study. The aerospace industry does not appear to be in a soon-to-be-reversed trend. The reduced supply of engineers applicable to our space industrial base may match future demand. It may not. We believe there is sufficient doubt to justify that an appropriate group, probably under the National Academies, study the issue. Our future capabilities in space will depend heavily on the availability of qualified young engineers and scientists.

Table of Contents

List of Figures

1

Introduction

The ability of the United States to advance its national interests in space — be they military, scientific, or economic — requires an industrial base that can translate bold and complex concepts into actual systems and services. The term "industrial base" is a broad one encompassing government, university, and private sector facilities, skilled manpower, and technical resources which are capable of producing space-related hardware and software. Examples of these include propulsion systems, guidance systems, complete launch vehicles for both orbital and suborbital flight, satellites of all kinds, remote sensing information systems, ground support systems, and related command, control, and communications systems.

The Vice President tasked his Space Policy Advisory Board to assess the current strength of the U.S. space industrial base and the outlook for its health and vitality over the next decade in light of recent changes in the world situation. These changes include the end of the Cold War and new prospects for both cooperation and competition in space activities. A panel of the Advisory Board was named on July 1, 1992 and charged with considering the implications of declining defense spending, the nature and scope of international competition, and current and projected national security needs. The panel was also to take into account changing trade relationships between the U.S. Government, the private sector, and other space-faring nations.

While the state of the defense industrial base has often been studied and reported on, no comparable level of examination has been done for the space industrial base. In part this has been because it is usually assumed that the space industrial base is a subset of the defense industrial base. Past reviews of space policy, from the 1969 Report of the Space Task Group to the 1990 Augustine Committee, did not directly address the question of whether the U.S. industrial base was adequate for the space tasks considered — partly for the reason that these studies were not initiated at a time coincident with a severe aerospace retrenchment.[1]

Today, there is increasing concern that declines in defense-related spending and increasing international competition are harming or will harm the ability of the United States to maintain an industrial base that is capable of meeting U.S. Government requirements and the demands of commercial competition. Success in meeting government needs does not always translate into commercial success. For example, the United States retains the capability to build the world's best warships, but the lack of an internationally competitive shipbuilding industry has resulted in additional costs to the government in maintaining that industry. On the other hand, the existence of a commercially competitive satellite navigation receiver industry meant the United States was able to supply critical civilian receivers to U.S. and allied armed forces during the Persian Gulf War, when military production lagged behind defense requirements.

The current situation of declining defense spending and decreasing growth in civil space expenditures is not the first time the U.S. space industrial base has faced a major decline. Total employment on NASA programs declined from a peak of 420,000 in 1965, of whom 33,000 were direct NASA employees. By 1971, this total had dropped to 114,000, of whom 30,500 were direct NASA employees.[2] In one year, from 1970 to 1971, approximately 16,000 space-related jobs were lost in California; 5,000

---

1 "The Post-Apollo Space Program: Directions for the Future," Space Task Group, September 1969, Washington D.C. and "Report of the Advisory Committee on the Future of the United States Space Program," December 1990, Washington D.C.

2 "Manned Space Projects Recede as Priorities Shift," Congressional Quarterly, page 404, February 13, 1970.

in Colorado; 7,100 in Louisiana, Mississippi, Alabama, and Texas; 11,000 in New England; and 5,600 in all other areas.[3]

In contrast to the early 1970s, today's space industrial base faces new and unprecedented challenges due to several important changes. The end of the Cold War has removed a major driver of defense spending and caused a reexamination of national security space needs. Defense-related space spending has exceeded civil space spending every year since 1982, driven primarily by DoD's increasing recognition of the force multiplication role of space. As a result, cutbacks in defense now have a greater effect on the space industrial base than twenty years ago. Finally, the increasing global spread of space technologies is eroding the unique technical advantages once held by the United States, fostering the entry of more competitors into international space markets, and making it more difficult for U.S. firms to move into commercial space ventures.

After an extensive literature review, the Task Group met in Washington to receive briefings from government agencies. It met again in Los Angeles to receive briefings from industry representatives (see Appendix IV for a list of presenters). The group held its final meeting in Washington to share what it had learned from government, industry, and its own research and to identify principal findings and recommendations.

This report is divided into two major sections and a summary of recommendations. The first is a brief factual overview of the space industrial base in regard to measures such as budgets, employment, and market shares. The second is a series of six major issue areas and associated recommendations that, if implemented, would strengthen the space industrial base so as to best serve the national security, scientific, and commercial interests of the United States during the remainder of this decade and beyond.

---

[3] Congressional Quarterly, op cit.

2

The U.S. Space Industrial Base in Transition

The U.S. industrial base as a whole is undergoing a number of changes; thus, attempts to characterize the status of the space industrial base are at best a snapshot of a moving target. This section is intended to provide a brief overview of the U.S. space industrial base using measures such as government budgets, economic growth, technical employment and education rates, and international competitiveness.

U.S. Government Space Budgets

U.S. Government FY 1992 space spending is expected to be over $30 billion, with $14.6 billion by NASA (over 95% of which is space-related) and over $15 billion in defense-related spending.[4] (Figure 1) Space-related spending by agencies such as the Departments of Energy, Commerce, and Transportation totals a few hundred million dollars. In the first two decades of U.S. space activity, NASA spending exceeded DoD spending, especially during the Apollo program. NASA spending declined in the 1970s, and DoD space spending increased significantly in the 1980s. DoD

---

[4] Office of the Secretary of Defense Comptroller, September 1992.

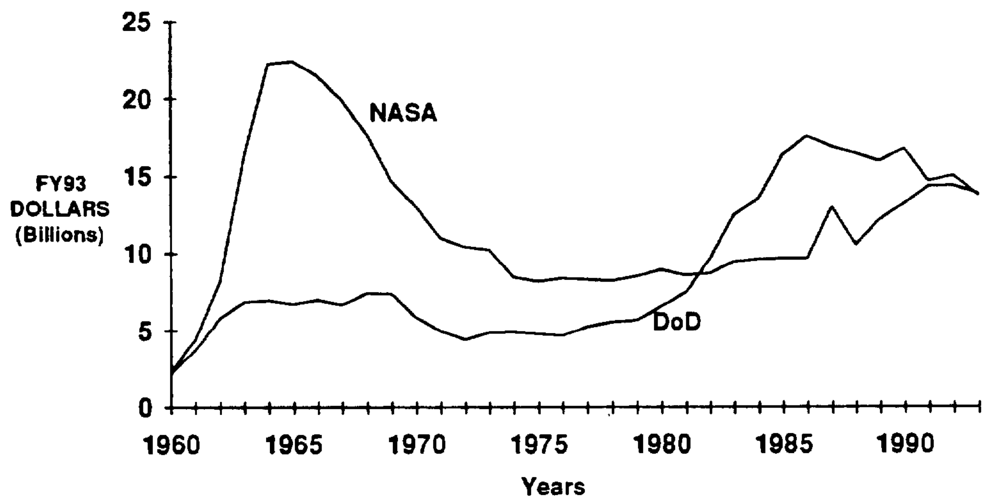

Figure 1. U.S. Space Budget

space spending exceeded NASA spending in 1982 and every year since. The 1987 NASA spending spike is due to the one-time cost of buying the Space Shuttle *Endeavor* after the loss of the *Challenger*.

NASA spending in current dollars increased from $6.6 billion in 1985 to $14.6 billion in 1992, or an average increase of 12% per year. Projections of future NASA budgets, however, have been uncertain, with wide variations between what is requested and what is actually appropriated by the Congress. (Figure 2) In 1987, "Leadership and America's Future in Space" (the Ride Report) outlined a number of space projects which would have required increasing NASA's budget to about $40 billion by the year 2000, about twice the peak funding of the Apollo program. In 1990, the "Report of the Advisory Committee on the Future of the U.S. Space Program" (the Augustine Committee report) suggested that accomplishment of its recommended "balanced" space program would require about a 10% per year increase in the NASA budget through the year 2000, resulting in a budget of about $30 billion.

Administration budget requests for 1991 and 1992 attempted to follow these recommendations, but actual congressional appropriations were for much slower growth. In response to fiscal constraints, estimates by the Electronic Industries Association project that real NASA budget authority

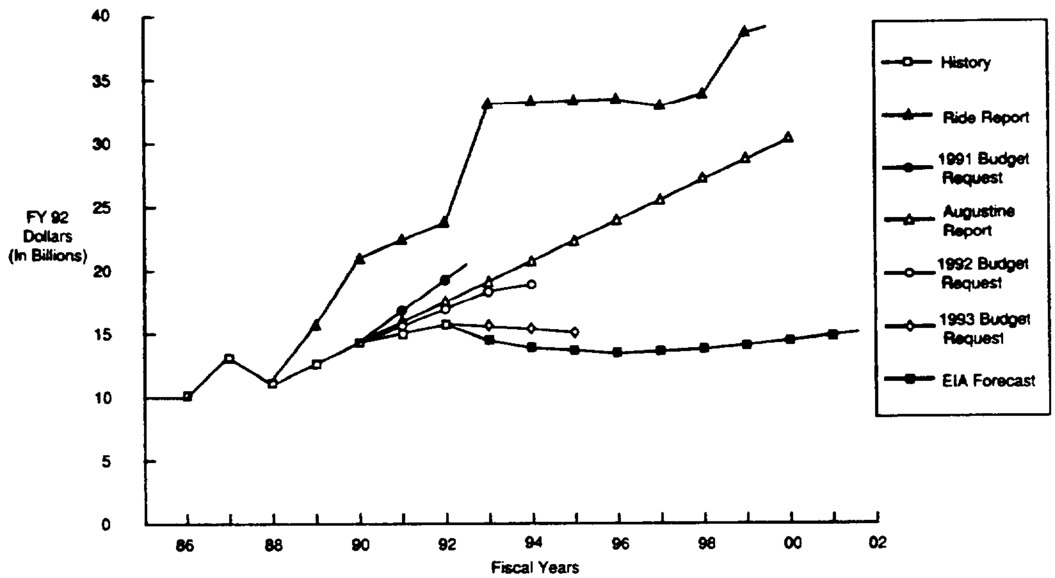

Figure 2. NASA Budget Predictions

will grow slowly, if at all, over the next decade. This projection resulted from surveys and interviews with about 500 persons in government, industry, academia, and the financial community.[5]

The DoD budget has decreased in real terms since 1985. Adjusted for inflation, the fiscal year 1992 $286.7B defense budget represents a decline of more than 5% per year since 1990. The greatest decline has been in procurement spending, that is, orders placed with manufacturers. This decline is considerably greater than that for operations and maintenance (O&M) and personnel costs. Research and development costs are also declining, but more slowly. The divergence resulting from reduced emphasis on major system acquisitions represents the largest gap between procurement/R&D and personnel/O&M accounts since 1945.[6] (Figure 3)

---

5 "EIA 10-Year Forecast of Defense and NASA Needs," Electronic Industries Association, September 1991, Washington D.C.

6 "Analysis of DoD Trends by Major Categories," Aerospace Industries Association, August 1992, Washington D.C.

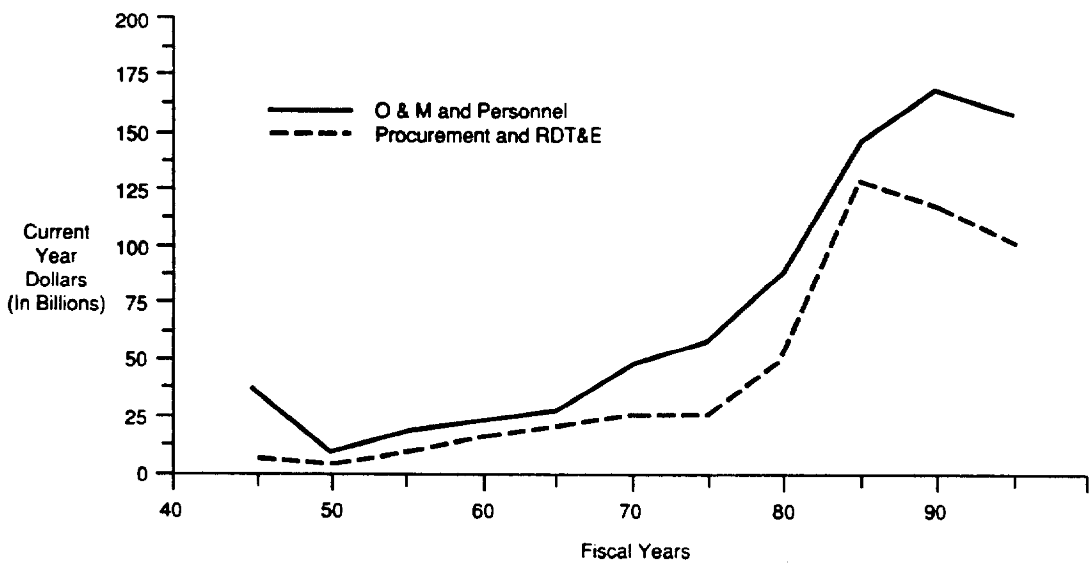

Figure 3. DoD Budget Authority

In contrast to almost all other areas, however, DoD space spending has increased a steady 2% per year, growing in current dollars from $12.8 billion in 1985 to $15.0 billion in 1992.[7] As a result, space activity is taking an increasingly larger share of a shrinking DoD investment budget for R&D and procurement. The Senate Armed Services Committee reported that "in fiscal year 1993, space investment will exceed 15% of total (DoD) investment, a doubling of (its) share since fiscal year 1986."[8] The current DoD budget forecast, Figure 4, shows DoD space spending continuing to grow in current year dollars.

---

7 Office of the Secretary of Defense Comptroller, September 1992.

8 U.S. Congress, "National Defense Authorization Act for Fiscal Year 1993 Report," Senate Committee on Armed Services, page 85, July 31, 1992.

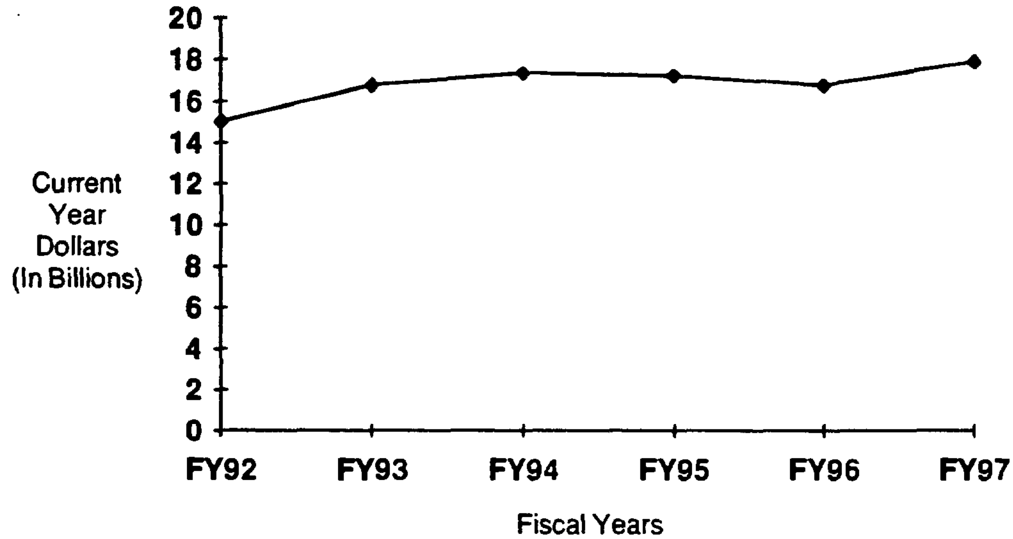

Figure 4. DoD Space Budget Prediction

Aerospace Industry Sales

NASA and DoD expenditures account for the bulk of aerospace product and service sales. (Figure 5) Space sales have continued to grow at a steady rate, but slower than other aerospace areas largely due to the greater dependence of space sales on government budgets. Most of the DoD and Non-U.S. Government expenditures are aircraft-related; these have shown increasing strength in the past few years.

In commercial markets, aerospace goods such as aircraft and satellites are the leading contributor to the U.S. balance of trade, about $31 billion in 1991.[9] While this represents a 9% increase over 1990, reflecting strong civil exports, imports continued to increase to a record high of $13 billion.

It is difficult, if not impossible, to separate the space industrial base from the U.S. aerospace industry. Nonetheless, space-related sales are clearly an increasingly important part of the total aerospace industry. Space

---

9 Aerospace Industries Association, 1992, Washington, D.C.

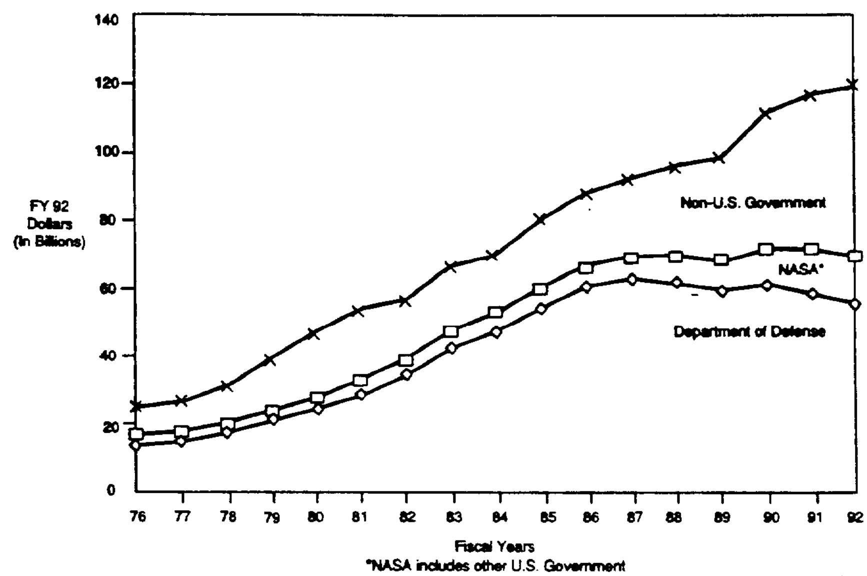

Figure 5. Aerospace Products and Services Sales by Customer Type

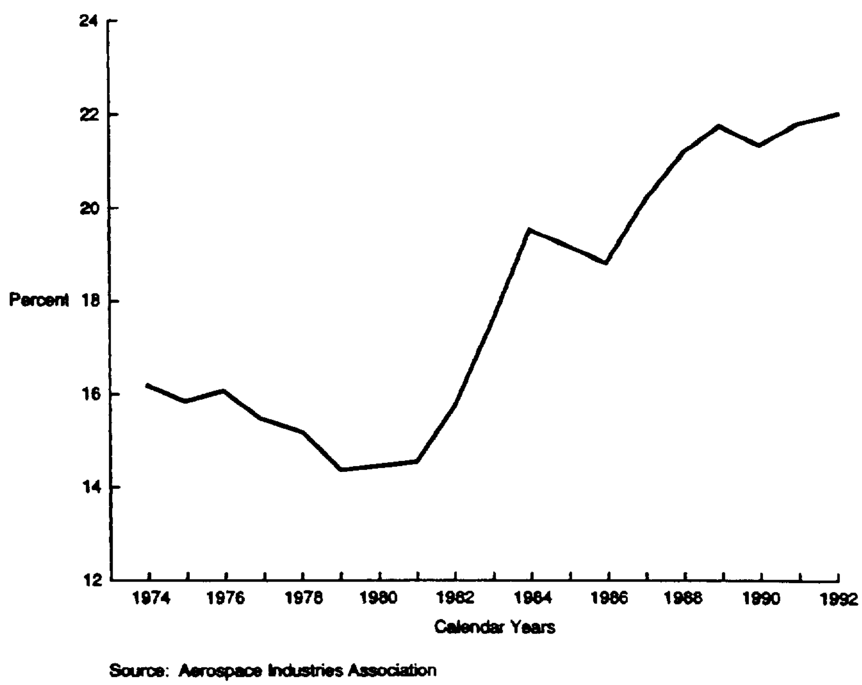

Figure 6. Space Industry Sales as a Percentage of Total Aerospace Industry Sales

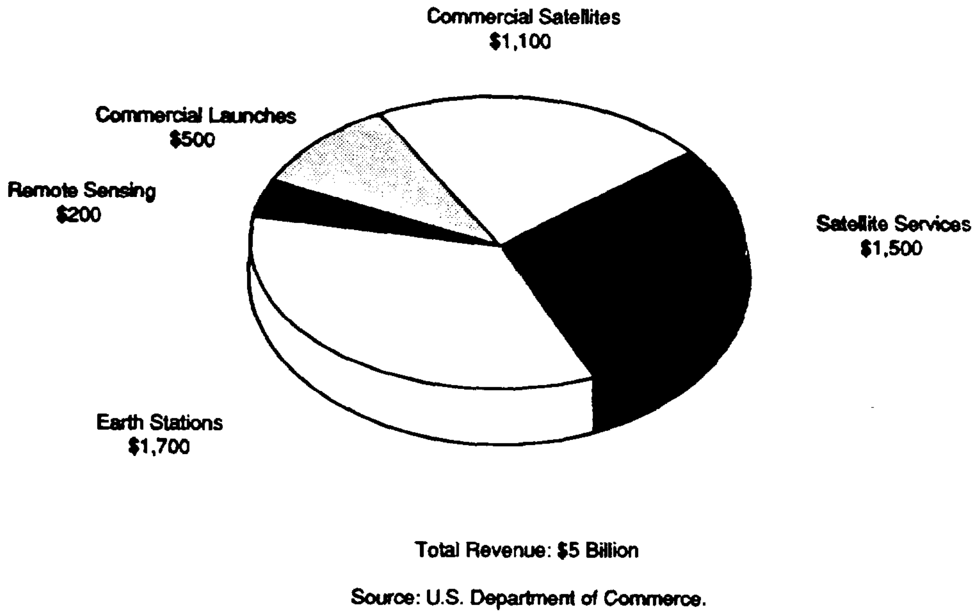

Figure 7. U.S. Space Commerce, 1992

industry sales now account for 22% of total aerospace industry sales, with steady growth since 1980.[10] (Figure 6)

Commercial Space Markets

Commercial space sector revenues are expected to increase by $600 million to about $5 billion in 1992, for a 14% increase over 1991. (Figure 7) Most of these revenues are generated by satellite communications-related goods and services. In addition, new technologies are generating economic growth in space-based mobile communications, portable satellite navigation receivers, and remote sensing data analysis. The United States is competitive in commercial space products, with 1991 exports of $240 million in satellites and $220 million in launch services.

Since the first fully commercial launches in 1988, U.S. commercial launch companies have won many international competitions. But the

---

[10] ibid.

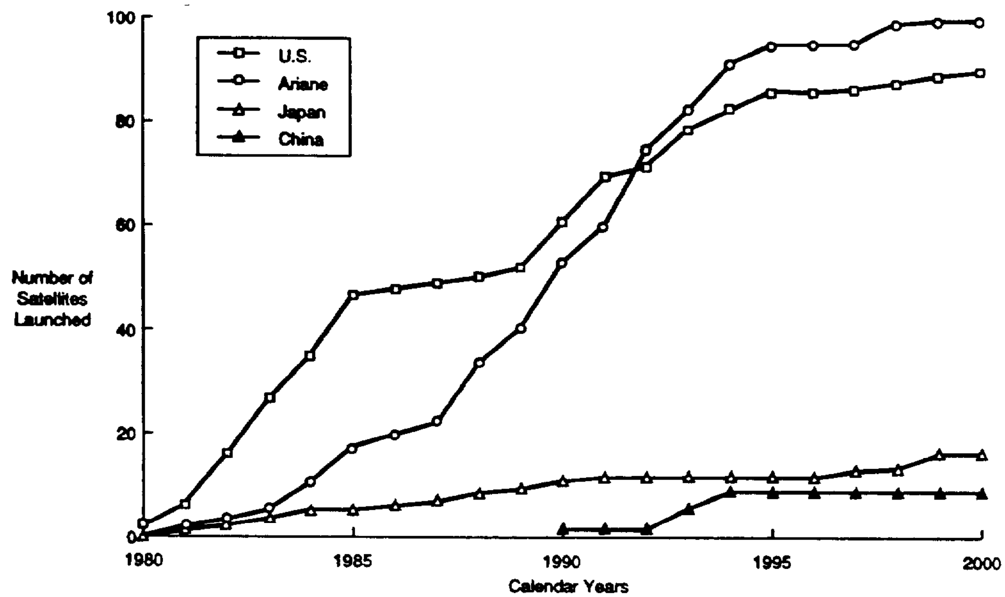

Figure 8. Cumulative Communications Satellite Launches since 1980

failure of several launches in 1985 and 1987, and the backlog created by the loss of the *Challenger* in 1986, allowed the European Ariane rocket to gain and keep a majority share of the international launch market. In terms of cumulative communications satellite launches since 1980, the United States has been recently passed by Ariane, in part as a result of the standdown by U.S. launchers in the 1980s. (Figure 8) Japan and China have launched satellites at a lower rate than the United States or Europe and as a result have much less experience. The international commercial market for launches of medium and large communications satellites is level and roughly split now between the European consortium, Arianespace, and U.S. firms. (Figure 9)

The U.S. commercial launch industry consists of about a half dozen companies offering commercial launch services for small (under 1,000 pounds) to very large (above 10,000 pounds) payloads. While demand for traditional communications satellites is expected to remain flat, a potential source of new demand is for small payloads launched to low Earth orbit (LEO). These payloads are primarily small telecommunications satellites in networks that can provide world-wide services. Other examples include distributed remote sensing platforms.

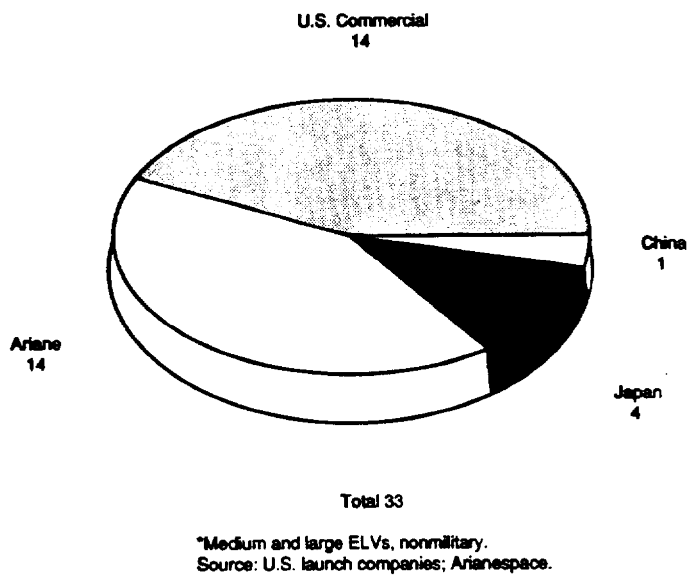

Figure 9. Commercial Space Launches by Country, 1990-91

The U.S. Government remains the largest consumer of U.S. launch services. NASA, DoD, and the National Oceanic and Atmospheric Administration have had a combined requirement for about 15 expendable launch vehicles per year, two or three of which are procured commercially, plus another three to four small orbital or suborbital launchers. The United States is expected to continue the policy of launching civil and military spacecraft on U.S. launchers. However, declining defense spending has resulted in downward revisions in DoD's launch plans.

The United States has fared better in the commercial communications satellite market, than in launch services, but is facing growing foreign competition. Of commercial communications satellites currently scheduled for delivery during 1992-1997, 69% will be built by a U.S. prime contractor. French companies are second with 13% of the market. (Figure 10)

Other nations have, however, made significant penetrations into a market which used to be a U.S. monopoly. In the 1970s, foreign manufacturers built 13% of all civil and commercial communication

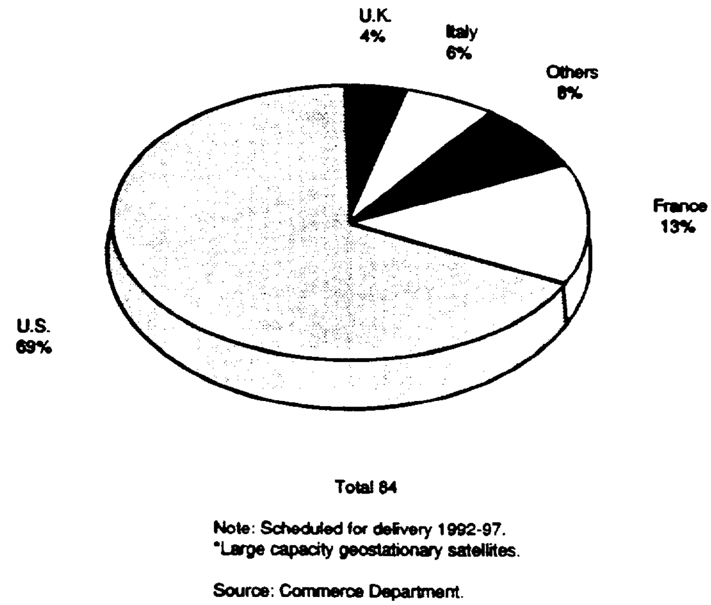

Figure 10. World Communications Satellite Orders

satellites. In the 1980s, market share captured by foreign manufacturers increased to 29%. In the 1990s, foreign manufacturers have already won contracts for 37% of the satellites to be built with about 29% of the contracts still undecided. The non-U.S. content in international satellites such as the Intelsat series has also increased, with Japan and Europe seeking to contribute more technology to the U.S. firms that have won the prime contract position.

The largest single sector of space commerce consists of satellite ground equipment, which generated estimated revenues of $1.7 billion in 1992. Asian manufacturers provide stiff competition for U.S. firms in larger, Intelsat-compatible, earth stations. They dominate the global market for lower-technology Television Receive-Only (TVRO) home dishes. U.S. companies, however, hold an estimated 85% world market share for mid-sized and smaller earth stations, such as Very Small Aperture Terminals (VSATs). U.S. technology is also seen as being at the cutting edge in emerging mobile satellite receiver markets. VSAT stations which sold for $30,000 in 1988 are now selling for $6,000 and are likely to sell for $2,000 by 1995. These trends will favor high-productivity, low-cost producers in a challenge familiar to other areas of commercial manufacturing.

Employment

Defense budget reductions have a strong impact on employment. For example, the DoD's Fiscal Year 1993 Budget Submission projects a 31 percent decrease in industry employment from 1991 to 1997, dropping from 3.3 million to 2.3 million jobs. As defense budget growth slowed in the late 1980s, employers continued to hire and retain workers, possibly in expectation of new defense spending. Employment at defense contractors (defined as firms receiving 50% or more of their revenues from military sales) peaked in 1987 at 1.4 million, and declined by only 33,000 over the next three years.[11] With the fall of the Berlin Wall and the collapse of the Soviet Union, defense-related employment began falling at more than 100,000 jobs per year. These losses represent about 15% of total job losses since the beginning of the current recession in July 1990. More recently, continued defense cutbacks resulted in the elimination of 17,000 jobs in July of this year, the largest single-month decline in the past two years.[12] Certain states, such as California and Massachusetts, in which defense spending plays a major role, have been particularly hard hit.

Aerospace industrial base employment has been strongly affected by defense procurement reductions. At the end of 1991, U.S. aerospace employment totaled 1.16 million workers, or about 6% of total U.S. manufacturing employment. This is a 13% decline since 1989, and another 7% reduction is expected in 1992, with most of that coming in military aerospace work.[13] (Figure 11) Increases in government funding for space and steady commercial space growth suggests that these cuts have fallen mostly on aircraft production workers. In 1990, employment in the missiles and space sector of the industry averaged about 186,000 persons.[14]

---

[11] U.S. Department of Labor Bureau of Labor Statistics, August 7, 1992, Washington D.C.

[12] ibid.

[13] Aerospace Industries Association, 1992, Washington, D.C.

[14] ibid

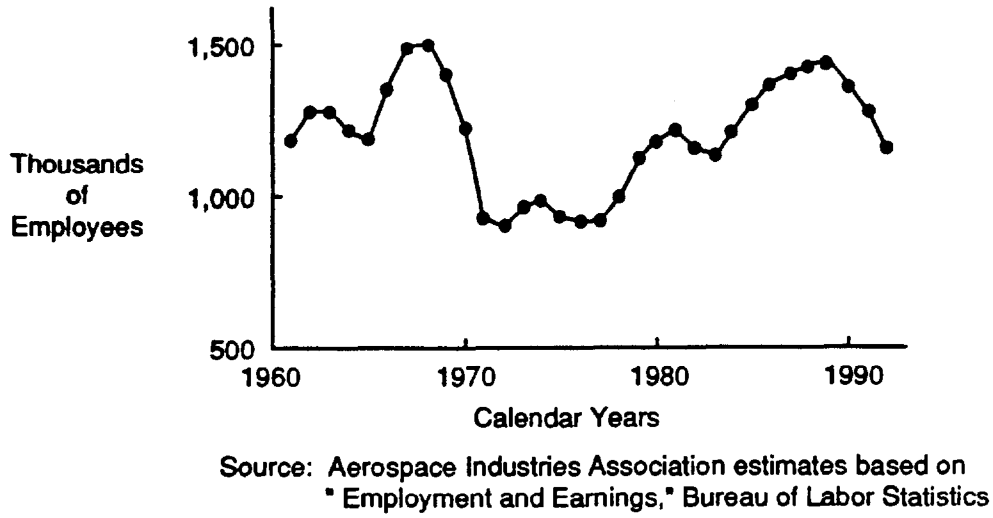

Figure 11. Aerospace Industry Employment

Overall, the total defense employment of engineers and scientists is expected to decline from 379,000 in 1991 to 279,000 in 1997. Aeronautical and astronautical engineers, those most directly associated with space systems, are expected to decline in defense employment from 29,000 in 1991 to 20,000 in 1992, or about 30%.[15] This should be compared with an estimated total employment of 73,000 aeronautical and astronautical engineers in 1990. Projections of future employment of such engineers have very high degrees of uncertainty – plus or minus 27% through 2005, according to the Bureau of Labor Statistics.[16]

[15] "Projected Defense Purchases Detail by Industry and State CY 1991-1997," Office of the Secretary of Defense, page 14, November 1991, Washington D.C.

[16] "Scientific and technical employment, 1990-2005," Douglas J. Braddock, Monthly Labor Review, page 35, February 1992.

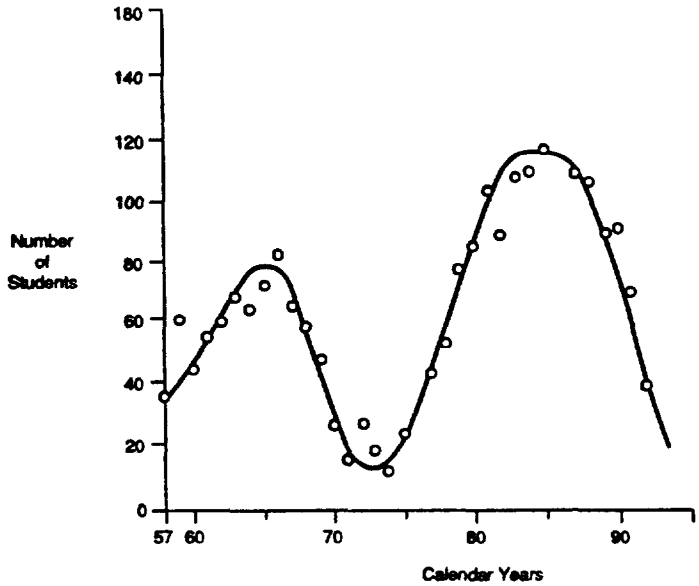

Figure 12. MIT Sophomore Enrollment in Aero/Astro

Engineering Education

Current workforce reductions and significantly lower new college graduate hiring by aerospace and other engineering intensive industries have sent a strong negative signal to potential entrants. Engineering enrollment has decreased from 115,000 in 1982 to 93,000 in 1991. While total engineering graduates have decreased 7% since a peak in 1986, B.S. graduates have decreased 22%, reflecting fewer incoming students to the field. At the undergraduate level, the U.S. educational system appears to be particularly responsive to market signals. (Figure 12) In the last three years, for example, the number of sophomores choosing to enroll in the Aeronautical / Astronautical Engineering Department at the Massachusetts Institute of Technology has fallen by more than 50%.[17]

[17] Dr. Jack Kerrbrock, Department of Aeronautics and Astronautics, Massachusetts Institute of Technology, Cambridge, Mass., September 1992.

The International Environment

Europe

Europe entered the 1990's as a major, if not the major, competitor to the United States in many space sectors such as launch services, communications, remote sensing, and microgravity research. The European Space Agency (ESA) has funded the European space community with a sometimes rigid system of "just return," assuring contract awards to industrial in member states in direct proportion to the contributions of member governments. Civil space spending is still largely below that of the United States. (Figure 13) At the height of the Apollo program in 1965, the United States (essentially NASA) outspent Europe by 35:1. By 1975, this ratio had fallen to 4.3:1 as a result of both lower U.S. expenditures and increased European attention to building its communications satellite and launch vehicle industries.[18] In 1992, the continuation of these trends has resulted in the United States' outspending Europe by only 3.1:1.[19]

Restructuring and consolidation in recent years has resulted in two large aerospace groupings in Europe. One consists of Matra Marconi Space, which includes Fairchild Space, a U.S. firm. The second is an alliance of Deutsche Aerospace, Alenia, Aerospatiale, and Alcatel which, in turn, owns 49% of Space Systems Loral, another U.S. firm. France is currently the leading space power in Europe in the scope and complexity of its activities. Germany has restructured its aerospace industry (combining Dornier, MBB, and Telefunken) in part to challenge French dominance, but the cost of reunification is slowing its space activities and its contributions to ESA. This, in turn, has placed greater pressure on the other ESA members and has caused a suspension, if not cancellation, of several programs such as the Hermes space plane.

---

[18] "The International Space Market: Increasing Cooperation and a Changing U.S. Role," Henry Hertzfeld, Aerospace Industries Association, 1992.

[19] Assuming a NASA budget of $14.61 billion, an ESA budget of $3.14 billion, and combined non-ESA civil space budgets for France, Germany, and Italy of $4.68 billion.

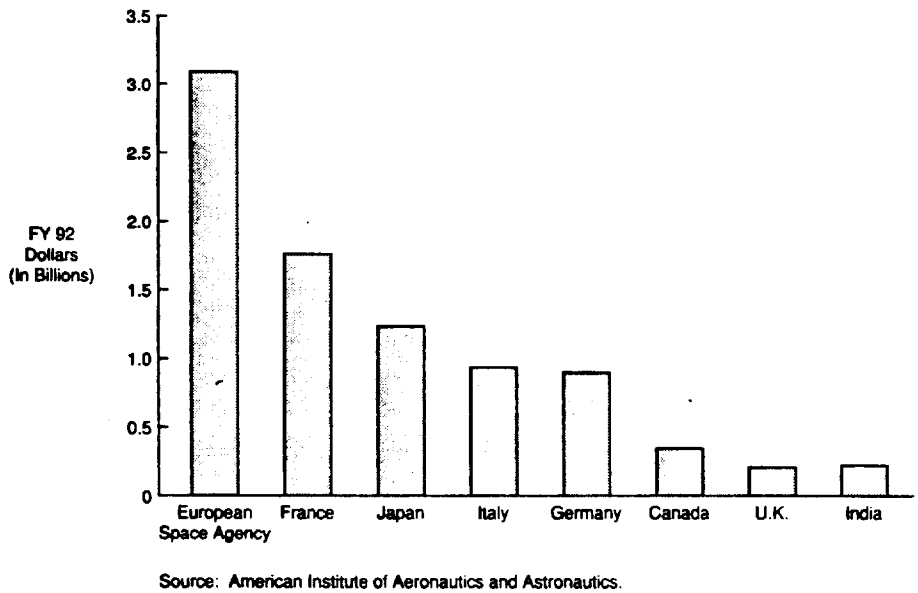

Figure 13. International Space Program Budgets

The European aerospace industry operates in a very different financial environment compared to U.S. industry. For example, governments, banks, and major companies commonly have equity positions in space firms. This creates a stable, lower-cost source of capital for new ventures, and currency mixes can be altered to enhance pricing flexibility. On the other hand, new ventures can sometimes suffer as a result of protection from competition, leading to rigidity in responding to new technologies and market opportunities.

Japan

Japanese firms also operate in a very different financial environment from U.S. space industry. Their *keiretsu* structures involve long-term close relationships between the suppliers and vendors for a major firm, which, in turn, takes a large degree of responsibility for their health. Perhaps more importantly, the Japanese government plays a leading role in promoting new technologies and industry ventures. The Ministry of Industry and Trade (MITI) established a space industry division in 1987 and has created at least 7 space consortia with a total of over 150 companies. They are exploring areas such as the commercialization of Japan's H-II rocket, remote sensing technology for oil and mineral exploration, and microgravity research. One statement from MITI highlights how Japan intends to focus its space efforts: "Our ministry is trying to promote the types of commercial space activity that will not entirely depend on the government's budget. If Japanese space efforts are limited to those supported by government spending, growth of the total industry will be slight."

The Former Soviet Union

The former Soviet Union (FSU) has considerable overcapacity in its defense industrial base as a whole, and specifically in its space industrial base. In 1991, open source estimates placed the size of the Soviet space effort at approximately 800,000 to 900,000 people. This included what might be called civil, scientific, and military activities, although the distinction is difficult to make. Most space activities were concentrated in Russia and Ukraine, with major launch operations at Tyuratam in Kazakhstan. With the current economic turmoil and withdrawal of government supports, some observers estimate that the Russian space effort may contract to only 100,000 - 200,000 persons in the next five to ten years.

The republics of the FSU, especially Russia and Ukraine, are making strong efforts to enter international markets and earn hard currency. Unfortunately, they are not yet bringing any new demand to the market (e.g., allowing Western firms to compete for launches of Russian payloads), but are seeking to take market share from existing competitors. Aside from launch services, Russian industrial organizations are engaging in joint ventures to sell communications satellites as part of complete service networks. Other joint ventures are seeking to find Western buyers for aerospace components such as high-precision turbine wheels which could be used in jet engines and rocket engine turbopumps.[20] Low-price, satisfactory quality Russian parts could represent a severe challenge to the commercial competitiveness of some U.S. component suppliers.

Recently, the United States and Russia have entered negotiations toward an agreement that would allow for entry of Russian launch services without market disruption. Preventing market disruption is both particularly important and difficult in the case of non-market economies such as Russia and China, as resource costs are typically unknown and pricing can be arbitrary. As a result of concerns with Chinese entry to the international market, the United States concluded a six-year agreement with the People's Republic of China to limit its participation in the international launch market to nine launches over the period of the agreement and to price its launch services fairly.

In summary, foreign governments have targeted space as a strategic industry with potentially high economic and national security leverage. This, in turn, has resulted in foreign aerospace companies enjoying substantial government support in addition to official budget expenditures. Europe is the current major competitor, possessing space technology on a par with that of the United States in many areas. Japanese industry is becoming increasingly capable, and Israel, Korea, and India are looming as potential future independent competitors. Future roles for non-market economies such as Russia, Ukraine, and China are unclear due to concerns about the stability of their space organizations and their current lack of market-oriented structures and business practices.

---

[20] "Recession Taking Toll on Sub-Tier Companies," Aviation Week and Space Technology, page 91, September 7, 1992.

3

Findings and Recommendations

The Task Group identified six key areas relating to the health of the U.S. space industrial base now and over the next decade. These are:

- Competency to Achieve National Objectives
- DoD/NASA Coordination
- Individual Agency Measures
- Space Launch
- Commercial Space
- Engineering Education

Where appropriate, we offer recommendations on actions that should be taken to ensure that the United States continues to have the industrial base to fulfill its goals in space.

Competency to Achieve National Objectives

Uncertainties in All Areas of the Space Industry

Today, a unique combination of circumstances is adversely affecting the U.S. space industrial base. The collapse of the Soviet Union and the end of the Cold War have led to an extensive reexamination of our national security needs and a corresponding decline in projections of future defense spending requirements. The DoD plays a much larger role in space today than it did twenty years ago and, hence, the space industrial base is affected almost equally by both NASA and DoD actions. Finally, over the past decade, commercial opportunities in space have grown along with increasing pressure from international competitors. The space industrial base is thus faced with major uncertainties from each of three business areas: military space, civil space, and commercial space.

Space-related spending has not been affected as much as other areas of the defense budget, as the United States continues to require access to space and space systems to support world-wide military and national security objectives. Nonetheless, the decline in defense spending means that the United States has industrial overcapacities in some areas and that it may lose some critical capabilities in other areas unless special actions are taken. The DoD strategy is to maintain its industrial base through a strong research and development effort and limited prototyping work, while delaying or foregoing some full-scale production efforts. Military space may fare better than other defense sectors since many of the systems in production (e.g., global positioning, meteorology, and communications satellites) are directed to world-wide national security objectives and their requirements are not dominated by the past Soviet threat.

Civil space spending has not been as greatly affected as defense spending by the end of the Cold War, and, in fact, new opportunities for international cooperation have been opened. Fiscal realities are such, however, that sustaining strong, continued budget growth will be very difficult. A large portion of NASA's budget is devoted to operations (about one third), and this portion undoubtedly will grow with the deployment and operation of Space Station Freedom. A flat budget and growing operational commitments mean that NASA will be hard-pressed to undertake the new initiatives in technology or space systems that are the major contributors to the competency of the space industrial base.

The commercial space sector — consisting largely of launch vehicles, communications satellites, satellite services, ground equipment, and remote sensing activities — has been growing rapidly in recent years. This growth has helped generate new sources of non-government revenues for the space industry and sharpen its technical capabilities through commercial competition (e.g., in communications services and satellite-based navigation). At the same time, U.S. firms are facing aggressive international competition that is either partially or fully government-supported. The United States continues to be a world leader, but it no longer has a monopoly on space technology.

The Industrial Base is Capable, but Fragile

The space industry has certain unique characteristics that set it apart from other areas of manufacturing. The production of spacecraft and launchers has historically involved low production quantities and a high degree of specialization of payloads, interfaces, and ground equipment. The successful design, manufacture, and operation of space systems have been heavily dependent on uniquely qualified systems engineers and skilled technicians. There is clear interdependence between the three sectors of the nation's space program. For example, if the military and/or civilian space budgets are cut significantly below current projections, the commercial sector will be impacted by the attendant reduction in the intellectual and industrial bases of the supporting industry.

Many aerospace prime contractors are concerned that cutbacks in government procurements or declines in export orders will quickly eliminate unique capabilities provided by second- and third-tier contractors, create foreign source dependencies, or even lead to production gaps ("dark factories") that can only be bridged at much greater expense than that associated with maintaining capabilities. In the space field, some important components such as solar cells, nickel cadmium batteries, and control moment gyros have only a few domestic sources.

There is at least one key technical skill that is particularly difficult to maintain in isolation from actual hardware development programs — systems engineering. Systems engineering involves steering an organization to respond to broad mission needs by specifying, designing, and integrating a complex set of hardware and software subsystems to provide cost-effective solutions. The necessary blending of many technical disciplines is a very difficult skill to maintain in academic or research environments due to the demands of specialization. Systems engineering skills are typically honed on actual flight projects, with younger engineers working under more experienced managers; and paper studies do not provide sufficient "real world" pressure.

Given the uncertainties facing the industrial base, our first judgment had to be whether we felt that the nation would be able to maintain capabilities sufficient to meet future national security, civil, and commercial objectives in space. Given continuing debate over the proper level and emphasis of space activity, it is difficult to quantify such an answer. From meetings with knowledgeable representatives of industry and government agencies and a review of materials provided to the Task Group, and combined with our own experiences, we concluded that the United States would be able to meet current expectations — with the important exception of competitiveness in commercial launch services (to be discussed in a later section). If expectations were to increase — for example, to support an accelerated effort to return humans to the Moon and journey to Mars — the industrial base would be able to respond given sufficient lead time. In the national security field, where warning may not always be available, certain critical technologies and capabilities will require special efforts to sustain.

Increasing Confidence in the Future Space Industrial Base

Our confidence in this conclusion on the adequacy of the space industrial base is fragile, however, as it depends on two key assumptions: (1) that adequate technology R&D is funded by the Defense Department and NASA, and (2) that industry downsizing is done efficiently enough that key capabilities are not so diffused that they cannot be brought to bear on demanding problems.

As part of its revised acquisition strategy, the DoD intends to maintain a strong technology base for continued leverage against potential enemies. From the standpoint of the space industrial base, it is important that DoD succeeds. Technology development will allow the retention of many crucial skills. Technology development also provides a hedge against uncertainty in the future direction of U.S. space activity, while avoiding the cost of major programs which may lack public support. If large flight projects in the DoD become rarer, NASA could play an important role in continuing to maintain a talented cadre of systems engineers through its contracts and possibly help retain other skilled personnel as well.

Current projections of the NASA budget do not show the 10% annual real growth suggested by the Augustine Committee. Unlike defense space spending, however, the current NASA projections do not show a decline and NASA should be able to maintain a diverse range of efforts in science, technology, and applications research. Unfortunately, as the Augustine Committee pointed out, "the technology base of NASA has now been starved for well over a decade and must be rebuilt." NASA has taken some useful steps in response to recommendations for increasing user-focused space technology research, notably their Integrated Technology Plan, but follow-through support and funding (to two or three times current levels) has lagged. Support for these efforts needs to be established now, or expected operational cost pressures (partly resulting from past underinvestment in lower-cost technologies) will make future remedies even more difficult.

In securing public support for technology development, it is in NASA's interest to help U.S. firms become and stay world-class competitors. In particular, NASA should give greater weight to commercial space needs, particularly in launch vehicles, in analogy to its successful aeronautics program that it (and earlier, its predecessor agency NACA) has carried out for many decades. The focus should be on high-risk R&D applied to commercially-important problems identified with industry and on rapid technology transfer.

Recommendation 1: To achieve the greatest leverage in maintaining the U.S. space industrial base, the DoD must be successful in implementing its policy to strongly support research and advanced technology; NASA should increase its efforts in space technology and work more closely with industry on technology transfer.

In response to budgetary realities, the U.S. aerospace industry well understands the need to downsize. The most appropriate path will vary from firm to firm, with some selling divisions or merging, while others diversify to serve new customers. Many firms will shrink, while others might grow, hence industry often uses the term "rightsizing" to describe adjustments to the new realities of space business. Such changes take place all the time in the market, but the space industry is unusual in that the government plays multiple roles as both a customer and a regulator.

Thus, the adjustment process is not very efficient and there is the danger that important capabilities could be unacceptably reduced, "critical masses" dispersed, and the industrial base damaged in its abilities to meet government needs.

The government cannot, and should not, manage "rightsizing" — that is industry's job to do in light of domestic and international opportunities. Our review confirmed that most aerospace companies have been performing continuing, intensive reviews of their government and commercial business bases, and many have already taken dramatic actions to refocus their efforts. U.S. laws and regulations may, however, seriously inhibit an orderly process of industry restructuring and adjustment. Probably the greatest obstacles are antitrust regulations, which prevent discussion and voluntary collaboration on corporate downsizing and specialization decisions that affect technologies and competencies important to the space industrial base. These rules should be amended to encourage the formation of closer relationships between suppliers and producers and the establishment of joint production (as well as R&D) ventures that can become successful world-class competitors.

Another set of obstacles to efficient industry restructuring are excess, underutilized production and test facilities. These facilities require maintenance, increase corporate overhead rates, and inhibit the redirection of corporate efforts to other lines of work. In the past, the government created second sources to foster competition even though one firm alone may have had sufficient capacity to meet government needs. In a period of retrenchment, the government should consider allowing accelerated depreciation or credits for the carrying costs of excess facilities and equipment created at government direction. Favorable tax treatment would speed up industry restructuring and help reduce overhead costs. Agreement on what facilities and equipment are legitimate excess should be coordinated between NASA and the DoD.

Recommendation 2: The government should promptly re-examine those laws and regulations that can inhibit efficient industry restructuring and "rightsizing" including areas such as antitrust regulations and tax treatment of excess facilities.

DoD/NASA Coordination

The space-related activities of NASA and the DoD have much in common. They require many of the same core competencies in science and engineering, and they draw new entrants from the same academic institutions. Certainly the missions are different, their management styles are not the same, and security classifications place additional burdens on most DoD programs. Nevertheless, they depend upon essentially the same industrial base for both technological expertise and production capabilities.

Decreasing funding for defense has spurred DoD to conduct a very systematic process to analyze its industrial base. This process encompasses all DoD activities, grouped into major categories such as shipbuilding, aircraft, missiles, and space. The DoD surveys itself and its contractors to identify unique technologies, skills, processes and facilities; to focus in on threatened areas; and presumably to recommend actions to preserve essential elements. At times, the DoD will coordinate its efforts with the Department of Commerce, which also monitors the defense industrial base, deals with foreign availability questions, and manages dual-use export controls. Thus far, the process has been focused on DoD needs, and NASA has not participated in the review of space-related industrial base issues, although some NASA contractors certainly have. While results of the DoD analysis are not yet available, from industry presentations it appears that certain key technologies may require special support. These technologies include large deployable structures (and optics), as well as the stabilization and control of agile spacecraft.

In contrast to the DoD, NASA does not track industrial base concerns in a broad, systematic manner across the agency. Rather, it has focused on solving individual problems such as parts availability and qualifying suppliers within specific programs. This approach may be satisfactory in periods of general expansion or when programs have relatively limited lifespans. It is not likely to remain so during periods when second- and third-tier suppliers are leaving the market and programs are expected to be operating over decades, as has been the case for the Space Shuttle and will be the case for Space Station Freedom.

We recognize, of course, that the national security and civil space communities have very different purposes and distinct institutional identities, and we are not suggesting role or structural changes of any sort. But in a period of declining budgets and rapidly-changing technology, closer cooperation between the two communities can provide useful opportunities to avoid redundant technology developments, maintain crucial skills, and ensure that unique space industrial facilities are available to the nation. In addition, it will be important that essential technologies, processes, or components that can only be procured through foreign sources (or whose domestic sources are at risk) are flagged by prime contractors or procuring agencies.

The lack of inclusion of NASA in the DoD process and the lack of a systematic overview of industrial base issues within NASA are of concern to the Task Group. It seems clear to us that key space technologies requiring special support should be coordinated between the DoD and NASA, with rational assignments of lead responsibilities to the appropriate agency. NASA should examine the well-defined DoD process for possible adoption, and the DoD must recognize the important role that NASA plays in supporting a portion of the industrial base of interest to defense.

Recommendation 3: The DoD and NASA should address space industrial base issues in a closely coordinated format. This should be a continuing effort to enable appropriate government action when critical capabilities are threatened.

NASA and DoD often have incompatible technical specifications, standards, and procurement practices for space components and subsystems. Such incompatibilities foster redundant industrial capacities and additional "transaction costs" for cooperative programs. NASA and DoD should work with industry to minimize government-unique technical specifications and qualification procedures that create incompatibilities in the design, production, and operation of civil and national security space systems. Current initiatives under way at the working levels of NASA and DoD to define common technical standards for electronic components and interoperable communications systems are a step in the right direction.

Unique national space facilities – such as large thermal-vacuum chambers, rocket engine test ranges, and anechoic chambers – have been constructed by industry and government to support U.S. space efforts. During periods of expansion, it was not unusual for the government to encourage duplicate facilities that would serve the time-urgent needs of specific programs. With exceptions in a few specialized areas, the United States will have an overcapacity of facilities for the next decade. As a result, government agencies and private industry will be hard-pressed to maintain these facilities in optimal working condition. Accordingly, a broad review of the need for and capabilities of national space facilities is in order. Certain DoE facilities have space-related applications; these should also be included in any assessment as well. The review should explicitly consider options such as joint ownership by the government and company consortia of facilities deemed vital, but for which the cost of ownership is too great for a single entity to bear. In the past, NASA and the DoD used the auspices of the Aeronautics and Astronautics Coordinating Board (AACB) to provide a framework and plans for aeronautical facilities that withstood the test of many years. We need such coordinated long-range plans for unique space facilities that will be required in the decades to come.

Recommendation 4: The DoD and NASA should jointly review the availability and capabilities of unique government and private space test facilities with the objective of developing a management plan for the rational "rightsizing" of the facility base consistent with projected needs. A revitalized AACB would be an appropriate vehicle for such an effort.

Individual Agency Measures

The forces affecting the space industrial base today and for the remainder of this decade are very different from those of the 1980s. The overall aerospace industry has slowed, some areas are suffering severe contractions, and there have been substantial layoffs at virtually all of the major aerospace firms. Many thousands of smaller suppliers have either left the defense business or closed their doors over the last few years.[21] Second, commercial markets are playing an increasingly important role in driving advances in important technologies such as computers,

[21] The Aerospace Industries Association estimates that approximately 78,000 second and third tier suppliers have left the defense business since 1985.

telecommunications, and flexible manufacturing, to cite only a few areas. It is increasingly apparent that government systems are no longer synonymous across-the-board with state-of-the-art technology. Since commercial development times are short compared to government programs – allowing the rapid incorporation of state-of-the-art technology – and since their production volumes are large, commercial items today can often provide higher performance at lower cost than those developed specifically for defense or civil space applications.

Government agencies should incorporate the new realities of lower defense spending and stronger commercial forces into procurement decision-making. It should not be surprising that procurement strategies designed for periods of rapid expansion are not optimal for a period of shrinkage. Where once the order of the day was to encourage duplication of facilities and production lines as a means of keeping costs down through competition, today's focus must be on preserving vital capabilities within a smaller base. Where once there was greater assurance of suppliers which allowed the specification of unique components, today supplies of needed elements can be more reliably and cost-effectively assured by using commercial capabilities.

Special or unique requirements for low-volume programs result in spares and logistics problems over a program's lifetime. As mentioned previously, NASA and DoD should increase system and component commonality across programs. Where components are applicable to several programs, their specifications and supply sources could be the same. The result would be lower overhead, more economical production runs, and a more economical and reliable spares and logistics program.

Many past studies, e.g., several Defense Science Board reports and the Augustine Committee report, have made recommendations to improve the value received from and efficiency of NASA and DoD procurements. These include minimizing agency-unique contract requirements to allow greater commonality between civil, military, and commercial suppliers, increased use of commercial components, reliance on performance specifications rather than detailed design specifications, and greater use of commercial business practices. These recommendations help the industrial base in several ways: by decreasing reliance on special items which are expensive and difficult to obtain over a long period of time, by using components and systems which require less oversight and documentation, and by permitting a larger percentage of financial resources to go into end items rather than overhead. The procuring agencies generally agree with these recommendations and they are reflected to one degree or another in statements of national space policy. Unfortunately, full implementation of these policy statements and recommendations has been very slow.

As a general approach, the government should take greater advantage of industry's capabilities by better defining its needs and then procuring services to meet those needs, as opposed to merely securing engineering talent to execute its hardware designs. This means specifying performance criteria rather than detailed design specifications, and defining data needs rather than specific spacecraft hardware.

Recommendation 5: The DoD and NASA should accelerate their adoption of the many past recommendations that have been made to increase the value received from contracted efforts. These should include minimizing unique requirements, using performance rather than design specifications, and greater use of commercial business practices and components.

Space-related procurements indirectly consider the health of the industrial base when they assess competitive factors such as a firm's past performance, facilities, skills base, and the like. But award criteria could be extended to directly address the preservation of critical industrial base competencies and the potential industry resizing/restructuring that could result from a given award. In addition, for situations where a prime contractor can locate only foreign sources for an essential capability, the prime should notify the procuring agency. Agencies should be able to make explicit decisions on whether to allow the use of foreign capabilities on an ongoing basis or to develop and sustain domestic sources.

Recommendation 6: The decision criteria for contract awards should give higher weighting to the preservation of critical capabilities through measures such as evaluation of past performance, available facilities and skills, and the potential industry restructuring that could result from the award.

As space systems become more operations-oriented, operating costs will represent a greater fraction of total life-cycle costs. But expenditures for operations contribute less to renewing the space industrial base than new research, development, and production. The major NASA effort to reduce the cost of Space Shuttle operations, through such activities as simplifying procedures and introducing system changes to improve operability, is essential. A program to manage operating costs will be even more important for the Space Station. Systems and subsystems to the maximum extent possible should be designed to be "technology transparent," allowing the incorporation of upgraded components over time to improve capability, reliability, and operability. Reducing the uniqueness of Station elements by employing commercially available components could result in lower costs and easier operations support, while at the same time making use of technology advances driven and supported by the commercial marketplace.

Recommendation 7: Greater emphasis should be given to managing and reducing the operating costs of space systems. Minimizing such costs should be a major design criterion for new systems.

The final area that must be discussed is the division of labor between industry (and appropriate academic institutions), government agencies, and their support contractors. What changes, if any, should occur during a period of industrial base downsizing? The Augustine Committee considered these division-of-labor issues for NASA and its contractors and concluded that the appropriate in-house "hands-on" role should be focused on frontier areas unique to NASA's mission, but not duplicating functions which could and are being performed elsewhere. The Committee also recognized the important role of contract monitoring by "professional systems managers with appropriate experience" but believed the numbers of persons involved in the process could be considerably reduced.

We not only strongly support these conclusions but believe they must be accented in the current environment. The downsizing of government and its support service contractors is necessary if overhead costs are not to consume a disproportionate share of already scarce funds. Furthermore, the government will require fewer oversight personnel as it implements the recommendations of this section. Agencies should resist the inclination to bring critical competencies in-house as industry rightsizes. Through its funding contracts and other relationships, government should position itself as a partner with industry and universities to preserve the industrial base. Government competition with industry further weakens the industrial base government requires and should be attempting to preserve.

Recommendation 8: Government agencies should promptly assess the commensurate downsizing of the in-house and support contractor base in the light of industry restructuring and the efficiencies that can be achieved by the adoption of more commercial procurement practices.

Space Launch

Space launch vehicles bring together technical skills that cut across the entire space industrial base. Launch vehicles utilize advanced materials, computer-aided design and manufacturing processes, sophisticated avionics and guidance systems, thermal controls, and systems integration skills that are found in few other places. At the heart of current launch vehicles are rocket propulsion technologies, which continue to be the key to space access. While it is hoped that programs such as the National Aerospace Plane will provide attractive future alternatives, U.S. access to space for at least the next decade and even beyond will depend on rockets. Not surprisingly, other space-faring nations such as France, Japan, India, Russia, and China have placed much of their space efforts on mastering rocket technologies.

The U.S. commercial space launch industry has been a significant success after initially having to compete with the Space Shuttle for payloads and close the lead established by the European launcher, Ariane. While competition from Europe remains the most immediate threat to U.S. commercial launch sales, the industry is also under tremendous pressure due to declining government orders at the same time that non-market competitors are arriving. Like other areas of international arms trade, non-market economies (NMEs) such as China and Russia are seeking to gain hard currency by offering advanced weapons and technologies to nations around the world in fierce export competitions. Unlike other areas of advanced military technology, however, launch services require less aftermarket support, and this already thin market (10 to 14 transactions per year) is more vulnerable to disruption by aggressive and/or arbitrary pricing and inducements to make sales. Also unlike other countries, NMEs usually do not (or cannot) distinguish between public and private sector activities, and they have little knowledge of actual resource costs.

If it was a poor idea for U.S. firms to have to compete against the U.S. Government in the case of the Space Shuttle, it is a poor idea for those same firms to have to compete against the Russian and Chinese governments. The ceiling set in the U.S.-PRC Launch Service Agreement should be considered the ceiling used for the total of all NME launchers (e.g., Russia, Ukraine, and China) until these countries make the transition to market economies with appropriate limits on government supports and involvement. A "rules-of-the-road" agreement with Europe on acceptable business practices could be a useful international standard for the entry of future market-driven competitors.

Recommendation 9: The United States should implement a fair-trade agreement to provide interim insulation of the U.S. commercial launch industry from unrestricted market access by NMEs and define a "rules-of-the-road" agreement with other governments.

Uncertainty over the international trade environment for launch services is an important issue; but lower-cost technologies are vital for the long-term health of the U.S. launch industry. The Space Shuttle constitutes the sole means of U.S. manned access to space, and the associated industrial base is sophisticated and costly. Our current Atlas, Delta, and Titan launch vehicles, while proven and reliable, are dated and costly. These later vehicles trace their design heritage to the initial generation of intercontinental ballistic missiles. Over the years, numerous modifications and upgrades have been made, but the basic designs make launch processing cumbersome, and little has been done to reduce the time it takes to stack the vehicle, mate the spacecraft to the vehicle, check out the spacecraft and payload, and prepare the combination for launch. In effect, each launch involves unique hardware and is processed uniquely, requiring an army of government and contractor personnel. As a result, the cost of placing a payload in orbit with these old boosters may be almost as much as the cost of the satellite itself, putting these vehicles at a cost and schedule disadvantage compared with newer designs such as the Ariane. Further, as the production and launch rates of these families of expendable boosters slow, experience suggests that launch reliability will also decline, as skills are lost and institutional memory fades.

While our old workhorse launchers may never achieve a cost advantage over a new design like that of the Ariane, there is much that can and should be done to reduce costs and improve operability. For example, laser-fired pyrotechnics decrease costs through simplicity, and they improve safety as well. The most immediate concerns seem to center on the need for infrastructure improvements at Cape Canaveral. U.S. and foreign satellite makers have all commented on the poor condition of facilities there and the preference of their technical personnel for many of the resources available at the Ariane site in South America. It is a sad commentary that French Guinea can be a more attractive working environment than one a few miles from Orlando, Florida. Increased efforts to improve the competitiveness, operability, and reliability of the existing family of expendable launch vehicles should be a coordinated NASA and DoD effort, building on current initiatives, and designed to complement and augment improvement programs of the vehicle manufacturers themselves. New U.S. launch-system concepts are still in the early phases and as a result, no matter what else we do, current launch vehicles and infrastructure will be with us for the remainder of this decade.

Recommendation 10: Through a coordinated NASA and DoD effort, the United States should improve existing launch vehicles and upgrade the operating infrastructure in order to drive launch costs down with improved reliability.

While improvements to existing launch systems are very much needed, they are ultimately limited in their potential for large operating cost reductions. The achievement of significantly lower launch costs will require a new vehicle. In hindsight, it would have been helpful if the technologies being pursued by the National Launch System (NLS) had been developed several years ago. The NLS held promise for creating a significant technological lead over existing Ariane vehicles (especially in manufacturing). Unfortunately, the NLS has received insufficient support to move forward. In part, this has been due to an overemphasis on government missions rather than on the expected private sector benefits from a more competitive launch industry.

Regardless of the vehicle design the United States chooses to develop, the urgent need is to develop and make operational a modern low-cost launch system. This includes not only the vehicle, but ground-support equipment and other supporting infrastructure for a stronger industrial base. Unlike today's vehicles, the system should be designed and built for routine operability and low cost. Such a system would serve several purposes. First, it would reduce the cost to the government of launching its national security and civil space missions. Second, it would provide the nation with a highly competitive commercial launch capability. Third, it would stimulate the increased use of space by lowering the cost of access. The effort applied to developing the new system would also greatly advance the space industrial base in key areas such as rocket propulsion, avionics and guidance, and advanced manufacturing techniques.

Recommendation 11: The United States must develop and make operational a modern low-cost launch system in order to reduce the cost of government space missions, provide the nation with a highly competitive commercial launch capability, and stimulate the increased use of space by lowering the cost of access.

If demand for space transportation does not increase, the United States cannot tolerate further erosion in its market share, or even continuation at current levels, and have a competitive industry without increased government financial involvement. Put simply, the decision is whether to pursue an offensive or defensive strategy to maintain a viable industrial base in space launchers. A defensive approach would protect domestic markets and make incremental, budget-limited improvements in the current fleet through government programs. Instead, we favor an offensive strategy that improves U.S. launch infrastructure and the operability of current vehicles, establishes fair trade rules for international commercial launch services, and makes an orderly transition to a new era of low-cost, high reliability access to space. The President's Commercial Space Launch Strategy already reflects these key ideas, but the U.S. Government has failed to aggressively implement them for a variety of fiscal and bureaucratic reasons. Advisory groups such as ours can only do so much. The nation must act on these and similar past recommendations or risk the continued decline of its space launch industrial base.

Commercial Space

In the United States, commercial space revenues are estimated to be $5 billion in 1992. Compared to over $30 billion of government expenditures, commercial revenues are only about 14% of total U.S. space-related spending. As such, it could be argued that commercial activities represent a small contribution to the nation's space industrial base. We have pointed out earlier, however, that space operations are taking a large and increasing portion of the government's space expenditures and that operations do less to sustain the industrial base than R&D or procurements. Operational costs, so far, take up a much smaller part of commercial programs. Many studies have been done to show that government programs often cost more than corresponding commercial programs, with estimates ranging from 30% to factors of 2 to 3 or more. Perhaps most importantly, commercial programs are continuing to grow, while defense programs and civil spending are, at best, staying flat. Combining all these factors, one can surmise that a healthy commercial sector is and will be more important to the industrial base than the current 14% share would imply.

World leadership in space endeavors cannot be built solely on government programs. Ultimately, it must include leadership in commercial space activities, which help generate a more balanced and efficient industrial base. Even today, commercial forces are dominant in spurring the development of numerous space-related technologies, such as mobile satellite communications, geographic information systems using remote-sensing data, and satellite navigation receivers. Growing commercial activities can counteract some of the decline in government spending over the next several years. More importantly, if strong growth is fueled by new investments in infrastructure and lower-cost access to space resulting from a new launch system, commercial activities could be comparable to those of the government within a decade.

There are a number of ways the government can promote commercial space activities without direct subsidies. Many of these measures have been recommended in previous studies and are being implemented to various degrees. The U.S. should accelerate its review of restrictions on exports in light of the changing international climate. For example, civil communications and remote-sensing satellites should be immediately removed from the State Department's U.S. Munitions List (USML) and controlled through the Commerce Department's Commerce Control List (CCL). This would create greater consistency between U.S. export controls and those of other COCOM members and speed the license review process. The Export-Import Bank should be allowed to provide financing when U.S. launch firms are competing against foreign launchers for U.S.-built satellites. Currently, foreign governments can provide export financing assistance but the U.S. government cannot. The U.S. Trade Representative, in cooperation with other agencies, should accelerate market-opening measures to provide greater export opportunities for U.S. firms in telecommunications and launch services, civilian satellites, and ground equipment. Proposals for international cooperation should be reviewed with the goal of increasing the reciprocal flow of technology to the United States and guarding against the activities of foreign government-sponsored or owned competitors.

Recommendation 12: The government should take action to remove impediments and implement policies in areas such as export regulations, trade financing, and market-opening measures in order to improve the competitiveness of U.S. firms.

Since the government remains the largest customer of U.S. space goods and services, what and how the government buys from private industry is very important to the health of the U.S. space industry. Government agencies should seek procurement opportunities that promote the development of a robust commercial space industry. If the government can utilize commercial items, that provides economies of scale to industry. If the government buys items — commercial or government-unique — with commercial business practices, that lowers paperwork requirements and avoids the cost of overhead for separate government and commercial accounts. For example, the government should consider being an "anchor tenant" in privately-funded projects that have future commercial potential, rather than managing the development of new space infrastructure directly. It should seek to procure services and data (e.g., communications services and remote-sensing data) rather than the hardware (e.g., satellites and ground stations) which produce the data. Technology demonstration programs, involving some risk-sharing with industry, can be a useful stimulus to industry-led R&D, which strengthens the industrial base and trains new generations of technical talent. Such actions will require congressional understanding and cooperation to provide and assure the enabling budgetary stability.

Recommendation 13: Government agencies should seek procurement opportunities that promote the development of a robust commercial space industry through anchor tenancy, buying services and data rather than hardware, and using risk-shared technology demonstration programs.

In preserving the national capability represented by the space industrial base, investment in new knowledge is more valuable than expenditures for operations or oversight. Scientific and technical challenges addressed through small projects often generate more technological innovation per dollar than is the case for large projects. Since there is less downside to risk-taking, small projects tend to be more innovative. Due to their limited scope, they also have shorter lifetimes, which means that recent technology developments are more promptly incorporated. In our view, agency funding of such projects is an extremely attractive and productive approach for preserving the space industrial base and encouraging conversion from national security to commercially valuable activities as well.

Recommendation 14: Government agencies should encourage multiple, small programs in developing space technology and systems in order to encourage innovation and accelerate the translation of ideas into useful products.

Humanity's future in space is greater than what can be accomplished by any one agency or group of agencies. Indeed, it is larger than what can be achieved by one government or any group of governments. Expansion into the solar system, and the strong industrial base that will enable and support that expansion will require governments and the private sector to play different but complementary roles. We need to take steps today to ensure that U.S. commercial industry is prepared to assume a leadership position in developing the economic benefits of the space frontier.

Engineering Education

The Task Group would like to express its concern regarding one aspect of the national infrastructure that will be affected by the shrinking of the aerospace industry — namely, the education of future engineers and scientists. In addition to training new technical and managerial talent, universities have other important roles in the nation's space industrial base. Universities can help maintain crucial, but specialized, skills and lines of research that may not be maintained by industry or government during restructuring. Universities can also provide a flexible mechanism for international cooperation and sharing of capabilities and facilities that are difficult to sustain by any one country.

Perhaps the most immediate questions concern the causes and significance of recent declines in undergraduate enrollment in aerospace engineering — similar to the declines of the early 1970s. While defense downsizing would appear to be a contributing factor to declining engineering enrollment at universities, many other factors seem to be at work as well. And even if the required quantity of engineering talent for space activities is lower over the next few years, ensuring high quality will be essential for meeting national goals.

Our group did not have the time to review these issues in detail. Given its importance, we believe that this area should be addressed by a qualified panel that includes members of the university community as well as representatives from industry and government. The National Research Council seems the most appropriate location for an independent review.

Recommendation 15: The government should initiate a study by the National Research Council to assess the effect of the current defense drawdown on the selection by undergraduates of future technical career paths and the impact on our future ability to accomplish national objectives in space.

4

Summary of Recommendations

Competency to Achieve National Objectives

Recommendation 1: To achieve the greatest leverage in maintaining the U.S. space industrial base, the DoD must be successful in implementing its policy to strongly support research and advanced technology; NASA should increase its efforts in space technology and work more closely with industry on technology transfer.

Recommendation 2: The government should promptly re-examine those laws and regulations that can inhibit efficient industry restructuring and "rightsizing" including areas such as antitrust regulations and tax treatment of excess facilities.

DoD/NASA Coordination

Recommendation 3: The DoD and NASA should address space industrial base issues in a closely coordinated format. This should be a continuing effort to enable appropriate government action when critical capabilities are threatened.

Recommendation 4: The DoD and NASA should jointly review the availability and capabilities of unique government and private space test facilities with the objective of developing a management plan for the rational "rightsizing" of the facility base consistent with projected needs. A revitalized AACB would be an appropriate vehicle for such an effort.

Individual Agency Measures

Recommendation 5: The DoD and NASA should accelerate their adoption of the many past recommendations that have been made to increase the value received from contracted efforts. These should include minimizing unique requirements, using performance rather than design specifications, and greater use of commercial business practices and components.

Recommendation 6: The decision criteria for contract awards should give higher weighting to the preservation of critical capabilities through measures such as evaluation of past performance, available facilities and skills, and the potential industry restructuring that could result from the award.

Recommendation 7: Greater emphasis should be given to managing and reducing the operating costs of space systems. Minimizing such costs should be a major design criterion for new systems.

Recommendation 8: Government agencies should promptly assess the commensurate downsizing of the in-house and support contractor base in light of industry restructuring and the efficiencies that can be achieved by the adoption of more commercial procurement practices.

Space Launch

Recommendation 9: The United States should implement a fair-trade agreement to provide interim insulation of the U.S. commercial launch industry from unrestricted market access by NMEs and define a "rules-of-the-road" agreement with other governments.

Recommendation 10: Through a coordinated NASA and DoD effort, the United States should improve existing launch vehicles and upgrade the operating infrastructure in order to drive launch costs down with improved reliability.

Recommendation 11: The United States must develop and make operational a modern low-cost launch system in order to reduce the cost of government space missions, provide the nation with a highly competitive commercial launch capability, and stimulate the increased use of space by lowering the cost of access.

Commercial Space

Recommendation 12: The government should take action to remove impediments and implement policies in areas such as export regulations, trade financing, and market-opening measures in order to improve the competitiveness of U.S. firms.

Recommendation 13: Government agencies should seek procurement opportunities that promote the development of a robust commercial space industry through anchor tenancy, buying services and data rather than hardware, and using risk-shared technology demonstration programs.

Recommendation 14: Government agencies should encourage multiple, small programs in developing space technology and systems in order to encourage innovation and accelerate the translation of ideas into useful products.

Engineering Education

Recommendation 15: The government should initiate a study by the National Research Council to assess the effect of the current defense drawdown on the selection by undergraduates of future technical career paths and the impact on our future ability to accomplish national objectives in space.

Appendix I

Task Group Members

Daniel J. Fink is President of D. J. Fink Associates, Inc., which provides management consulting to technology based industries. His over 40 years in aerospace engineering and management include service in the DOD as Deputy Director, Defense Research & Engineering, Strategic & Space Systems. Following his government service he joined the General Electric Company in 1968. He was Vice President of that company where he first led GE's Space Division, then its Aerospace Group, and later was Senior Vice President Corporate Development and Planning. Mr. Fink served on the Defense Science Board and is a former Chairman of the NASA Advisory Council. He is a Member of the National Academy of Engineering and was Chairman of the NRC Space Applications board and its Board on Telecommunications and Computer Applications. His honors and awards include the DOD Distinguished Service Award, the NASA Distinguished Public Service Medal and the Collier Trophy (for his work on Landsat). He is an Honorary Fellow of the American Institute of Aeronautics & Astronautics and a former President. He received his B.S. and M.S. in aeronautical engineering from the Massachusetts Institute of Technology.

Joseph P. Allen is President and Chief Executive Officer, Space Industries, Inc., in Houston, Texas. From 1967 until 1988, Dr. Allen served as an astronaut with NASA. His management duties involved astronaut candidate selection and training and he additionally served as a ground support crewman and CAPCOM for Apollo 15, Apollo 17 and STS-1. He flew as a prime crew member on STS-5, the first Shuttle flight to deploy cargo in space, and on STS 51-A, the first space flight to salvage equipment from space. Dr. Allen also served at NASA Headquarters as Assistant Administrator for Legislative Affairs from 1975-1978. He is the author of "Entering Space", a personal account of the space flight experience, and has published widely in the fields of science education and nuclear physics research. Dr. Allen received an undergraduate degree in mathematics and physics from DePauw University and holds Masters and Doctorate degrees in physics from Yale University.

Robert Anderson is chairman emeritus of Rockwell International Corporation. He served nine years as Rockwell's chairman and 14 years as its chief executive officer before retiring from these posts in February 1988. Prior to being named chairman, Anderson served nine years as the corporation's president. He joined Rockwell in 1968 as corporate vice president and president of the company's Commercial Products Group. He was named a corporate executive vice president in 1969, and elected the chief operating officer in 1970. Prior to joining Rockwell, Mr. Anderson spent 22 years with the Chrysler Corporation. He began in 1946 as a graduate student in the Chrysler Institute of Engineering and earned a master's degree in automotive engineering two years later. After holding several engineering positions with Chrysler, he was named chief engineer of the Plymouth Division in 1953 and served in that capacity until 1957, when he was appointed executive engineer for chassis. He became Chryslers' director of Product and Cost Estimating 1958, vice president Planning in 1961, and group vice president of Corporate Automotive manufacturing in 1964. He was named vice president and general manager of the Chrysler-Plymouth Division in 1965.

Philip Culberton is an Aerospace Consultant. From 1965 to 1988 he held a variety of positions with the National Aeronautics and Space Administration (NASA), including General Manager, Associate Deputy Administrator, Associate Administrator for Space Station, and Deputy Associate Administrator for Space Transportation Systems. He served as Staff Director of the President's Committee on Science and Technology and, while assigned by NASA to the Department of State, served as a member of the U.S. team negotiating an anti-satellite weapons treaty with the Soviet Union. Prior to joining NASA he was with the General

Dynamics Corporation. Mr. Culbertson is a former National Executive Vice President of the American Astronautical Society and is a member of the International Academy of Aeronautics. He received a B.S. in Aeronautical Engineering from the Georgia Institute of Technology and an M.S. in Aeronautical Engineering from the University of Michigan.

Don Fuqua is President and General Manager of the Aerospace Industries Association and serves as a leading spokesperson for the U.S. aerospace industry. Before joining AIA, Mr. Fuqua served 12 terms as a U.S. Congressman, representing Florida's Second Congressional District. He was elected Chairman of the House Science and Technology Committee in 1979 after serving on the Committee since joining Congress in 1963. He is a member of the National Aeronautics and Space Administration's Advisory Council and is a founding member of the Challenger Center for Space Science Education. Mr. Fuqua has received numerous awards including the Rotary National Award for Space Achievement in 1988, and the National Aeronautics and Space Administration Distinguished Public Service Medal and the National Science Foundation Distinguished Public Service Award, both in 1986. Mr. Fuqua graduated from the University of Florida with a degree in agriculture economics. He also has honorary doctorate degrees from the University of Notre Dame, Florida Institute of Technology, Florida State University, Florida A&M University, and the University of Florida.

Alan M. Lovelace is Corporate Vice President, General Dynamics Corporation and Chairman, Commercial Launch Services, Inc. a subsidiary of General Dynamics Corporation. Prior to that he was corporate vice president and general manager of Space Systems Division, General Dynamics Corporation. Dr. Lovelace joined General Dynamics in July 1981 after serving as acting administrator of the National Aeronautics and Space Administration since January of 1981. Dr. Lovelace joined NASA in 1974 as associate administrator for the Office of Aeronautics and Space Technology. He was named deputy administrator in June 1976. Since entering Federal service with the U.S. Air Force in 1954, he has held many research management positions. He served at the Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio from 1954 through 1972, having been named Director in 1967. From 1972 to 1973, he served as Director of Science and Technology with the Air Force Systems Command. From 1973 to 1974, Dr. Lovelace was Principal Deputy Assistant Secretary of the Air Force for Research and Development. Dr. Dr. Lovelace received bachelor's, master's, and doctoral degrees in chemistry from the University of Florida. He is a fellow and past president of American Institute of Aeronautics and Astronautics and is a member of the National Academy of Engineering, the International Academy of Astronautics, the Air Force Association, Sigma Xi, and Phi Beta Kappa.

Richard J. Messina is president of the management consulting firm of Messina & Graham, which provides advice to technology-oriented enterprises on strategy formulation, organization design, and operations improvement. A consultant for fifteen years - eight of them with McKinsey & Company - he has served the senior executives of major corporations in such industries as aerospace, electric utilities, financial services, health care, and telecommunications. Dr. Messina has had extensive experience in designing organizations for meeting new strategic challenges efficiently and effectively. This included working with NASA's Johnson Space Center in a year-long study to plan the organizational transition from the era of Space Shuttle design and development to that of Shuttle operations. A graduate of the Amos Tuck School of Business Administration at Darmouth College, Dr. Messina was an Edward Tuck Scholar (the highest academic distinction awarded a Tuck student prior to graduation.) Before entering Tuck, he received his Ph.D. in astrophysics, from Darmouth, specializing in the observation of the optical counterparts of celestial X-ray sources. He graduated from Boston College with majors in physics and philosophy.

John L. Piotrowski, USAF (Ret.), began his Air Force Career as a enlisted man studying basic electronics and ground radar. He was accepted into the aviation cadet program and was commissioned a Second Lieutenant in 1954. General Piotrowski was a project officer on the electro-optical Walleye missile program, after which he introduced the weapon into combat in Southeast Asia. He also was instrumental in establishing the E-3A Sentry as an operational Air Force weapon system. He is a command pilot with more than 5,000 flying hours, including 100 combat missions, and he attained the rank of General in 1985. Major positions held include: Commander, 552nd Airborne Warning and Control Wing Vice Commander, Tactical Air Command; Commander, 9th Air Force; Vice Chief of Staff, U.S. Air Force; and in 1987 until his retirement in 1990, Commander-in-Chief, United States Space Command and North American

Aerospace Defense Command. Mr. Piotrowski now works as an independent consultant.

Charles R. Trimble, President of Trimble Navigation, Ltd., was one of the company's four founders in 1978. From Trimble Navigation's early position as a manufacturer of high-end marine LORAN C radio-navigation systems, the company expanded to its current industry position in the manufacturing and application of the Navstar Global Positioning System (GPS). He received his B.S. degree in Engineering (Physics), with honors, in 1963, and his M.S. degree in Electrical Engineering in 1964 from the California Institute of Technology. Mr. Trimble holds four patents in signal processing and one in GPS. His expertise is in entrepreneurial management and innovation in high technology and he lectures at Stanford University on the Management of Innovation. He has published numerous articles in the fields of signal processing, electronics, and GPS, and has been featured in articles about entrepreneurs in high technology. He chaired the IEEE Electrics Group Seminar on "Large Scale Integration; Approaches and Techniques."

Committee Support

Dr. L.V. (Joe) Scifers, National Space Council
Mr. Courtney Stadd, National Space Council
Dr. Scott Pace, Department of Commerce
Dr. Eva Czajkowski, ANSER Corporation
Mr. Stephen Hopkins, ANSER Corporation
Ms. Kip Stacy, ANSER Corporation

Appendix II

Task Statement

A panel of the Vice President's Space Policy Advisory Board will assess the current strength of the U.S. space-related industrial base and prospects for its health and vitality over the next decade. In conducting this assessment, the panel should consider the implications of declining defense spending, the nature and scope of international competition, and current and projected national security needs. The panel should take into account the changing trade relationship between the U.S. public and private sectors and the government and industries of the former Soviet Union. The panel should also consider the emerging and long-term market and industrial base implications of the entry of other space industry nations such as China, Japan, and members of the European Space Agency.

The panel should not focus on specific companies, but rather should look across a broad range of industries. Issues to be addressed should, at a minimum, include:

- The effects of defense budget reductions on U.S. space related industries including:
  - The magnitude of job losses and the potential for loss of critical skills within the American workforce.

- The potential for loss of industrial capacity and the implications for the maintenance of a domestic competitive base for future government acquisitions.

- The identification of industry sectors where the U.S. risks loss of an indigenous capability and potential reliance on foreign sources for the acquisition, operation, or maintenance of critical space program elements.

- The implications of defense cutbacks for sustaining the cutting edge technology base needed to maintain space leadership well into the 21st century.

-- The implications of expanded international trade enabled by the end of the Cold War, the proliferation of space technology, and the growing interest in international space programs.

-- Impediments to expanded trade, if any, resulting either from current government regulations or from uncertainties associated with federal government policy.

-- Long-term prospects in terms of maintaining U.S. aerospace industrial leadership and worldwide competitiveness.

The panel should provide information and advice on whether actions by the federal government are necessary or should be considered to strengthen the U.S. space industry as a whole. A brief written report and a briefing on the findings are desired by approximately October 1, 1992.

Appendix III

Legal Compliance

Some members of the Task Group, through their private employment, have interests in the aerospace community and consequently, the space industrial base. This factor was taken into serious consideration when they were appointed to the Task Group and pursuant to applicable laws, it was determined that the need for the individuals' services outweighed the potential for a conflict of interest. It was the further determination of the Vice President and the National Space Council that the private interests of the individuals appointed to the Task Group were not so paramount as to impede their objectivity or integrity as members of the Task Group. These determinations were made after coordinating with the Office of Government Ethics to ensure full compliance with existing laws and regulations regarding the avoidance of conflicts of interest.

In addition, the members of the Task Group, recognizing there was an important concern as to avoiding even the mere appearance of a conflict of interest, endeavored throughout their Task Group activities to minimize, wherever possible, any such possible appearance.

Appendix IV

Presentations to the Task Group

August 6-7, 1992

Federal Advisory Committee Act	Lew Fischer Dep. Counsel to the Vice President
Historical Perspective	Dr. Robert Smith National Air and Space Museum
Defense Perspective	Nick Torelli DASD, Production Resources Office of the Secretary of Defense
NASA Perspective	Aaron Cohen Acting Deputy Administrator NASA
Commerce Perspective	Dr. Scott Pace Office of Space Commerce Department of Commerce
Labor Perspective	Charles Bofferding, Vice President Harold Ammond, Legislative Dir. Council of Engineers and Scientists Organization

Treasury Perspective	Edward Murphy Department of Treasury
Defense Industry Perspective	Jacques Gansler TASC Corp.
Wall Street Perspective	Wolfgang Demish UBS Securities
International Perspective	Steve Berner Berner, Lanphier and Assoc.
Professional Association Perspective	Cort Durocher Executive Director, AIAA
Academia Perspective	Ron Kutscher Bureau of Labor Statistics Dr. George Hazelrigg National Science Foundation
Industrial Base Review	Matt Jones ANSER Corporation

August 26-27, 1992

Rockwell International Perspective	Mr. Sam F. Iacobellis Executive Vice President and COO
Hughes Aircraft Perspective	Mr. Donald L. Cromer Group Vice President, Space and Communications Group Dr. J. Koehler, Vice President, Telecommunications and Space
Martin Marietta Perspective	Mr. K. M. (Mike) Henshaw V.P., Business Development

McDonnell Douglas Perspective	Mr. Dave Wensley Vice President of Advanced Product Development and Technology
Lockheed Perspective	Mr. George Cline Vice President, Business and Support Operations
Orbital Sciences Perspective	Mr. David Thompson President and CEO
General Dynamics Perspective	Mr. Carey J. Riley V.P., Business Development General Dynamics Space Systems
TRW Perspective	Mr. Gordon Williams V.P., General Manager TRW Space and Technology Group
Thiokol Perspective	Mr. Ed Garrison Chairman and CEO
Engine Consortium Perspective	Mr. Marc Constantine Program Manager, STME Program
American Rocket Perspective	Dr. Paul N. Estey President and COO
General Electric Perspective	Dr. Albert W. Weinrich
Congressional Perspective	Congressman Bob Lagomarsino
Space Systems/Loral Perspective	Mr. Robert Berry President, Space Systems/Loral