Maintaining international competitiveness through attempting to eliminate subsidies--for example, through the General Agreement on Trade and Tariff (GATT) framework--would be most consistent with the commercialization option. Alternatives, such as providing government subsidies for operating costs or technology development to specific U.S. private firms, would be possible, although less consistent with this option's emphasis on private investment and markets. Finally, the ELV commercialization option would provide a model for the future transfer of the shuttle technology to the private sector, but it would not facilitate an easy and integrated reintroduction of the shuttle to the commercial market in the early 1990s, if that were desired.

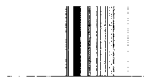
The **public sector option** of allowing NASA to provide ELV services to the commercial market would offer no immediate competitive advantage compared with the other alternatives. Government regulatory requirements and administrative overhead could actually make the price NASA could offer the commercial market higher than the price a commercial ELV vendor would charge for the same service.

The NASA option suggests different U.S. responses to the changing competitive circumstances of the 1990s. Subsidies for operating existing vehicles and developing new ones could be provided more easily, but the force of U.S. agruments for free and unsubsidized competition in the launch market would be diminished accordingly. The NASA option could promote effective use of the shuttle system by including commercial cargos on shuttle flights that would be flown in any case. Nevertheless, the NASA option would maintain NASA's role as an operator of space transportation, a role critics have argued distracts NASA from its primary research function.

The **mixed enterprise option** would create a public/private-sector partnership. Elements of NASA, U.S. aerospace firms, and even the general public (through a stock offering) would be melded into an entity that would operate the shuttle and U.S. ELV services. The enterprise would provide services to the commercial market and federal government, possibly even including all national security needs. The enterprise would require substantial financial and administrative efforts to begin operations, and might involve some additional short-term costs relative to the other options. As under the other alternatives, the mixed enterprise option would probably gain a substantial part of the market in the early 1990s.

Advocates of a mixed enterprise option argue that it would substantially enhance U.S. competitiveness in the 1990s. Like the NASA option, the

mixed enterprise alternative would offer the prospect of an integrated ELV and shuttle capacity, but unlike the NASA option, the enterprise would not maintain NASA as a system operator. The integration of federal and commercial ELV demand would also permit the most competitive U.S. ELV presence in the world market, particularly if, as some advocates suggest, the more favorable market of the interim period would permit the development of a modernized U.S. ELV. Although such new investments would be possible under the other two options, they would be less likely to occur.



CHAPTER I

INTRODUCTION

Important matters of U.S. space policy must be decided in the near future and their ramifications will carry into the next century. In the wake of the Challenger accident, space transportation--and therefore space programs--will be less capable and more costly just as major new military and civilian space efforts (most notably, the space station) are being formulated and as the Congress seeks to meet the targets of the Balanced Budget Act. Thus, questions concerning national space transportation policy--what type, how much, and in what institutional framework--are being considered at a time of programmatic urgency and budget stringency.

MAJOR ISSUES

Since the Challenger accident, the Administration has developed three major initiatives in space transportation that could affect U.S. policy for the foreseeable future. First, expanded use of expendable launch vehicles (ELVs) by the Department of Defense (DoD) has already been approved by the Congress. Second, replacement of the Challenger is now being considered by the Congress as part of the 1987 budget process. Third, the Administration plans to move commercial satellite launches from the National Aeronautics and Space Administration (NASA) and the shuttle to rocket launches by private industry, unless the Congress directs otherwise.

Neither the Administration's objectives nor the means proposed to attain them are shared universally, nor have all the issues raised by the loss of the Challenger been fully addressed. In considering the Administration's space program in the fiscal years 1987 and 1988 budgets, the Congress will evaluate these proposals. The Challenger could be unreplaced, procured more quickly, purchased by the DoD as the Senate appropriations bill proposes, or even bought by the private sector and leased back to the government. Both the scientific and commercial communities could be provided with expendable launch vehicles through NASA, or through a U.S. mixed enterprise modeled on the Arianespace example. 1/

1. Arianespace is a quasipublic enterprise that is one-third owned by the French National Space Agency and two-thirds owned by European banks and aerospace firms. Its ongoing (continued)

This analysis addresses these issues of national space policy in the context of the debate over replacing the launch capacity lost in the Challenger accident. It examines the total demand for the U.S. space launch capability through the end of the century, the options available to meet that demand, and the budgetary implications of these options. As this study examines these alternative technological and institutional combinations, it also considers their implications for the larger issues confronting the future of the U.S. space program.

BACKGROUND

Before the Challenger accident, U.S. space officials thought that the late 1980s would see the realization of the shuttle's promise.[2] Planners at NASA and DoD foresaw few obstacles to filling the anticipated capacity of 24 flights a year. The shuttle system had been declared operational and was to enter its second year as the workhorse in deploying satellites. The market traditionally serviced by U.S. launch capability was projected to require the equivalent of 30 shuttle flights annually in the early 1990s, roughly four times the level of actual average launch activity experienced from 1970 to 1985. (Moreover, this estimate was based on scaled-down immediate demands of new, space-based commercial enterprises and excluded the deployment requirements for a new defense system.) While emerging international competition was expected to win a portion of the commercial market that had formerly been a U.S. monopoly, NASA had established a minimum shuttle price that positioned the system to win the dominant share of that market.

The proficient shuttle system was not to be limited to a bulk cargo carrier. Its unique capability, already demonstrated in satellite repair and retrieval, was to be put to use as more Spacelabs were launched and Strategic Defense Initiative (SDI) experiments were conducted. These activities would provide the vital experience in on-orbit construction needed to fulfill the key shuttle role in building NASA's "next logical step," the space station.

---

1. (continued)
research and development program is conducted by the European Space Agency, a consortium of Belgium, Denmark, France, Germany, Ireland, Italy, Netherlands, Spain, Sweden, Switzerland, and the United Kingdom..

2. See Congressional Budget Office, *Pricing Options for the Space Shuttle* (March 1985) for a more detailed history of the space shuttle program.

Space officials also anticipated the realization of cost-effective shuttle operations that would redound favorably on the capability of the entire space program. From a budgetary standpoint, commercial activities would produce revenues in excess of current costs, as would servicing DoD launch requirements. These revenues not only would enable NASA to offset some of the high fixed costs of operating the shuttle system, but also--with modest real growth (one percent annually) in its budget--would allow it to conduct a vigorous space science program and to begin the international space station. NASA also had started to develop a framework for operating the space station, extending NASA's responsibilities to the operation of space infrastructure as well as its primary research and development mission.

The Challenger accident has forced these plans to be held in abeyance. Subsequent developments may all but completely undermine them. Even NASA no longer sees a four-orbiter shuttle system--much less one of three--as capable of reaching a level of 24 flights annually. The DoD is firmly committed to a mixed fleet of the shuttle and rockets and, by 1990, will have available an annual complement of four Titan IVs and at least four medium-lift launch vehicles, the equivalent of almost six shuttle flights. The Administration's announced goal of removing commercial communication satellite traffic from the shuttle will eliminate this source of revenues in the future, and budgetary transfers from DoD are likely to be less than anticipated in the early 1990s, as a portion of the national security workload is carried by DoD expendable launch vehicles (ELVs). The physical capability of even a four-orbiter fleet to build and support the space station has not been proven in actual experience. Finally, the future NASA budget outlook is yet to incorporate reduced DoD transfers, lower commercial revenues, uncertain future real growth, and new costs to improve shuttle safety and replace the Challenger.

Against this backdrop, the arguments for and against the various options facing the Congress assume new complexity. The question of replacing the Challenger can be examined against the demand for space launches in general and demand for the shuttle's unique capability in particular, and how that capability relates to specific programs. The Administration's proposal to replace Challenger does not specify the source of its funding, but is clear that the orbiter will not be built with all new funds. This raises the question of what previously planned activities will suffer cuts and how these cuts will effect the overall national space agenda. The current Senate alternative proposes DoD funding, but leaves open the question of which planned DoD activities will have to be cut back to provide for the orbiter.

Proposals to commercialize ELV launches have been resurrected by the Challenger accident. Yet, commercialization may be a short-sighted option since foreign public and mixed enterprises are likely to crowd the launch market of the early and middle 1990s. Other alternatives have been raised, including a return to ELV services provided by NASA or the establishment of a U.S. mixed enterprise similar to Arianespace. The current situation marks a turning point in U.S. space transportation policy. Therefore, the Congress may wish to consider these alternatives as they could affect not only the remainder of the 1980s but the competitive position of the United States in commercial space activities throughout the rest of the century.

CHAPTER II

FEDERAL AND COMMERCIAL DEMAND FOR SPACE TRANSPORTATION

The federal government has been its own best customer for launch services over the past 15 years and is likely to remain so over the next 15 years. Anticipating these requirements, thus, is a major factor in determining the proper investment in federal space transportation. At the same time, a consistent objective of U.S. space policy has been to foster and serve the commercial demand for launch services that currently is dominated by communication satellites. Gaining a share of this market for the United States remains a policy objective in spite of evolving competition in the international launch market. For this reason, the total anticipated demand for launch services must be considered in the decision to invest in space transportation.

The demand for space launches is defined as payloads that are ready to be integrated with launch vehicles and that have enough financing, public or private, to cover launch costs. Launch demand is measured in units of shuttle flight equivalents (see box). Total demand is usually presented as the sum of demands from three different categories of users: U.S. defense and national security, U.S. civilian government (including NASA), and foreign and commercial. The primary **defense and national security demand** arises from the launch of satellites that provide communications, photo reconnaissance, early warning, and weather forecasting. In the immediate future, navigational aids will be added to this list. **Civilian government demand** consists of deployable scientific payloads for such purposes as planetary exploration; satellites providing public services, such as the Tracking and Data Relay Satellite (TDRS); and a new set of round-trip scientific experiments, some with commercial potential, made possible by the shuttle. The space station (currently planned for the 1990s) would initiate significant new demand for space transportation during its construction period and an ongoing requirement to serve space station personnel and projects. **Commercial demand** includes both private payloads and those of foreign governments that lack appropriate launch services. It is currently dominated by deployable communications satellites, but could expand in the future to include early space manufacturing ventures.

MEASURING LAUNCH ACTIVITY

The "shuttle flight equivalent" is used as a unit of measure throughout this report and is defined in standard terms and conditions established by NASA convention over the years. While the unit is precise enough to provide a reasonably accurate representation of the level of launch activity, it is defined with reference to a specific set of parameters that not all shuttle launches, past or projected, conform to. A shuttle equivalent is defined as an orbiter capable of carrying 65,000 pounds (lbs.), launched with a 50,000 lbs. load from the Kennedy Space Center to a low earth orbit of 28.5 degrees, 160 nautical miles above the Earth. This represents a load factor of slightly above 75 percent, acknowledging that:

- Not all shuttle flights can be reasonably expected to be loaded fully at all times;
- Not all orbiters are capable of carrying the 65,000 lbs.; for example, the older, heavier Columbia cannot carry as heavy a load as the newer Atlantis and Discovery; and
- The 65,000 lbs. capability requires that the space shuttle main engines must run at 109 percent of rated capacity and other key systems--for example, the orbital maneuvering system--must operate at safety margins too thin to be acceptable in a presumably more conservative postaccident environment.

Thus, the shuttle equivalent used by NASA and in this report can be seen either as a fully capable shuttle carrying 75 percent of a load on average, or as a fully loaded but less capable shuttle.

Both the historical estimates and demand projections of annual launch activity developed in this chapter and the capacity projections presented in Chapter III require that the capability of U.S. expendable launch vehicles be converted into equivalent space shuttle loads. Conversion introduces additional imprecision into the estimation procedure in that the capabilities of specific ELVs have grown through time--for example, the Delta of 1970 is not precisely the same as the Delta of 1980. These discrepancies have been corrected to the extent possible. The specific equivalencies used in converting the historical activity of ELVs into equivalent shuttle flights were: Saturn I = .6; Titan III = .5 to .7; Titan Agena = .33; Atlas Agena = .33; Atlas E/F = .25; Delta = .15 to .21; Atlas Centaur = .33; and Scout = .125. Past shuttle flights themselves were adjusted downward to account for their carrying less than a full shuttle equivalent according to estimates of actual loads provided by NASA and data presented in *Space Shuttle Payload Flight Assignments*, NASA Space Transportation System (November 1985).

THE OFFICIAL CASE

The NASA and DoD have projected the level of launch demand that will need future U.S. launch capability. In addition, NASA contracts with Battelle's Columbus Laboratories to perform an annual survey of commercial launch demand. 1/ Although developed before the Challenger accident, these projections provide an official view of U.S. space transportation demand between now and the end of the century; for example, they are the basis for estimating the backlog of payloads awaiting launch when shuttle service is reinstituted. Before the Challenger accident, federal officials anticipated impressive growth both in traditional satellite deployment and in new kinds of activity, such as space construction, servicing orbiting spacecraft, and round-trip scientific experimentation. According to this official view, the group of users traditionally served by the United States would rapidly expand its requirements from about 7.5 shuttle flight equivalents annually in the first half of the 1980s to almost 30 equivalents annually throughout the 1990s.

Official Case Projections

A set of projections constituting one version of the official case is presented in Table 1. Rapid growth in launch demand was anticipated in the late 1980s as the demand traditionally met by U.S. providers climbed from an actual level of 12 equivalent flights (including ELVs) in 1985 to a projected level of more than 30 flights in 1989. The latter level was projected to last throughout the 1990s, with a peak of 35 reached in 1993, the assumed starting year of space station construction. 2/ Under the official case, the shuttle flights lost from 1986 through 1988 would create a backlog of about 60 equivalent flights to be added to new demand beginning in 1989. Even these high demand levels could be viewed as a conservative version of the official case, in that two potential sources of launch demand growth--deployment of a space system to defend against nuclear attack (as a result of the Strategic Defense Initiative, or SDI), and extensive manufacturing in space--are not included in this case.

---

1. Battelle's Columbus Laboratories, "Outside Users Payload Model" (July 1985).

2. In the past, demand projections were synonymous with demand for U.S. capacity. The commercial component, some 25 percent to 30 percent of the total load projected, however, will now be partially served by foreign launch providers, such as Arianespace.

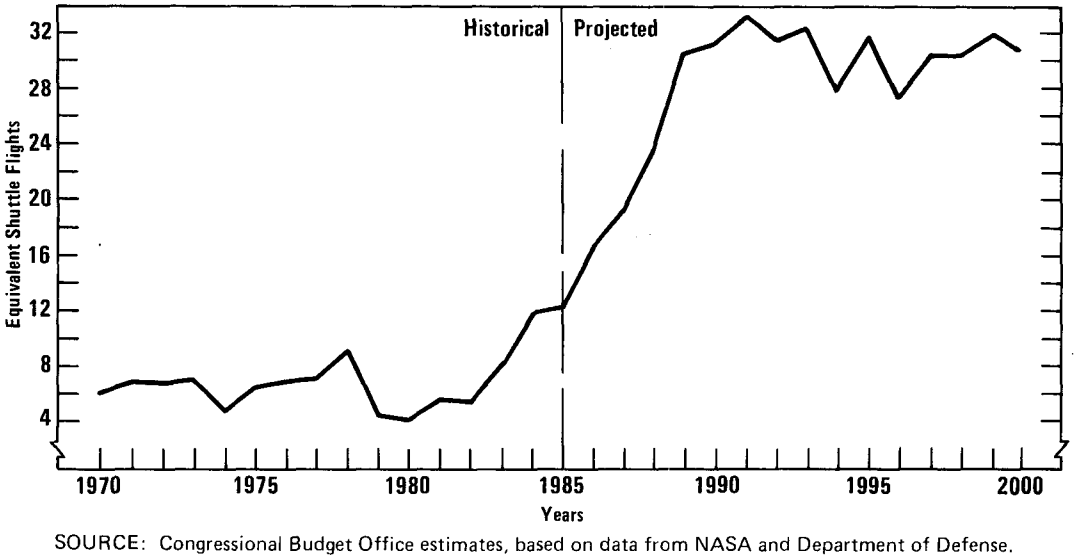
TABLE 1. OFFICIAL CASE DEMAND PROJECTIONS, BY MAJOR COMPONENTS, 1986 THROUGH 2000
(In equivalent shuttle flights)

Year	Department of Defense	NASA and Other Federal Agencies	Commercial	Total
1986	3.0	7.2	6.7	16.9
1987	5.7	8.7	5.1	19.5
1988	12.0	6.9	4.8	23.7
1989	15.2	8.7	6.9	30.8
1990	13.8	12.2	5.4	31.4
1991	16.9	9.7	6.8	33.4
1992	14.4	11.0	6.2	31.6
1993	15.1	10.0	7.4	32.5
1994	12.4	9.0	6.7	28.1
1995	12.4	13.0	6.3	31.7
1996	10.4	11.0	5.9	27.3
1997	12.1	11.0	7.4	30.5
1998	12.1	11.0	7.3	30.4
1999	12.1	11.0	8.9	32.0
2000	12.1	11.0	7.7	30.8

SOURCES: The official case projection is drawn from several primary sources. Federal government projections for 1986 through 1992 reflect the preaccident shuttle manifest as presented by NASA at a briefing to National Research Council, May 16, 1986, and publicly announced DoD plans to begin operations of the Titan IV and Titan II ELVs in the late 1980s. DoD requirements for 1993 through 1995 reflect the DoD mission model of January 28, 1986 less three flights in 1993 and six flights each in 1994 and 1995 for Strategic Defense Initiative deployment. Requirements for 1995 through 2000 are projected at the annual average level of the preceding five years. NASA and other federal government requirements for 1993 through 1995 are estimates of space station construction, logistics, and payload support as presented in a statement by John D. Hodge, Space Station Administrator, NASA, before the Subcommittee on Space Science and Applications of the House Committee on Science and Technology, 99:2, April 10, 1986. The estimates for 1996 through 2000 are the average annual requirements of the preceding five years. Commercial demand for 1986 through 1994 is based on the 1985 Battelle low model estimate of commercial demand. Battelle's Columbus Laboratories, "Outside Users Payload Model" (July 1985). Demand thereafter through 2000 reflects the Battelle model plus one additional shuttle equivalent in 1995 and 1996 for commercial operations taking advantage of the space station, two additional flights for the same purpose in 1997 and 1998, and three of this type of flight for 1999 and 2000.

According to official case projections, all types of shuttle users would increase their launch demands above current levels. In the late 1980s, DoD requirements are projected to increase threefold above the five to six shuttle equivalents they required in the early 1980s. This increase would stem from deployment of two new systems (Global Positioning System--to support precision navigation--and Milstar--an advanced communication system); limited SDI tests and experiments; and upgrading of existing satellite systems. In order to build and support the space station, NASA requirements would grow dramatically during the first half of the 1990s to an average of more than 10 flights a year. Thereafter and through the end of the century, NASA activity would continue at a high level (11 flights annually) to support the space station, the activities of other on-orbit spacecraft, and general civilian government requirements. The emergence of Arianespace as a competitor, on the other hand, was expected to diminish the U.S. share of the annual average of 7 equivalent flights required by the commercial market. Nevertheless, the shuttle's unique capabilities and low prices were expected to capture 75 percent of that market. Figure 1 presents this projected official case and compares it with actual launch demands during the 1970 through 1985 period.

Figure I.
Historical and Projected Official Case Launch Activity



SOURCE: Congressional Budget Office estimates, based on data from NASA and Department of Defense.

NOTE: The launch activity represented here is for the market traditionally served by U.S. launch capacity. Until 1983, that market was monopolized by the United States. Begining in 1983, foreign commercial launches are included as follows: 0.5 equivalent shuttle flights for 1983 and 1 each for 1984 and 1985.

Critiquing the Official Case

The official case is based on NASA and DoD projections of their own requirements and projected commercial demand as estimated by contractor studies sponsored by NASA. In the past, these projections of launch demand have been greatly overstated. Moreover, the Challenger accident has reinforced the conditions that tend to force actual launch demand below official projections.

Previous projections of launch demand have overestimated actual demand in both the immediate future (one to three years beyond the date when the forecast was made) and the longer term (beyond three years). The history of the NASA forecast of launch activity for 1985 is illustrative. Like the official case projected above, this forecast was used in policy planning and represented a synthesis of NASA's internal needs, DoD's assessment of its own needs, and contractor projections of commercial demand. In 1979, 44 shuttle flight equivalents were projected for 1985, but this estimate dropped to only 39 flights in the 1980 projection for 1985 and 22 flights in the 1983 projection.

Some of this decline represented a fall in anticipated shuttle capacity. But if problems of shuttle capacity created the 22 flight difference for 1985 between the projections of 1979 and those of 1983, then 1983 was sufficiently early for users--public and private alike--to procure ELV launches to assure access to space. The clear implication is that part of the 44 flights projected in 1979 resulted from overestimation of demand. The history of forecasts for 1985 ends with an early 1985 forecast of 14 shuttle flight equivalents, close to the level of slightly over 12 (including ELVs) actually undertaken. 3/

In the current situation, overestimated demand for 1986 through 1992 could lead to an unrealistically high estimate of the backlog waiting to be flown when both the shuttle and expendable launch vehicles are again in service. If the backlog is defined as the flights that would have been flown from 1986 through 1988, the official case backlog would be 60 flight equivalents. As seen in Figure 2, the 1979 forecast for 1986 through 1988 projected 49 flights in 1986, 52 in 1987, and 58 in 1988. Like the forecast for 1985, these estimates have fallen over time. Between 19 and 25 shuttle equivalents are projected in more recent versions of the official case.

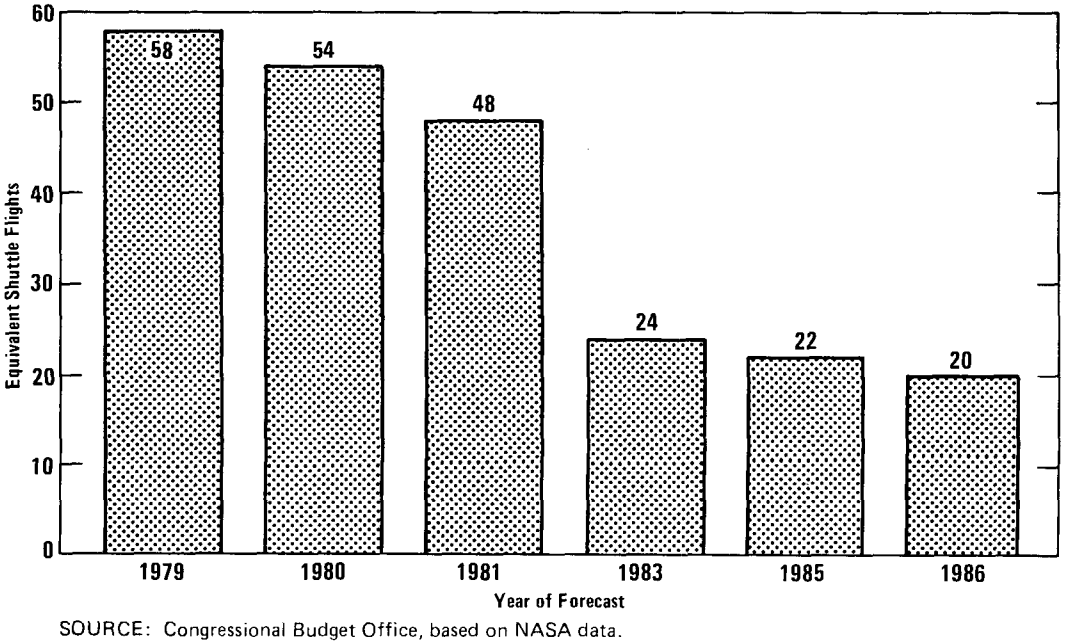
---

3. General Dynamics, Space Systems Division, "Launch Vehicle Availability Assessment" (prepared for annual NASA forecast data, March 1986).

There are several reasons for the consistent overestimation of launch demand. First, in responding to projection surveys, potential launch service users systematically underestimate the technical, market, and budgetary constraints that tend to force actual space transportation demand below planned demand. Second, military launch requirements are overestimated because DoD assumes that satellite life spans will be far shorter than actual experience indicates. Third, NASA's projections of its own needs, particularly when the shuttle system is concerned, are often overstated because it is assumed that planned capacity (usually overstated itself) will be filled by budget-supported demand when, in fact, the Congress regularly has approved lower appropriations than reflected in NASA's advanced planning.

Budgetary considerations are likely to have a greater effect on the official case projection in the future then they have in the past because of the Challenger accident. All other budgetary issues aside, the accident will require unanticipated NASA spending to reconstitute the system. If, as the Administration proposes, a replacement orbiter would be only partially financed by new funding, decreases would be likely in the funds available to plan and prepare for future launches. Accordingly, NASA's demand will be less than predicted in the official case.

Figure 2.
NASA Forecasts of Launch Activity in 1988



SOURCE: Congressional Budget Office, based on NASA data.

The cost of launching also is likely to increase as more conservative methods are introduced into shuttle operations. This point is pertinent to fulfilling DoD requirements which will cost more than anticipated in the official projection, whether they are carried on the shuttle or ELVs. Higher launch costs will tend to decrease the attractiveness of marginal activities and accordingly lower DoD demand.

The current official case is likely to go the way of its predecessors--that is, over time it will come to represent an overly optimistic vision of what actually will occur. Consequently, an alternative reference point is needed to examine future launch needs. Historical launch activity and its determinants are a place to begin.

LAUNCH ACTIVITY: 1970-1985

From 1970 through 1985, the launch market traditionally served by the United States averaged 7.5 equivalent shuttle flights each year, excluding the Apollo launches of the early 1970s. Table 2 presents the Congressional Budget Office's (CBO) estimate of this activity for 1970 through 1985. This launch demand was entirely served by U.S. launchers until 1983. From 1983 through 1985, these estimates include the foreign activities that contributed between 0.5 and 1 shuttle flight equivalent during each year. Table 2 shows an upward trend in annual average total launch activity. Actual launch activity in any given year need not equal the demand for launch services in that year--for example, problems with launch vehicles have periodically delayed the launch of payloads that were ready to fly. Throughout the 1970s and until the shuttle-induced delays in the early 1980s, however, the supply of ELVs was sufficiently flexible to permit actual launch activity to reflect total demand. In other words, the annual production levels of ELVs could be matched to total demand.

Federal requirements have consistently dominated the demand for U.S. launch services. Over 80 percent of launches from 1957 through 1982 were used by the public sector. From 1970 through 1985, national security alone accounted for an average of 45 percent of the payloads flown on U.S. systems. During the same period, other federal requirements--NASA and the National Oceanic and Atmospheric Administration (NOAA)--accounted for another 25 percent of the spacecraft launched by the United States, with foreign and commercial demands making up the remaining 30 percent. The

TABLE 2. U.S. SPACE LAUNCHES, 1970 THROUGH 1985
(In equivalent shuttle flights)

Years	Flights
1970	6.1
1971	7.0
1972	6.9
1973	7.1
1974	5.0
1975	6.6
1976	7.2
1977	7.3
1978	9.3
1979	4.5
1980	4.2
1981	5.7
1982	5.5
1983	8.4
1984	12.2
1985	12.4

SOURCES: Congressional Budget Office estimates. Expendable launch vehicle activity is taken from TRW Electronics and Defense Sector, *TRW Space Log 1982-1983* (TRW: Redondo Beach, Calif., 1984), pp. 40-44; and Congressional Research Service, *Space Activities of the United States, Soviet Union and Other Launching Countries/Organizations: 1957-1984*, Report No. 84-85 (1985). Shuttle flights themselves were adjusted downward according to estimates provided by NASA.

national security share has been stable over the past 15 years.[4] The NASA share fell during the 1970s when the agency and its budget were preoccupied with the shuttle. The foreign and commercial portion has increased during the 1980s as telecommunications deregulation in the United States has permitted new entries into the long-distance telephone market and low shuttle launch prices have encouraged acceleration of satellite launch schedules.

4. Primary data for distribution of activity by type drawn from *TRW Space Log 1982-1983* (TRW Redondo Beach, Calif., 1984); Congressional Research Service, *Space Activities of the United States, Soviet Union and Other Launching Countries/Organizations: 1957-1984*, Report No. 84-85 (1985); and *Aeronautics and Space Report of the President*, (various issues).

Within the bounds of existing launch technology, public policy, both at home and abroad, has been the most significant determinant of total launch demand. Federal demand has been fueled by programs that require the use of space and their supporting budgets. Military and national security programs need satellite systems for communications, photo intelligence, early warning, weather prediction, and navigation. The demand from foreign governments--primarily to launch communications satellites--is also motivated by public spending and constitutes half of the commercial market. During the 1970s, public policy heavily influenced the demand of private communications firms for launch services because of the Federal Communication Commission's (FCC) authority to allocate the orbital positions occupied and the radio frequencies used by private communications satellites.

Spacecraft technology ranks second in significance as a determinant of the demand for launch services. But improvements in satellite capability do not have an unambiguously positive or negative influence on the demand for launch services. On one hand, the demand for launch services is increased by improvements in satellite reliability and capability that permit wider use of space in meeting new private and public demands, or by lower costs of providing established services. On the other hand, increases in satellite reliability, capability, and lifespan diminish the demand for launch services as new satellites are not required to replace old ones, or as a single spacecraft is used to preform the work previously undertaken by several. Larger satellites are more capable, but also more costly. Increases in spacecraft cost, with all other factors held constant, will tend to decrease the requirements for launch services, particularly those that would originate with the budget-constrained public sector.

Private market demand has been a less significant determinant of the demand for launch services than public policy and technology during the last 15 years. When the FCC opened domestic telecommunications to private competition, a surge of private demand for launch services occurred, but this demand, while increasing throughout 1985, remains small relative to that of the public sector. The advent of competition to launch these spacecraft during the 1980s introduced the phrase "commercial launch market" into the space transportation vocabulary. The commercial launch market evokes visions of private satellite companies purchasing launch services from private launch companies. To date, not a single communications satellite launch is true to this vision, however, unless the quasipublic Arianespace is considered a private firm. If the launch reservation by Federal Express on a Martin Marietta Titan vehicle leads to an actual launch, a new era in space will be initiated.

This analysis does not formalize the relationship between historical experience and identifiable determinants of launch demand. These elements are brought to bear in a less formal way, however, to create a more realistic view of demand than the official case. The resulting range of demand provides a basis to assess the adequacy of U.S. space transportation capacity and the need for new investment.

THE DEMAND FOR SPACE TRANSPORTATION: ALTERNATIVES TO THE OFFICIAL CASE

The range of demand estimates offered in this analysis are bounded by a **constrained case** (a downscaled version of the official case) and a **historical case** (a linear projection of the previous 16 years of experience from 1970 through 1985). The constrained case foresees total demand increasing to 21 flight equivalents in 1991 and maintaining a level slightly below 20 flights per year during the 1990s. The historical case projects a smaller increase over the next 16 years, from the level of about 10 flight equivalents annually in the early 1990s to almost 12 flights per year by the end of the century. Table 3 provides the projected annual launch demands for the constrained and historical cases.

The Constrained Case

The constrained case can be thought of as a downscaling of the official case in order to correct for the budgetary and technical optimism that exaggerates federal requirements and to recognize the role foreign providers will play in meeting demand in the commercial market. The average annual launch demand for 1986 through 2000 would be 16.5 flight equivalents compared with 28.5 flights in the official case. The difference between the official and the constrained cases approximates the difference between projected and actual launch activities during the 1980s. While constrained relative to the official view, these projections still represent a historically high level of demand--more than twice the average level of the preceding 16 years.

Table 4 presents the major demand components included in the constrained case--DoD, NASA and other government agencies, and commercial. The DoD and national security demand is reduced to 70 percent of the official case projection. The projected eight to eleven flight equivalents through the 1990s is still significantly above the three to five flights undertaken over the last 15 years and consistent with the historical share of U.S.

TABLE 3. DEMAND PROJECTIONS FOR TWO ALTERNATIVE CASES, 1986 THROUGH 2000
(In equivalent shuttle flights)

Year	Constrained Case	Historical Case
1986	7.1	9.0
1987	10.5	9.2
1988	14.9	9.4
1989	17.3	9.6
1990	18.9	9.8
1991	21.3	10.0
1992	19.8	10.2
1993	18.9	10.4
1994	16.0	10.6
1995	18.3	10.9
1996	15.9	11.1
1997	17.4	11.3
1998	17.6	11.5
1999	16.3	11.7
2000	16.7	11.9

SOURCE: Congressional Budget Office.

activity accounted for by DoD. Demand by NASA and other government agencies is reduced by 50 percent to five to six flights a year--a level slightly above that undertaken in the preceding 16 years. This reduction from the official case anticipates budgetary and technical problems in launching the space science, planned for the late 1980s, and a slower, smaller, and more incremental approach to the space station than currently planned. Finally, the commercial portion of the constrained case projection would be 50 percent of the preliminary Battelle model projection of 1986.[5] The resulting level of three to five flights a year is consistent with emerging foreign competition for the previous U.S. launch monopoly and the setback dealt to space manufacturing by the Challenger accident. Even these levels of commercial demand, it should be noted, represent an optimistic assessment of both the entire commercial market and the U.S. share

5. Battelle Columbus Laboratories, "Outside Users Payload Model" (Draft, August 1986).