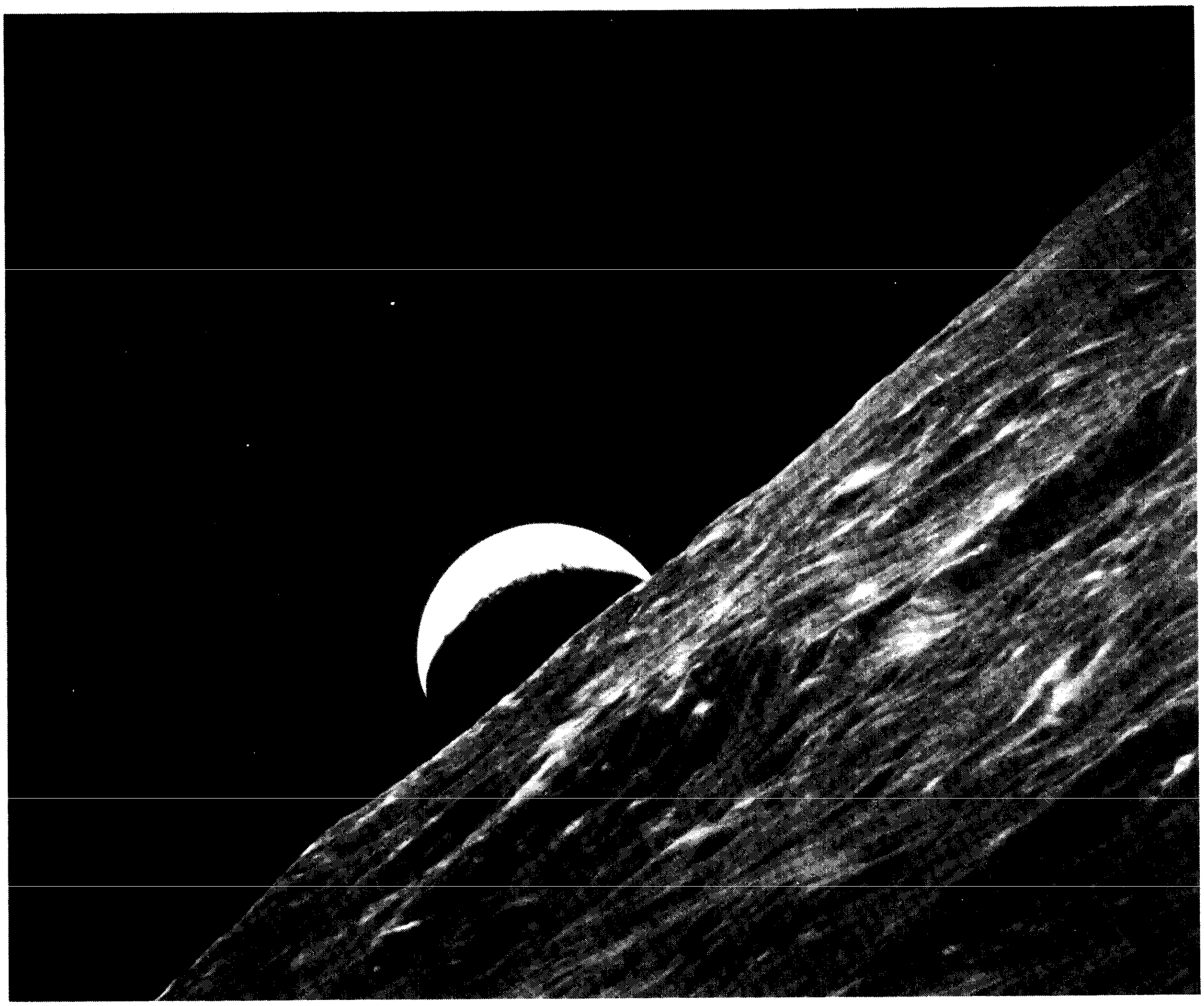
Chapter 2

Space Program Futures



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INTRODUCTION

As the result of long-term constraints on the Federal budget, the Nation can pursue only a few of the many good space transportation concepts that are proposed today. **Until the Nation chooses what it wants to accomplish in space, and what the U.S. taxpayer is willing to pay for, neither the type nor number of necessary launchers and facilities can be estimated with accuracy. Possible driving forces behind additional space transportation capabilities to support publicly funded space activities include the Space Station, space-based ballistic missile defense, a permanent lunar base, and landing people** on Mars. Some have suggested that more modest Government expenditures are appropriate, especially in the face of pressing domestic needs, until we have reduced our current budget deficit and reversed our foreign trade imbalance. Congress, the Administration, and the American people as a whole are faced today with making choices among these or other, alternative options for the U.S. future in space.

The tremendous economic and political changes now taking place in the Soviet Union, Eastern and Western Europe, the Pacific Rim nations, indeed in the entire world, suggest that charting a course will be fraught with considerable uncertainty about the future, and the United States' place in the world economy. It will be important to weigh the future course of our Government's space activities in the context of these uncertainties. A failure to debate these choices vigorously and to select among them decisively will nevertheless result in some sort of national space program, but one that may not serve the long-term political and economic interests of the United States as well as a carefully considered policy.

This chapter focuses on the broad implications for space transportation of following specific space program futures; they were chosen by OTA to span the range of policy options open to the United States. Later chapters present launch technologies and systems and assess their economic and technological implications for the future of U.S. space activities.

SPACE PROGRAM OPTIONS

The choice among policy options such as those summarized below will determine the demand, and hence costs, for U.S. space transportation. The options are not necessarily exclusive; for example, Options 2 and 4 could be pursued at the same time.

Option 1: Continue Existing NASA and DoD Space Programs.

This option assumes that NASA would continue with its current plans to build the planned Space Station and launch several large space-based observatories and robotic planetary spacecraft by the end of the century. It also assumes that no DoD or NASA spacecraft would weigh more than current launch vehicles could lift.

The United States possesses a capable fleet of launch vehicles and the facilities necessary to meet current launch demands and provide for limited near-term growth. By 1992, the year the Shuttle orbiter *Endeavour* comes on line, planned space transportation capability (table 2-1) would be sufficient to lift about 900,000 pounds of payload into low Earth orbit (LEO)[1] per year, assuming there are no major delays or failures.[2] By comparison, in 1984 and 1985, the last years all U.S. launch systems were full y operational, the United States launched an average of about 600,000 pounds into orbit.

Launching 900,000 pounds to LEO each year would cost the Nation about $7 billion per year for transportation alone, assuming no major failures occur.[3] However, as the launch failures of 1985, 1986, and 1987 illustrate,[4] space transportation is risky. No **launch vehicle is 100 percent reliable; launch success rate, which is an indicator of reliability, varies from 85 to 97 percent (table 2-2). If space transportation capacity is limited to**

[1] To a reference orbit 110 nautical miles high, inclined to 28.5" from the equitorial plane.

[2] To reach 890,000 pounds per year the United States would have to launch payloads equivalent to 9 Space Shuttle flights, 6 Titan IVs, 4 Titan IIIs, 5 Titan IIs, 4 Atlas IIs, 12 Delta IIs, and 12 Scouts.

[3] This estimate, in fiscal year 1989 dollars, includes the expected costs of operations and failures, but no amortized nonrecurring costs or cost risk.

[4] Between November 1985 and Mm,h 1987, the *United* States had lost two Titan IIIs, one Delta, one Atlas *Centaur*, the orbiter *Challenger*, and their payloads as a result of technical or human failures. Loss of *Challenger* also resulted m a loss of seven crewmembers. These failures, and the recovery from them, cost the United States an estimated$16 to $18 billion. Arianespace, the French launch company, also sustained a launch failure of an Ariane 3 in May 1986, which cost insurers, Arianespace, and the European Space Agency well over $100 million.

Table 2-l-Maximum Lift Capability of U.S. Launch Vehicles Using Existing Manufacturing and Launch Facilities

Launch vehicle	Mass delivered	Production rate[b]	Launch rate[c]	Capability[d]
scout	570	12	18	6,840
Titan II	5,500	5	5	27,500
Delta H (3920)	7,600	12	18	91,200
Atlas/Centaur	13,500	5	4	54,000
Titan Ill	27,600	10	4	110,400
Titan IV	39,000	6	6	234,000
Space Shuttle	52,000”	n.a.[f]	9	486,460
Total				992,400 pounds
	x90 percent manifesting efficiency[g]=890,000 pounds			

[a]Pounds delivered to a 110 nm circular orbit at 28.5° inclination, unless otherwise noted.
[b]Maximum sustainable production rate with current facilities, in vehicles per year.
[c]Maximum Sustainable launch rate with current facilities,in vehicles per year.
[d]Mass delivered X the lessor of the maximum production rate or the maximum launch rate
[e]This figure is an average of the three existing orbiters' performance to a 110 nm circular orbit (OV102: 45,600 pounds; OV103 and OV104:49,100 pounds).
[f]Not applicable since the orbiter is reusable. No orbiter production is currently planned beyond the *Challenger* replacement.
[g]Vehicles often fly carrying less than their full capacity. Manifesting efficiency is the amount of lift capability that is actually used by payloads or upper stages. Volume constraints, scheduling incompatibilities, or security considerations often account for payload bays being less than full by weight.

SOURCE: Office of Technology Assessment, 1990.

Table 2-2-Launch Vehicle Success Rate

Launch vehicle	Total launches	Percentage successful	
		. Overall	Last 20 attempts
Scout	112	88	95
Delta*	182	93	95
Atlas Centaur**	66	85	85
Titan	145	95	85
Shuttle	33	97	95

*Does not include flights of Delta II.
**Does not Include flights of Atlas II.

SOURCE: National Aeronautics and Space Administration & U.S. Air Force.

Lower Confidence Bounds on Reliability for 95 Percent Confidence (in percentage)*

Launch vehicle	Based on all launches	Based on last 20 launches
Scout	82	78
Delta	89	78
Atlas Centaur	76	66
Titan	91	66
Shuttle	86	78

*Exact, nonrandomized, one-sided lower confidence bounds.

SOURCE: Office of Technology Assessment, 1990.

vehicles currently in the fleet and on order, the United States runs a significant risk that some planned missions—most notably the Space Station-could be delayed, disrupted, or lost because of technical difficulties or accidents. If such risks are deemed too high, additional space transportation capacity may be needed before the end of the century just to carry out current plans.[5] Near-term additional capacity could be provided by one or more additional Shuttle orbiters or a Shuttle-C.

Even if growth of the Nation's space programs is moderate (less than 3 percent per year in terms of total mass lifted to low Earth orbit), it would be prudent to continue to improve the reliability and capacity of current systems by incorporating new technologies into launch vehicles and launch operations. A continuing program to make such improvements to systems and facilities could cost a billion dollars per year. In addition, the United States may need a means independent of the Shuttle for returning crews from the Space Station in case of

[5]Note, however, that purchasing extra space transportation capacity carries a certain cost risk If the extra Capacity were not needed, the expenditures would have been wasted.

emergency. A crew emergency return vehicle and the facilities to support it would add between $1 billion and $2 billion in development costs to NASA's space transportation budget over the next decade, plus an unknown amount of operating costs.

Option 2: Limit growth of NASA's activities for humans in space.

This option would defer beginning construction of the Space Station until the early part of the 21st century and place greater near-term emphasis on space science and robotic planetary exploration. It **would require only six to eight Shuttle flights per year and reduce NASA's need for a heavy-lift launch vehicle such as Shuttle-C.**

Limiting Space Shuttle flights to eight per year would reduce space transportation costs for 1989-2010 by about $10 billion, compared to space transportation costs for OTA's Option 1, in which the Shuttle flight rate would increase to 12 per year by 2005.[6] Probably, even more would be saved on other NASA accounts, because 65 to 70 percent of NASA's budget goes to support space activities involving people in space—a fraction that will increase as Space Station funding grows.

The United States possesses the technology to improve the capabilities of existing launch vehicles and facilities through evolutionary modifications. Even if overall space transportation demand fell well below U.S. capability, **the incremental improvement of current vehicles and facilities could provide a low-cost means to enhance U.S. launch capabilities. Evolutionary improvements will be most effective if they are guided by a long-term plan that includes both a concrete goal and the steps to reach it.**

Option 3: Establish a lunar base or send crews to Mars.

On the 20th anniversary of the Apollo Moon landing, President Bush announced his intention to support "a sustained program of manned exploration of the solar system and the permanent settlement of space."[7] His vision includes the construction of the Space Station during the 1990s and the establishment of a permanent lunar base, as well as human exploration of Mars sometime in the next century (box 2-A).

A long-term program of this magnitude would require building new heavy-lift cargo systems, such as the Shuttle-C or the Advanced Launch System now under study, or even larger ones,[8] and would require new crew-carrying systems. It would also need orbital maneuvering vehicles and reusable orbital transfer vehicles.[9] In addition to scientific instrumentation, crew accommodations, and propulsion units, cargo would consist of large amounts of fuel and supplies to support both Moon or Mars crews and the necessary Earth-orbit infrastructure.[10] Such a program would continue the strong dominance of government in the development and deployment of space infrastructure and require considerable growth in the U.S. budget for the civilian space program.

Option 4: Continue the trends of launching increasingly heavier payloads and/or pursue an aggressive Strategic Defense Initiative (SDI) test program.

The size and weight of spacecraft for communications, navigation, reconnaissance, and weather observations have been increasing slowly and have been forcing the lift capacity of launch systems up with them. An aggressive SDI test program would also require vehicles of greater weight capacity than we now possess.

Although it would be feasible to expand the lift capacity of current launch systems to meet such growth in payload weight, if demand is high, new, advanced systems may be more reliable and cost-effective. This option would require moderate growth in the Nation's capacity to launch payloads.

6 U.S. Congress, Office of Technology Assessment, *Launch Options for the Future A Buyer's Guide*, OTA-ISC-383 (Washington, DC: U.S. Government Printing Office, July 1988). However, the average cost per launch would increase somewhat.

7 President George Bush, Speech at the Smithsonian Institution's National Air and Space Museum, July 20, 1989.

8 National Aeronautics and Space Administration, *Report of the 90-Day Study on Human Exploration of the Moon and Mars* (Washington, DC: November 1989), sec. 5.

9 An orbital maneuvering vehicle is designed t. move payloads around in space Within a single orbit. An orbital transfer vehicle would transfer payloads from one orbit to another, e.g., from low-Earth transfer orbit to geosynchronous orbit.

10 I.e., orbital maneuvering and orbital transfer vehicles, and other supporting elements

Box 2-A--Space Transportation and the Human Exploration Initiative

On July 20, 1989, 20 years after man first set foot on the Moon, President Bush announced his intention to support "a sustained program of manned exploration of the solar system and the permenent settlement of Space."[1] In particular, the President suggested establishing a permanent base on the Moon after the turn of the century and exploring Mars sometime later. The President's initiative follows through on a recommendation first made to President Nixon by the Space Task Group in 1969,[2] and reexamined in the 1986 report of the National Commission on space,[3] and in NASA's "Ride" report of 1987.[4]

Shortly afterward, NASA began a 90-day study to frame alternative strategies for accomplishing these goals. NASA's report starts with the assumption that "reliable access to space will be provided through a mixed fleet of launch vehicles that includes the Space Shuttle, existing expendable launch vehicles, and planned heavy-lift launch vehicles."[5] It also assumes that the Space Station will serve as an orbital space transportation node.

The transportation needs of the Human Exploration Initiative would be substantial. NASA estimates that in order to establish the lunar outpost, it would need a vehicle having a lift capacity of about 60 metric tons (132,000 pounds), capable of launching a payload 7.6 meters in diameter and 27.4 meters long. With three Space Shuttle Main Engines, the proposed Shuttle-C could carry such a payload. NASA estimates total payload mass per year necessary to support contstruction and operation of the lunar outpost would equal 110 to 200 metric tons, depending on whether or not the lunar transfer vehicle is reusable, and whether those missions carry cargo and crews, or cargo only. About three Shuttle-C flights would be sufficient to accomplish this task.

For the Mars mission, NASA estimates it would need a vehicle capable of lifting 140 metric tons (308,000 pounds). This large heavy lift vehicle is about 50 percent larger than any vehicle yet proposed for the ALS program and about twice as large as the largest Shuttle-C NASA has contemplated. Building such a vehicle would require a new development effort, including development of high-thrust liquid engines. Yearly masses delivered to orbit to support the Mars mission are estimated to range between 550 and 850 metric tons (1,210,000 to l,870,000 pounds) depending on mission type and the place in the overall mission schedule.

According to NASA, the existing ELV fleet, with a few enhancements, could support "all the robotic lunar and Mars missions that are required before the human missions begin."[6] However, some of these missions might be made cheaper or simpler if a heavy-lift vehicle were already available. For heavy-lift capacity prior to the end of the century, NASA expects to use its planned Shuttle-C. After that, larger, cheaper vehicles would be required to carry out the Human Exploration Initiative.

Other groups, including the Aerospace Industries Association, and the American Institute of Aeronautics and Astronautics, are exploring space transportation and other requirements for the initiative. For example, a group working at Lawrence Livermore National Laboratory has suggested that the mass requirements for a Mars mission might be vastly smaller than NASA has proposed.[7] As these and other interested groups develop their proposals, space transportation requirements will be an essential part of planning for a return to the Moon or the exploration of Mars.

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1 President George Bush, Speech at the Smithsonian Institution's National Air and Space Museum, July 20, 1989.

2 Space Task Group, *The Post-Apollo Space Program: Directions for the Future*, September 1969.

3 National Commission on Space, *pioneerin, the Space Frontier* (New York, NY: Bantam Books, May 1986).

4 Sally K. Ride, Leadership *and* America's *Future in Space*, a report to the Administrator {Washington, DC: National Aeronautics and Space Administration, August 1987).

5 National Aeronautics and Space Administration, *Report of the 90-Day Study on Human Exploration of the Moon and Mars*, p. 5-1.

6 Ibid., p. 5-4.

7 Lowell Wood, "The Great Exploration: Assuring American Leaderhsip in Manned Exploration of the Solar System," briefing presented to the National Space Council, Nov. 29, 1989.

Option 5: Develop the capability to launch small-and intermediate-size payloads quickly and efficiently to support DoD needs.

DoD space policy calls for the development of a launch system, or systems, to launch satellites at substantially reduced costs with increased responsiveness, capability, reliability, availability, maintainability, and flexibility, plus the ability to operate in peace, crisis, and war. The Air Force Space Command (AFSPACECOM) has stated that to perform its mission, primarily the operation of satellites, it would need the ability to schedule a launch within 30 days, change out payloads on 5 days' notice, and launch 7 satellites in 5 days. AFSPACECOM noted that "the DoD's inability to provide launch support at heightened conflict levels has been highlighted by both policy emphasis on warfighting capability and by the constriction of DoD's launch capability caused by recent Space Shuttle and expendable launch vehicle groundings."[11] The proposed Advanced Launch System (ALS), with its family of launch vehicles, could help meet the requirement for responsiveness—at least in peacetime. ALS is also being designed for a' 'surge' rate higher than average in order to recover from a backlog or to respond in crisis.

It may be impractical to assure launch support in wartime,[12] but if such support proves practical, it would probably require additional launch systems to complement the ALS. For example, the National Aero-Space Plane (NASP) Program is examining the potential for building a highly responsive launch system that could fly to orbit with a single propulsion stage from a conventional runway. If the experimental X-30 that would be built in this program proves successful, it might lead to operational vehicles that are more responsive than an ALS and potentially as survivable as, say, SR-71 aircraft.

Small, transportable rockets, such as the Pegasus or Taurus,[13] could provide a survivable, responsive capability to launch payloads, such as "lightsats"[14] much sooner, but neither they nor operational aerospace planes could launch the largest satellites that have been proposed. U.S. Space Command is currently conducting an Assured Mission Support Space Architecture study to evaluate the potential role of lightsats and survivable launch.

Option 6: Deploy a full-scale space-based ballistic missile defense system and/or dramatically increase the number and kind of other military space activities.

Deployment of a full-scale, space-based missile defense[15] would require large cargo vehicles that are relatively inexpensive to launch. In 1988, the Air Force Space Command stated that:

> . . . deployment of a [SDI] Strategic Defense System. . will require payload capability and launch rates beyond the capacity of present systems.
> . . . even if available, such lift capability and launch rates would not be affordable at today's launch cost.[16]

This remains true in 1990. The Administration has not yet decided on the form a Strategic Defense System would take, but AFSPACECOM established its requirements for ALS payload capability per launch (220,000 pounds[17]) and per year (over 5 million pounds) to accommodate the numerous payloads that a Phase I Strategic Defense System might require and the very heavy payloads that a Phase II Strategic Defense System might require.[18] A Phase I Strategic Defense System, by itself, might

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11 Air Force Space Command, *AFSPACECOM Statement of Operational Need (SON) 003-88 for an Advanced Launch System (ALS)*, Aug. 12, 1988.

12 The Air Force Space Command recognizes that a wartime launch capability is not the only means of providing wartime mission capability; alternatives include proliferation, hardening, or defense of satellites, or reliance on terrestrial systems. None of these, including wartime launch, can assure capability to perform all missions in wartime; see U.S. Congress, Office of Technology Assessment, *Anti-Satellite Weapons, Countermeasures, and Arms Control*, OTA-ISC-281 (Washington, DC: U.S. Government Printing Office, 1985).

13 See later section (ch. 4) entitled *Small Launch Systems*. Pegasus is being designed to launch up to 900 pounds to a 110 nautical mile orbit inclined to 28". Taurus should carry up to 3,000 pounds to a similar orbit.

14 See U.S. Congress, Office of Technology Assessment, *Affordable Spacecraft—Design and Launch Alternatives*, OTA-BP-ISC-60 (Washington, DC: U.S. Government Printing Office, January 1990), ch. 4.

15 Under current plans, the full-scale, space-based ballistic missile defense structure would only be undertaken in Phase II of deployment.

16 Air Force Space Command, Op. cit., footnote 11.

17 Specifically, AFSPACECOM requires launch of 160,000-pound payloads to polar orbit; a rocket that could do that could also launch 200,000 to 220,000 pounds to a low-inclination, low-altitude orbit.

18 For examples, see U.S. Congress, Office of Technology Assessment, *SDI: Technology, Survivability, and Software*, OTA-ISC-353 (Washington, DC: U.S. Government Printing Office, June 1988), pp. 148-153.

require much less capacity,[19] especially if a limited system intended primarily for protection from a few accidental launches is deployed. Current U.S. launch systems can launch only about 52,000 pounds per launch and 890,000 pounds per year.[20]

In some form or another, each of these alternatives has been championed by one or more advocates. Choosing among them and following through with the necessary funding will require political and economic consensus on the part of the American people and continued, focused attention from Congress and the Administration.

Meeting the space transportation needs of specific programs is only part of the reason for making changes to the current launch systems. Other, more qualitative, goals serve to guide policy choices, and may be even more important in setting the Nation's agenda in space. For example, Congress may wish to find the development of critical new capabilities or improvements to the quality of space transportation, or Congress may wish to ensure that funding serves abroad national objective of maintaining leadership in space activities.

PEOPLE IN SPACE

One of the distinguishing characteristics of the U.S. civilian space program is its emphasis on activities by people in space, to demonstrate U.S. leadership in the development and application of high technology. Since the early days of the Apollo program, the "manned" space efforts of the National Aeronautics and Space Administration (NASA) have served as a major driver of the direction and spending of its space activities. Today, NASA's projects involving people in space, primarily the Space Shuttle and Space Station programs, consume about 70 percent of NASA's budget.

Critics of NASA's emphasis on humans in space, especially individuals in the space science community, have questioned the wisdom of continuing to emphasize these activities because of the heavy explicit and implicit demands they place on the civilian space budget.[21] In particular, critics note that using the Shuttle to launch the Hubble Space Telescope and large solar system probes, like Galileo and Ulysses, subjects space science to unnecessary reliance on the Shuttle's ability to meet a launch schedule, and exposes the crews to unnecessary danger. Costs for launching such payloads are generally higher on the Shuttle than with ELVs. These critics point out that Europe and Japan, while spending considerably less on space than the United States, have nevertheless achieved noteworthy scientific and technological results. However, supporters of maintaining the human presence in space argue that such activities provide essential visibility for the U.S. space program and underscore America's international technological leadership:

> The [reamed] space[flight] program is a visible symbol of U.S. world leadership; its challenges and accomplishments motivate scientific and technical excellence among U.S. students; and it provides for a diverse American population a sense of common national accomplishment and shared pride in American achievement.[22]

Current administration space policy calls for demonstrating U.S. leadership by expanding "human presence and activity beyond Earth orbit into the solar system, ' and developing "the Space Station to achieve permanently manned operational capability by the mid-1990s."[23] This policy directs NASA to improve the Space Shuttle system and start the Space Station by the mid-1990s. It also directs NASA to establish sustainable Shuttle flight rates for use in planning and budgeting Government space programs, and to pursue appropriate enhancements to Shuttle operational capabilities, upper stages, and systems for deploying, servicing, and retrieving spacecraft as national requirements are defined.[24] Recently, President Bush announced his intentions to complete the Space Station before the end of the century, establish a permanent Lunar base at the

[19] In U.S. Congress, Office of Technology Assessment, *Launch Options for the Future: A Buyer's Guide,* OTA-ISC-383 (Washington, DC: U.S. Government Printing Office, July 1988), OTA assumed that 50 Titan IV launches per year, in addition to launches for other missions, would suffice to deploy and maintain a representative Strategic Defense System. This corresponds to 2 million pounds per year.

[20] Ibid., p. 3, table 2-1.

[21] Robert L. Park, ''~efica's $30 Billion Pie in the Sky,"*Washington Post*, Jan. 21, 1990, p. B3; Robert Bless, "Space Science: What's Wrong at NASA,''lssues *in Science and Technology,* winter 1988-89, pp. 67-73; Bruce Murray, "Civilian Space: In Search of presidential Goals, ''Issues in Science *and Technology,* spring 1986, pp. 25-37.

[22] John M. Logsdon, "A Sustainable Rationale for Manned Space Flight," *Space Policy*, vol. 5, 1989, pp. 3-6.

[23] The White House, Office of the Press Secretary, "National Space Policy," Nov. 2, 1989.

[24] Ibid.

beginning of the next century, and later send crews to explore Mars.[25]

Achieving each of these goals would be expensive. In the Apollo era, the Nation had the well-defined political goal of landing a man on the Moon within a decade and returning him safely, a goal that carried the rest of the space program and a large budget commitment with it. If the budget for space activities were unlimited and if the needs of the various space interests could all be met equally well, then many space program goals might be usefully pursued at the same time. However, as a result of the current budgetary stringency, and many demands on the Federal budget, Congress must choose among competing ideas for the United States to demonstrate its leadership, rather than attempting to demonstrate leadership across the board as it once did.[26]

In contrast to U.S. civilian activities, the military space program has spent relatively little on crews in space, despite numerous efforts over the years by some to identify military missions that would require crews. Indeed, DoD has recently reaffirmed that it has no requirements for crews in space, although the Air Force has articulated requirements for piloted aerospace vehicles. Production of a piloted aerospace plane for military use, such as is contemplated for a follow-on to the current National Aero-Space Plane Program, would reverse DoD's historical stance.

Expanded commitment to crews in space, as contemplated by NASA and the Air Force, would require increasing budgetary outlays and require the development of new crew-carrying space vehicles. These systems would be costly to develop, but might return their investment over time if operational costs can be kept extremely low.

To illustrate the problem Congress faces, the Space Shuttle system and the Space Station, both of which require crews, dominate NASA's budget for the 1990s.[27] As noted in a 1988 Congressional Budget Office report, simply to maintain NASA's "core program," which includes these major programs, but no large additional ones, will require NASA's overall budget to grow from $10.5 billion in fiscal year 1989 to about $14.4 billion in fiscal year 1995.[28] NASA plans to spend about $2.5 billion per year for investment in its space transportation system, including improvements to the Shuttle, an advanced solid rocket motor, and in-orbit transportation vehicles. Operating the Shuttle will cost at least $2.0 billion per year. Anything new, such as an additional orbiter beyond OV-105, major modifications to the Shuttle, a Shuttle-C, a Personnel Launch System, or an emergency crew return vehicle, will add to these costs.

Spaceflight is inherently risky. As noted in a previous section, the exact reliability of the Shuttle system is uncertain, but experts estimate that it lies between 97 and 99 percent. Therefore, the United States may expect to lose or severely damage one or more orbiters within the next decade, perhaps with loss of life. One of the major challenges for the U.S. civilian space program will be to learn how to reconcile America's goals for the expansion of human presence in space with this potential for loss of life. **In particular, if the United States wishes to send people into space on a routine basis, the Nation will have to accept the risks these activities entail. If such risks are perceived to be too high, the Nation may wish to reduce its emphasis on placing humans in space.**

[25]"Remarks by the president at the Twentieth Anniversary of Apollo Moon Landing," The White House, Office of the Press Secretary, July 20, 1989.

[26]U.S. Congress, Office of Technology Assessment, *Civilian Space Policy and Applications*, OTA-STI-177 (Washington, DC: U.S. Government Printing Office, June 1982), ch. 3.

[27]Most of President Bush's requested 20 percent budget increase for NASA in fiscal year 1990 derived from increases to build the Space Station, which is now scheduled for completion in 1999.

[28]U.S. Congress, Congressional Budget Office, *The NASA Program in the 1990s and Beyond* (Washington, DC: May 1988), pp. x-xiv.