SECTION IV

ACCESS TO SPACE

INTRODUCTION

Nothing has been more significant for the long-term development of the Space Age than the ability to reach Earth orbit. When *Columbia* was lost on Saturday morning, 1 February 2003, one of the issues the accident brought to the fore was the long and complex history of the Space Shuttle's origins, evolution, and operation, as well as the continuing challenge of space access. Even more, the accident opened the issue of space access from the dawn of the Space Age in the 1950s to the present. This is a rich and inviting history, requiring serious inquiry, critical thinking, and hard-edged analysis. The first-generation launchers were all ballistic-missile-derived vehicles that served well; with some upgrades over the years, they are still the backbone of the U.S. space launch fleet. Indeed, Redstone, Atlas, Titan, Delta, and Saturn were all scaled-up variants of the ICBMs, but with notable improvements. The Space Shuttle, the only human-carrying vehicle of the United States since the Apollo program of more than 30 years ago, followed those earlier space launch systems and has served many space-access needs for more than a quarter century.[1]

After more than four decades of effort, access to space remains a difficult challenge. Although space transport services should not be measured by terrestrial standards, if the grand plans of space visionaries and entrepreneurs are to be carried out, there is a real need to move beyond currently available technologies. Unfortunately, the high cost associated with space launch from 1950 to 2005 has demonstrated the slowest rate of improvement of all space technologies. Everyone in space activities shares a responsibility for addressing this critical technical problem. The overwhelming influence that space access has on all aspects of civil, commercial, and military space efforts indicates that it should enjoy a top priority.[2]

Of course, a key element in the spacefaring vision long held in the United States is the belief that inexpensive, reliable, safe, and easy spaceflight is attainable. Indeed, from virtually the beginning of the 20th century, those interested

1. For a discussion of the overarching space-access history, see Roger D. Launius and Dennis R. Jenkins, eds., *To Reach the High Frontier: A History of U.S. Launch Vehicles* (Lexington: University Press of Kentucky, 2002).

2. More than 50 space-access studies have reached this conclusion over the last 40 years. See Roger D. Launius and Howard E. McCurdy, *Imagining Space: Achievements, Projections, Possibilities, 1950–2050* (San Francisco: Chronicle Books, 2001), chap. 4; United States Congress, Office of Technology Assessment, *Launch Options for the Future: Special Report* (Washington, DC: Government Printing Office, 1984); Vice President's Space Policy Advisory Board, "The Future of U.S. Space Launch Capability," Task Group Report, November 1992, NASA Historical Reference Collection, Washington, DC; NASA Office of Space Systems Development, *Access to Space Study: Summary Report* (Washington, DC: NASA, 1994).

in the human exploration of space have viewed as central to that endeavor the development of vehicles of flight that travel easily to and from Earth orbit. The more technically minded recognized that once humans had achieved Earth orbit about 200 miles up, the vast majority of the atmosphere and the gravity well had been conquered, and that persons were now about halfway to anywhere they might want to go.[3]

Although a large number of issues could be explored in the history of space access, five central legacies offer tantalizing possibilities for space history and represent critical issues in the field. These include the following:

1. The limitations of chemical rocket technology.
2. The ICBM legacy of space access.
3. The costly nature of space access.
4. Launch vehicle reliability.
5. The value of reusable launch vehicles (RLVs) versus expendable launch vehicles (ELVs).

The two chapters that follow review each of these legacies, sometimes explicitly but more often indirectly, and raise serious policy issues that must inform any debate concerning access to space.[4]

In chapter 9, John M. Logsdon asks the poignant question, why is there no replacement for the Space Shuttle despite the longevity of the issue on the national agenda? From almost the first flight of the Space Shuttle in 1981, NASA realized that planning should begin on an eventual replacement. Most observers in those early years of the program believed that the current fleet could remain operational for about 20 years but that by about the year 2000, replacement would probably be necessary. Understanding that it took most of a decade, sometimes even more, to carry a major spaceflight program to fruition, they thought it important to begin the process of building a successor second-generation reusable space-access vehicle capable of human launch. Yet, as of 2005 and despite a plethora of studies, little has been accomplished.[5]

Logsdon asserts that there was a fundamental "failure of national space policy over the past three plus decades, and that the lack of a replacement for the Space Shuttle is just one of the most obvious manifestations of that policy failure." At sum, he finds that the "lack of a clear 'mandate' for human spaceflight

3. G. Harry Stine, *Halfway to Anywhere: Achieving America's Destiny in Space* (New York: M. Evans and Co., 1996).

4. Roger D. Launius, "Between a Rocket and a Hard Place: Legacies and Lessons from 50 Years of Space Launch" (presentation in Lessons Learned Session of the 36th American Institute of Aeronautics and Astronautics [AIAA] Joint Propulsion Conference, sponsored by AIAA Solid Rocket Technical Committee [SRTC], Huntsville, AL, July 17, 2000).

5. See Roger D. Launius, "After Columbia: The Space Shuttle Program and the Crisis in Space Access," *Astropolitics* 2 (July–September 2004): 277–322.

over the past 35 years has meant that the U.S. human spaceflight program, and indeed the NASA program overall, has been sustained by a complex coalition of interests, not by a clearly articulated national goal and a stable political consensus in support of achieving that goal."[6] This is an important observation, for it gets to the heart of the overarching issue of rationales for human space exploration. Those rationales have not proven especially compelling, and NASA and its human spaceflight effort have been forced to deal with a lack of motivating reasons for the Agency's activities since the Apollo program.

Instead of developing a finely honed and convincing rationale for the necessity of humans in space, NASA has cobbled together a loose coalition of government interests, industry contractors, politicians of all stripes who are supportive because of "pork" for districts as well as patriotism, and spaceflight enthusiasts who dream of becoming a multiplanetary species. They came together to support the Shuttle as a means of achieving reliable, assured, and flexible access to space and have continued to support it to the present because of the lack of anything better—however "better" might be defined by the various interest groups—on the horizon.

Logsdon offers the bold assertion that the reason for undertaking human spaceflight was reconsidered by the nation soon after the United States began to fly astronauts in 1961 and that this reflection has led to a less supportive public commitment than NASA or the spaceflight community would like. "The people of the United States and their government have been willing over the past 35 years to continue a human spaceflight program," he writes, "but only at a level of funding that has forced it to constantly operate on the edge of viability." Logsdon concludes, "The lack of a replacement for the Space Shuttle is a symptom of this larger reality."

Logsdon goes on to ask how badly Americans want to fly humans in space and finds that the answer to that is "not very badly." Accordingly, at least by the time of post-Apollo planning, the United States, through the democratic process, had reached the conclusion that spaceflight in general, and human spaceflight particularly, had to stand behind a long list of other national needs. Its funding level would be something less than 1 percent of the federal budget per year, and within that budget, NASA should advance a useful space exploration agenda. Logsdon concludes that spaceflight enthusiasts have failed to align their vision of the future with the democratically arrived-at decisions relative to space policy. In other words, something less than the bold visions of the past are necessary in the realities of the present and the future.

At sum, Logsdon concludes that both the community of spaceflight advocates in the United States and the personnel of NASA have overemphasized

6. John M. Logsdon, "'A Failure of National Leadership': Why No Replacement for the Space Shuttle?" chap. 9 in this volume.

human spaceflight's centrality to the modern nation. Instead, he argues for a more realistic perspective that reduces the spaceflight agenda to a realm that might be successful with the funding available. But a question that must be asked is, despite an unwillingness by the public to open the treasury more fully to achieve the human spaceflight vision, would the American public accept a scaled-back program that is far less grandiose? More important for the policy debate concerning a replacement for the Space Shuttle, however, would the American public accept an end to the human spaceflight mission that NASA has conducted since 1961, since failure to replace the vehicle signals that end? Only time will tell if this is how the policy decisions relating to the Shuttle replacement effort will turn out.

In chapter 10, Andrew J. Butrica assesses the historical debate over reusable launch vehicles versus expendable launch vehicles. RLV advocates have been convincing in their argument that the only course leading to "efficient transportation to and from the earth" would be RLVs and have made the case repeatedly since the late 1960s.[7] Their model for a prosperous future in space is the airline industry, with its thousands of flights per year and its exceptionally safe and reliable operations. Several models exist for future RLVs, however, and all compete for the attention—and the development dollars—of the federal government.

Prior to the Mercury, Gemini, and Apollo programs of the 1960s, virtually everyone involved in space advocacy envisioned a future in which humans would venture into space aboard winged, reusable vehicles. That was the vision from Hermann Oberth in the 1920s through Wernher von Braun in the 1950s to the U.S. Air Force's X-20 Dyna-Soar program in the early 1960s.[8] Because of the pressure of the Cold War, NASA chose to abandon that approach to space access in favor of ballistic capsules that could be placed atop launchers originally developed to deliver nuclear warheads to the Soviet Union. NASA developed its human-rated ballistic launch and recovery technology at enormous expense and used it with a 100-percent success rate between 1961 and 1975. As soon as Apollo was completed, NASA chose to retire that ballistic technology, despite its genuine serviceability, in favor of a return to that earlier winged, reusable vehicle. The Space Shuttle was the result.[9]

7. This was the argument made to obtain approval for the Space Shuttle. See *The Post-Apollo Space Program: A Report for the Space Task Group* (Washington, DC: National Aeronautics and Space Administration, September 1969), pp. 1, 6.

8. This quest has been well documented in Ray A. Williamson and Roger D. Launius, "Rocketry and the Origins of Space Flight," in *To Reach the High Frontier*, ed. Launius and Jenkins, pp. 33–69.

9. On this issue, see T. A. Heppenheimer, *The Space Shuttle Decision: NASA's Search for a Reusable Space Vehicle* (Washington, DC: NASA SP-4221, 1999); Roger D. Launius, "NASA and the Decision to Build the Space Shuttle, 1969–72," *The Historian* 57 (autumn 1994): 17–34.

Then there is an alternative position that suggests that the most appropriate approach to space access is through the use of throwaway "big, dumb boosters" that are inexpensive to manufacture and operate. Although reusable rockets may seem to be an attractive cost-saving alternative to expendables because they allow repeated use of critical components such as rocket motors and structural elements, ELV advocates claim, they actually offer a false promise of savings. This is because all RLV savings are predicated on maximizing usage of a small number of vehicles over a very long period of time for all types of space launch requirements. Accordingly, cost savings are realized only when an RLV flies many times over many years. That goal is unattainable, they claim, because it assumes that there will be no (or very few) accidents in the reusable fleet throughout its lifespan.[10]

The reality, ELV advocates warn, is that the probability of all RLV components' operating without catastrophic failure throughout the lifetime of the vehicle cannot be assumed to be 100 percent. Indeed, the launch reliability rate of even relatively "simple" ELVs—those without upper stages or spacecraft propulsion modules and with significant operational experience—peaks at 98 percent with the Delta II, and that took 30 years of operations to achieve. To be sure, most ELVs achieve a reliability rate of 90 to 92 percent—again, only after a maturing of the system has taken place. The Space Shuttle, a partially reusable system, has attained a launch reliability rate of slightly more than 98 percent, but only through extensive and costly redundant systems and safety checks. In the case of a new RLV, or a new ELV for that matter, a higher failure rate has to be assumed because of a lack of experience with the system. Moreover, RLV use doubles the time of exposure of the vehicle to failure because the vehicle must also be recovered and be reusable after refurbishment. To counter this challenge, more and better reliability has to be built into the system, and this exponentially increases both R&D and operational costs.[11]

Designing for one use only, those arguing for ELV development suggest, simplifies the system enormously. One use of a rocket motor, guidance system, and the like means that it needs to function correctly only one time. Acceptance of an operational reliability of 90 percent or even less would

10. Barbara A. Luxenberg, "Space Shuttle Issue Brief #IB73091," Library of Congress Congressional Research Service Major Issues System, 7 July 1981, NASA Historical Reference Collection; *Economic Analysis of New Space Transportation Systems: Executive Summary* (Princeton, NJ: Mathematica, Inc., 1971); General Accounting Office, *Analysis of Cost Estimates for the Space Shuttle and Two Alternate Programs* (Washington, DC: General Accounting Office, 1973); William G. Holder and William D. Siuru, Jr., "Some Thoughts on Reusable Launch Vehicles," *Air University Review* 22 (November–December 1970): 51–58; Office of Technology Assessment, *Reducing Launch Operations Costs: New Technologies and Practices* (Washington, DC: U.S. Congress, Office of Technology Assessment, 1988).

11. Stephen A. Book, "Inventory Requirements for Reusable Launch Vehicles" (paper presented at the Space Technology & Applications International Forum [STAIF-99], Albuquerque, NM, copy in possession of the author).

further reduce the costs incurred in designing and developing a new ELV. Indeed, many experts believe that reliability rates cannot be advanced more than another 1.5 percent above the 90-percent mark without enormous effort, effort that would be strikingly cost-inefficient.[12]

The debate is far from decided. As Butrica shows in this essay, human spaceflight advocates seem driven toward RLVs for space access. This has been an enormously costly perspective over time and directly affects the search for a replacement for the Space Shuttle. Butrica recounts the depressing story of failed attempts to build new vehicles and their eventual cancellation.

Collectively, Logsdon and Butrica encapsulate a critical issue for both the history of NASA and the current policy arena as the space agency struggles to deal with an aging Shuttle fleet, a major reorientation of its mission, and prospects for a post-*Columbia*-accident spacefaring future.

12. B. Peter Leonard and William A. Kisko, "Predicting Launch Vehicle Failure," *Aerospace America* (September 1989): 36–38, 46; Robert G. Bramscher, "A Survey of Launch Vehicle Failures," *Spaceflight* 22 (November–December 1980): 51–58.

CHAPTER 9

"A FAILURE OF NATIONAL LEADERSHIP": WHY NO REPLACEMENT FOR THE SPACE SHUTTLE?

John M. Logsdon

If the policy for the future of U.S. civilian space activity first laid out by President George W. Bush on 14 January 2004 is pursued, the United States will retire the Space Shuttle from service in 2010. Ending Shuttle flights will leave the United States without its own capability to carry its astronauts into orbit until a replacement crew-carrying vehicle makes its first flight with astronauts aboard. According to the Bush "Vision for Space Exploration," this may not happen until 2014.[1] As leading space historian Roger D. Launius has commented, "The inability to ensure a continued capability for human space access has placed the United States in a situation that is unenviable and unfortunate as the twenty-first century begins."[2]

This essay attempts to set out the reasons why the United States has found itself in this "unenviable and unfortunate" situation, with a focus on why the country had not, by the time of the Space Shuttle *Columbia* accident on 1 February 2003, developed a replacement for the Shuttle as a U.S. means for carrying humans into space. That same question was asked by the Columbia Accident Investigation Board (CAIB) set up in the immediate aftermath of the *Columbia* tragedy. (I was a member of that 13-person group.) In addition to its investigation of the physical and organizational causes of the accident, CAIB, in its 26 August 2003 report, offered brief but pointed observations on the broader policy context within which the accident took place and on "future directions for the U.S. in space."[3] This kind of look ahead was not part of CAIB's original charter; it became part of the CAIB focus after members of Congress asked the Board Chair, retired Admiral Harold Gehman, to have the Board's report "set the stage" for a national debate on the future directions of the U.S. civilian space program. Including a discussion of national space policy in an accident investigation report was unprecedented; neither the internal NASA report following the Apollo 1 fire in January 1967 nor the Rogers Commission

1. White House, "A Renewed Spirit of Discovery," January 2004.

2. Roger D. Launius, "After *Columbia*: The Space Shuttle Program and the Crisis in Space Access," *Astropolitics* 2 (autumn 2004): 279.

3. Columbia Accident Investigation Board, *Report*, vol. 1 (Washington, DC: NASA and GPO, August 2003), p. 209.

investigation of the *Challenger* accident had gone beyond identifying and suggesting remedies for the immediate causes of those tragedies.

The brief section titled "Long-Term: Future Directions for the U.S. in Space" in chapter 9 of the CAIB report has had an impact well beyond the Board's expectations. It is not too grandiose a claim to suggest that it led to a fundamental change in national space policy. Staff members in the Executive Office of the President have confirmed that the Board's observation that there had been a "lack, over the past three decades, of any national mandate providing NASA a compelling mission requiring human presence in space" was the direct catalyst for the White House deliberations in fall 2003 that led to the 14 January 2004 announcement by President George W. Bush of the new space exploration vision. This "Vision for Space Exploration," with its call for a "sustained and affordable human and robotic program to explore the solar system and beyond," is explicitly intended as the "national mandate" that had been missing since Americans landed on the Moon in 1969.

The Board made a second set of general observations. The CAIB report noted that "following from the lack of a clearly-defined long term space mission," there had been no "sustained national commitment over the past decade to improving access to space by developing a second-generation space transportation system." The Board concluded that "*the United States needs improved access for humans to low-Earth orbit as a foundation for whatever directions the nation's space program takes in the future.*" The CAIB report suggested that it was "*in the nation's interest to replace the Shuttle as soon as possible as the primary means for transporting humans to and from Earth orbit.*" Finally, it contained the following indictment: "*previous* [unsuccessful] *attempts to develop a replacement vehicle for the aging Shuttle represent a failure of national leadership*" (all emphasis in original).[4]

In his recent comprehensive and insightful analysis of U.S. policy towards access to space, Launius has used even stronger language than the Columbia Board. He suggests that "the lack of a firm decision to develop a Shuttle replacement represents the single most egregious failure of space policy in history."[5]

This essay will argue that there has been an even more fundamental and "egregious" failure of national space policy over the past three-plus decades and that the lack of a replacement for the Space Shuttle is just one of the most obvious manifestations of that policy failure. The series of decisions regarding a Shuttle replacement must be cast in the broader context of U.S. policy with respect to the reasons for sending people to space in the first place. The lack of a clear "mandate" for human spaceflight over the past 35 years has meant that the U.S. human spaceflight program, and indeed the NASA program overall, has been sustained by a complex coalition of narrow interests, not by a clearly

4. CAIB, *Report*, pp. 209–211.
5. Launius, "After *Columbia*," pp. 278–279.

articulated national goal and a stable political consensus in support of achieving that goal. As the CAIB report observed, without such a goal, NASA

> has found it necessary to gain the support of diverse constituencies. NASA has had to participate in the give and take of the normal political process in order to obtain the resources needed to carry out its programs. NASA has usually failed to receive budgetary support consistent with its ambitions. The result . . . is an organization straining to do too much with too little.[6]

It is this situation—"straining to do too much with too little"—that reflects the fundamental failure of U.S. space policy. In the 1969–1970 period, the administration of President Richard M. Nixon made a purposeful decision not to continue in the post-Apollo period the type of space effort that had taken Americans to the Moon. As Nixon stated in March 1970:

> Space expenditures must take their proper place within a rigorous system of national priorities. What we do in space from here on in must become a normal and regular part of our national life and must therefore be planned in conjunction with all of the other undertakings which are important to us.[7]

This declaration was more than rhetorical. The NASA budget was rapidly reduced in the early 1970s to less than 1 percent of the federal budget, approximately one-fifth of its budget share at the peak of Apollo 10 years earlier. Outside of postwar demobilization, few government activities have seen such a rapid decline in the resources devoted to their implementation. More to the point of this essay, this lowered level of budget allocations has persisted to the current time.

WHAT DOES "REPLACING THE SPACE SHUTTLE" MEAN?

Many people talk of replacing the Shuttle as if the meaning of such an undertaking is quite clear. Such is not the case. There are several meanings that could be attributed to the term "replacing the Space Shuttle." They include the following:

6. CAIB, *Report*, p. 209.

7. Richard M. Nixon, "Statement About the Future of the United States Space Program," 7 March 1970, in U.S. President, *Public Papers of the Presidents of the United States: Richard Nixon, 1970* (Washington, DC: GPO, 1971), p. 251.

- Developing an advanced-technology, second-generation vehicle similar in its capabilities to the Shuttle, including the ability to carry both a sizable number of people and large and/or heavy cargo into low-Earth orbit, to provide living and working space for the crew for some period of time, and to be capable of various space operations such as payload deployment and retrieval and in-orbit servicing. Such a vehicle, presumably, would be as reusable as the Shuttle, preferably more so.

- Developing a vehicle that can carry either cargo or passengers to space and deliver its payload to an orbital destination such as the International Space Station; reusability would be a desired, but not necessary, characteristic.

- Developing a vehicle only to carry people to another destination in space and to return them to Earth, with limited or no cargo-carrying capacity. Again, reusability would be a desired, but not necessary, characteristic.

- Developing a vehicle capable of transporting people both to low-Earth orbit and to destinations beyond Earth orbit, such as the Moon, Mars, or a Lagrangian point.

Each of these types of vehicles could be considered a Shuttle replacement, and failure to differentiate among them has caused, and will continue to cause, policy confusion. For the purposes of this essay, the central meaning to be attributed to the term "Space Shuttle replacement" is a vehicle having the capability to transport humans to and from low-Earth orbit. Whether that vehicle would be reusable or not and whether it would be capable of going beyond Earth orbit are secondary considerations. This certainly was what the CAIB had in mind when it judged that "*it is in the nation's interest to replace the Shuttle as soon as possible as the primary means for transporting humans to and from Earth orbit*" (emphasis in original).

What did not happen, either during the CAIB's deliberations or since, was a corresponding adjustment in either the expectations placed on NASA by the nation's leaders or the ambitions of those committed to the vision of an expansive future in space. *The reality that national space policy did not bring ambitions and resources into balance in the 1970s, nor in the subsequent two decades, is the basic policy failure.* Either NASA should have been forced by the White House and Congress to plan and carry out a less ambitious program, or those national leaders should have been willing to provide the resources needed to carry out the ambitious program, with human spaceflight at its

core, that NASA has proposed to implement.[8] By allowing NASA to try to "do too much with too little," national leaders failed in their responsibility as stewards of well-conceived national policy. The space sector has suffered as a result, most visibly with two Space Shuttle accidents and the loss of 14 astronaut lives.

AN ALBUM OF FRUSTRATION

How has this "unenviable and unfortunate" situation come to be? The answer to this question can be portrayed by a set of "snapshots" taken at various times during the evolution of the U.S. human spaceflight effort.[9] This "photo album" of the steps towards the current situation will set the stage for a fuller analysis of *why* ensuring reliable, affordable, and safe human access has been a continuing policy problem for the past two decades:

1. From almost the start of serious thinking about human spaceflight, visionaries have expected that people would travel to and from space in a reusable, winged spacecraft; this image has continued to influence thinking about how to send people to space for most of the time since.

2. The pressures of Cold War competition drove the United States and the Soviet Union to abandon a winged approach to spaceflight and to develop instead crew-carrying ballistic capsules launched into space on top of expendable rockets, most of them derived from missiles designed to deliver nuclear warheads over intercontinental distances. Until the Space Shuttle was approved in 1972, only the U.S. Saturn family of boosters was designed from their start in the 1950s as space launch vehicles.

3. Once the United States had won the race to the Moon, the National Aeronautics and Space Administration in 1969 proposed an ambitious post-Apollo space effort beginning with the rapid development of a Saturn V–launched, 12-person space station. As a "logistics vehicle" for such a station, NASA proposed developing a reusable Earth-to-

8. In May 1992, then-new NASA Administrator Daniel S. Goldin did recognize this situation and told his senior officials to stop making plans that anticipated future budget increases. This was one of the foundations of Goldin's "faster, better, cheaper" guidance. But Goldin was also impatient and wanted to lay the foundation for human missions to Mars. This made his attempts to limit future ambitions not very effective.

9. In his *Astropolitics* article cited earlier, Roger Launius provides a parallel and well-stated account of this history.

orbit launch vehicle called the Space Shuttle. In NASA's 1970 budget presentation, the space station and Space Shuttle were presented to Congress as a single program. When the Nixon administration refused to approve the space station, NASA, in the fall of 1970, deferred—not canceled—its space station plans and directed its Shuttle contractors to design a vehicle capable of carrying pieces of a space station into orbit. This requirement defined the width of the Shuttle payload bay as no less than 14 feet. Thus the currently unbreakable link between the Space Shuttle and International Space Station programs actually has its roots in decisions taken 35 years ago.

4. In 1971, there was intense debate within the Executive Branch and its advisers of whether to approve Space Shuttle development. This debate led, in January 1972, to approval of Shuttle development as a product of "a series of political compromises that produced unreasonable expectations—even myths—about its performance," with a "technically ambitious design [that] resulted in an inherently vulnerable vehicle."[10] The Space Shuttle program was approved even in the face of a fundamental policy decision, made two years earlier, to reduce the priority of and resultant budget allocations for the civilian space program.[11] Based on that decision, the Office of Management and Budget forced NASA, in May 1971, to accept a $5.15-billion development cost ceiling for the Space Shuttle; this led NASA to abandon hopes for a two-stage, fully reusable vehicle and to quickly examine a wide variety of designs that could be developed within that cost cap.

5. In order to make the case that the investment in developing the Space Shuttle was cost-effective, NASA had to gain the agreement of the military and intelligence communities that when it became operational, the Space Shuttle would be the only launch vehicle for almost all government payloads, both human crews and robotic spacecraft. In order to gain this agreement, NASA had to design a Shuttle with specific performance characteristics that increased its technological risks. CAIB noted that "the increased complexity of a Shuttle designed to be all things to all people created inherently greater risks than if more realistic technical goals had been set from the start."[12] Certainly, if the

10. CAIB, *Report*, p. 21.

11. Accounts of the process that led to the decision to develop the Space Shuttle can be found in John M. Logsdon, "The Space Shuttle: A Policy Failure?" *Science* 232 (30 May 1986): 1099–1105; and T. A. Heppenheimer, *The Space Shuttle Decision: NASA's Search for a Reusable Space Vehicle* (Washington, DC: NASA SP-4221, 1999).

12. CAIB, *Report*, p. 23.

Space Shuttle design had been optimized for its crew-carrying role, a less risky vehicle, with more provisions for crew safety, could have been designed.

6. A byproduct of the decisions to develop in the Space Shuttle a vehicle capable of launching all types of payloads was the drying up, beginning in the 1970s, of NASA funding for research and technology development related to any aspect of space transportation not associated with the Shuttle. Thus there was a limited base of technology from which NASA could draw when it did initiate or participate in Shuttle replacement efforts in the 1980s and 1990s.[13]

7. Soon after the first flight of the Space Shuttle in April 1981, the new NASA leadership set as its two top priorities bringing the Shuttle to operational status as soon as possible and getting presidential and congressional approval to develop a (Shuttle-launched) space station. No alternatives to using the Shuttle in this role were considered at the inception of the space station program.[14]

8. Also in 1981, after only two Shuttle flights, President Ronald Reagan approved a formal policy statement saying that the Space Shuttle "will be the primary space launch system for both United States military and civil government missions."[15] This policy was reinforced in a 1982 statement of National Space Policy, which said that "completion of transition to the Shuttle should occur as expeditiously as possible" and that "government spacecraft should be designed to take advantage of the unique capabilities of the STS [Space Transportation System, another designation for the Space Shuttle]."[16]

9. The U.S. Air Force, as the launch agent for both military and intelligence spacecraft, early on recognized the dangers of this "all eggs in one basket" policy. Soon after the Shuttle was declared operational on

13. This statement is not quite accurate. There continued to be some low-level efforts within NASA to examine future space transportation vehicles and technologies even as the Shuttle was being developed during the 1970s, but there was very limited financial support of these efforts.

14. For a discussion of the steps leading to President Reagan's approval of a space station program, see Howard E. McCurdy, *The Space Station Decision: Incremental Politics and Technological Choice* (Baltimore, MD: Johns Hopkins, 1990).

15. John M. Logsdon, ed., *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program*, vol. 4, *Accessing Space* (Washington, DC: NASA SP-4407, 1999), pp. 333–334.

16. John M. Logsdon, ed., *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program*, vol. 1, *Organizing for Exploration* (Washington, DC: NASA SP-4407, 1995), pp. 591–592.

4 July 1982, after only four flights, the Air Force began to argue that the risks and costs of the system could be a detriment to its ability to perform its launch responsibilities for critical national security payloads. Most of those payloads had been designed since the late 1970s so that they could only be launched on the Shuttle. Beginning in 1983, the Air Force campaigned for approval of a backup to the Shuttle in order to provide assured access to space for such payloads. NASA fought this move. The dispute between the Air Force and NASA reached the White House in early 1985, where it was decided in favor of the Air Force.[17] This decision led to the development of the Titan IV expendable launch vehicle, which was capable of launching the largest military and intelligence spacecraft. After the 1986 *Challenger* accident, the Titan IV became the primary launcher for large national security missions, and those spacecraft that had been intended for Shuttle launch had to be redesigned at high cost.

10. Discussions within NASA about the need to develop a second-generation replacement for the Space Shuttle began even before the Shuttle was launched.[18] The first public statement of this need came in the report of the National Commission on Space in January 1986 (made public a few days after the *Challenger* accident). The Commission concluded that "the Shuttle fleet will become obsolescent by the turn of the century." It recommended separating cargo and "passenger" (its term) launches and developing, within 15 years, a new system for "passenger transport to and from low Earth orbit."[19] In contrast, an inside-the-government NASA-DOD National Space Transportation and Support Study during 1985–1986, while agreeing that in the future, separate human-carrying and cargo-carrying launch systems were desirable, concluded that "there was not an urgent need for an advanced manned vehicle; incremental improvements to the Space Shuttle would suffice."[20]

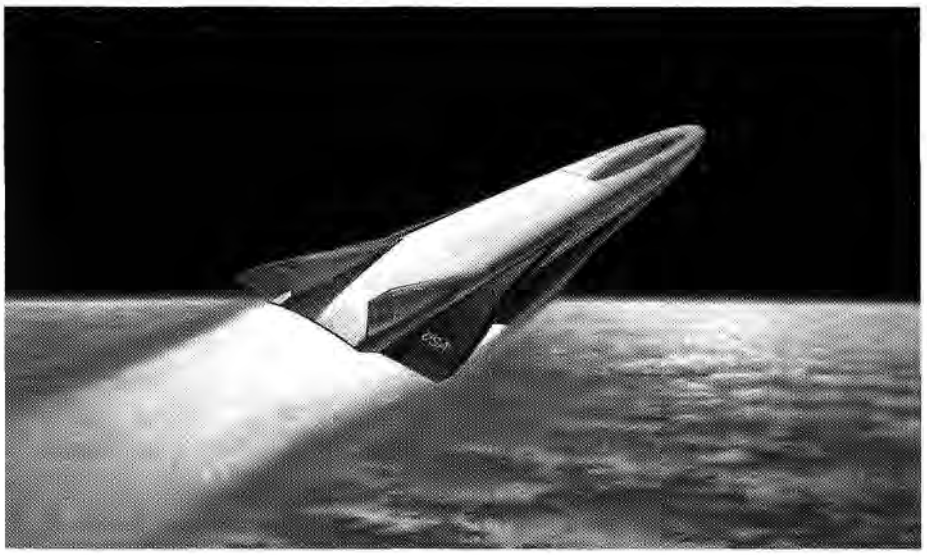
11. While NASA during the 1970s and early 1980s allocated only limited funding to advanced space transportation technology, the Department of Defense did support a fair amount of such research and technology

17. This dispute can be traced in John M. Logsdon, ed., *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program*, vol. 2, *External Relationships* (Washington, DC: NASA SP-4407, 1996), documents II-40 through II-45.

18. Launius, "After *Columbia*," pp. 287–288.

19. *Pioneering the Space Frontier*, Report of the National Commission on Space, quoted in Launius, "After *Columbia*," p. 288.

20. Ivan Bekey, "Exploring Future Space Transportation Possibilities," in *Exploring the Unknown*, ed. Logsdon, vol. 4, pp. 505–506.



The National Aero-Space Plane (NASP) began as a NASA-DOD joint project in 1982. It called for the development of two vehicles capable of SSTO at Mach 25. It was intended to use a multicycle engine shifting from jet to ramjet to scramjet; it would use liquid-hydrogen fuel with oxygen scooped and frozen from the atmosphere. President Ronald Reagan had high hopes for it, announcing in the State of the Union Address in 1986: "We are going forward with research on a new Orient Express that could, by the end of the decade, take off from Dulles Airport, accelerate up to 25 times the speed of sound attaining low Earth orbit, or fly to Tokyo within two hours." It was canceled in 1992 without ever having flown. *(NASA KSC photo no. EL-2001-00432)*

development related to advanced-technology crew-carrying systems. By the early 1980s, these efforts were focused on a vehicle that used air-breathing engines to accelerate to hypersonic or perhaps even orbital velocity. The Air Force program was focused on a TransAtmospheric Vehicle (TAV), while a separate, highly classified, Advanced Research Projects Agency (ARPA) study was called Copper Canyon.[21] In late 1985, all Department of Defense research and development activity on hypersonic flight was consolidated into a program that became known as the National Aero-Space Plane (NASP); NASA joined the Department of Defense as a minority funder and comanager of the NASP effort. This program was given presidential endorsement in the 1986 State of the Union Address, delivered by President Ronald

21. The National Aero-Space Plane Program is discussed in Andrew J. Butrica, *Single Stage to Orbit: Politics, Space Technology, and the Quest for Reusable Rocketry* (Baltimore, MD: Johns Hopkins, 2003), chap. 4.

Reagan on 5 February of that year. In his address, the President spoke of an "Orient Express" that would, "by the end of the decade," be able to "take off from Dulles Airport [near Washington, DC], accelerate up to 25 times the speed of sound attaining low Earth orbit, or fly to Tokyo within two hours."[22]

12. The President's 1986 address came only a few days after the 28 January explosive burning and breakup of the Space Shuttle *Challenger*; seven crew members died in the accident. In the following months, policy toward use of the Space Shuttle came under intense scrutiny. First, the White House, on 15 August, announced that a new Shuttle orbiter would be built to replace *Challenger* but that the Shuttle would no longer be used to launch commercial payloads such as communication satellites. On 27 December, President Reagan signed a directive that established a "mixed fleet" concept for government payloads, with "critical mission needs" supported by both the Shuttle and expendable launch vehicles "to provide assurance that payloads can be launched regardless of specific launch vehicle availabilities." According to this directive, the Space Shuttle would only be used to support programs requiring "manned presence and other unique STS capabilities."[23] These decisions formally reversed the policy that had been one of the foundations of the decision to develop the Space Shuttle—that it could serve as a reliable, affordable launch vehicle for all U.S. payloads. It focused future Shuttle use on missions where the human presence was essential to the mission, not merely crew members delivering cargo to orbit. In 1987, the Air Force announced its support for resuming production of the Delta and Atlas expendable launch vehicles, with the clear implication that the military would in the future use the Space Shuttle only for those few missions that required its specific capabilities. The sum of these post-*Challenger* decisions meant that NASA became not only the operator, but also the main future user, of the Space Shuttle. With fewer missions to fly, with NASA having to pay all the costs of its operation, and with a flat or decreasing NASA budget for most of the 1990s, the Shuttle became a "mortgage" on the NASA budget that had to be paid. Funds for investing in its replacement could be made available only if the NASA budget were increased or the Shuttle program's budget were reduced.

22. Quoted in ibid., p. 65.

23. See the essay by Ray A. Williamson, "Developing the Space Shuttle," and documents II-42 and II-43 in *Exploring the Unknown*, ed. Logsdon, vol. 4, for an account of this policy shift.

13. While DOD-NASA work on NASP continued in the late 1980s, with DOD bearing some 80 percent of its costs, NASA gave top priority to returning the Space Shuttle to flight. Leading that effort was Admiral Richard H. Truly, a former Shuttle astronaut who was brought back to NASA in the weeks following the *Challenger* accident as Associate Administrator for Spaceflight.[24] Truly was a firm believer in the value of the Shuttle. When in 1989 the new administration of President George H. W. Bush selected him as NASA Administrator, the Space Shuttle gained a strong proponent at the top of the space agency. Then President Bush proposed an ambitious long-range vision for the nation's space program in July 1989. The NASA plan for implementing that vision did not include a proposal to replace the Shuttle as the means for taking people to orbit, even though the plan extended over several decades.

    Administrator Truly's personal embrace of the Shuttle as key to NASA's future was reflected by others in NASA, particularly those working on the Space Shuttle program in NASA Headquarters and at Johnson Space Center and Marshall Space Flight Center. Rather than respond to criticisms of the Shuttle and calls for its replacement, they strove to "impose the party line vision on the environment, not to reconsider it." Central to this behavior was the belief that the Space Shuttle could be made a safe and reliable system and should play a central role in NASA's human spaceflight efforts for many years to come. This behavior, in the judgment of the Columbia Board, led to "flawed decision-making, self deception, introversion and a diminished curiosity" about alternatives to the Shuttle.[25]

14. In 1990, the Advisory Committee on the Future of the U.S. Space Program, usually called the Augustine Committee after its chairman, aerospace executive Norm Augustine, concluded that "we are today overreliant on the Space Shuttle as the backbone of the civil space program." The Committee recommended rapid development of "an evolutionary, unmanned but man-rateable, heavy lift launch vehicle" to replace the Space Shuttle in supporting space station assembly and utilization. Noting that there was no alternative to the Shuttle for human transportation, the Committee recommended "expedited

24. See John M. Logsdon, "Return to Flight: Richard Truly and the Recovery from the Challenger Accident," chap. 15 in *From Engineering Science to Big Science*, ed. Pamela E. Mack (Washington, DC: NASA SP-4219, 1998).

25. Yale University organizational studies scholar Gary Brewer, quoted in CAIB, *Report*, p. 102.

development of a two-way [human] transportation capability" on such a launch vehicle "for use in the event of a Space Shuttle stand-down." The Augustine Committee was critical of the low level of NASA spending on space technology, including that related to advanced propulsion and aerodynamics, and called for a "two-to-three-fold enhancement" of NASA's space technology budget. It recommended an annual increase of 10 percent in the NASA budget if the nation was serious about wanting a successful space program.[26] The Committee concluded its report by recommending that the United States should reduce "dependence on the Space Shuttle . . . for all but missions requiring human presence."[27]

15. After receiving presidential endorsement in 1986, the NASP program over the subsequent several years struggled to achieve its technological and schedule goals. A 1988 Defense Science Board report concluded that the program's advocates had been overly optimistic in their initial promise of an early flight demonstration and suggested that the program should be "realistically presented to its sponsors." A year later, after the Air Force withdrew funding from the program, the White House, in 1989, approved a stretch-out of the program (rather than its cancellation as proposed by Secretary of Defense Richard Cheney), with a flight demonstration of the X-30 test vehicle to come only after relevant technologies had been developed.[28] In the face of competing budget priorities and slow technological progress, the NASP program was canceled in 1992, after $1.7 billion had been spent on it.[29] At that point, the cost of a full X-30 flight-test program was estimated at $17 billion, with another $10–20 billion to develop an operational vehicle.[30] No flight demonstration was attempted, but the program left a technological legacy for future advanced space transportation efforts.

    Andrew Butrica observes that "the NASP concept was the wrong road." By pursuing an air-breathing approach to a single stage to orbit

26. The administration of George H. W. Bush took to heart the advice that the NASA budget should be substantially increased and proposed significant increases for FY 1992 and FY 1993. However, after coming to the White House in January 1993, the administration of President Bill Clinton reversed this upward trend in the NASA budget, which actually lost more than 10 percent in constant dollars during the eight years that Clinton was President.

27. *Report of the Advisory Committee on the Future of the U.S. Space Program* (Washington, DC: GPO, December 1990), pp. 21, 31, 33–34, 48.

28. Logsdon, *Exploring the Unknown*, vol. 4, documents IV-9, IV-10, quotation from p. 562.

29. Launius suggests that the costs were probably higher since some of the work on the NASP program was classified, and thus not all cost information was readily available ("After *Columbia*," p. 290).

30. Global Security.Org, "X-30 National Aerospace Plane (NASP)," *http://www.globalsecurity.org/military/systems/aircraft/nasp.htm* (accessed 13 January 2005).

vehicle rather than one using rocket power, NASA "propelled the nation into an expensive program that had no chance of success." Its failure "demonstrated unmistakably that an air-breathing, single-stage-to-orbit was not the road to travel." Ivan Bekey adds that "being airplane-like, the NASP concept attracted powerful backing because it was intuitively easy to grasp. The nation fooled itself into believing that because the NASP image was what was desired, the reality itself was therefore attainable."[31] Whatever the reason, the United States had lost several years and almost $2 billion in pursuing a failed path towards a Shuttle replacement.

16. On 1 April 1992, Daniel S. Goldin replaced the fired Richard Truly as NASA Administrator. In contrast to Truly, Goldin would prove to be no fan of the Space Shuttle, viewing its budget demands as a major barrier to initiating new, innovative NASA programs.[32] This was especially the case after 1993, when the new administration of President Bill Clinton retained Goldin as Administrator but declined to increase the NASA budget to both meet the demands of the Space Shuttle and the International Space Station programs and allow significant investments in major new efforts such as a Shuttle replacement. The Space Shuttle budget had peaked at over $5.5 billion per year as NASA recovered from the *Challenger* accident; the Bush administration, in early 1992, had proposed a $4.1-billion allocation. By the time Dan Goldin left office in November 2001, the Shuttle budget had been reduced by another 25 percent, to $3.2 billion per year. Goldin initiated the switch of Shuttle operations to private-sector management both as a cost-savings measure and as a way to encourage NASA engineers to focus on developing new capabilities. Until 1999, when he declared a "space launch crisis," Goldin was unwilling to allocate significant resources to Shuttle upgrades. Even so, Goldin, during his long tenure, came to recognize that successful and safe operation of the Shuttle was critical to political and public support of NASA's programs. His expectation was that by innovative partnerships with the private sector, the technological developments on which to base a Shuttle replacement could be achieved without a multibillion-dollar government investment. This unfortunately proved to be a false hope.

31. Butrica, *Single Stage to Orbit*, pp. 66, 81; Bekey, "Exploring Future Space Transportation Possibilities," p. 508.

32. As one indication of his attitude, it is reported that Goldin had removed from the cabin of the NASA Administrator's airplane all the pictures of the Space Shuttle that had been placed there under Richard Truly.

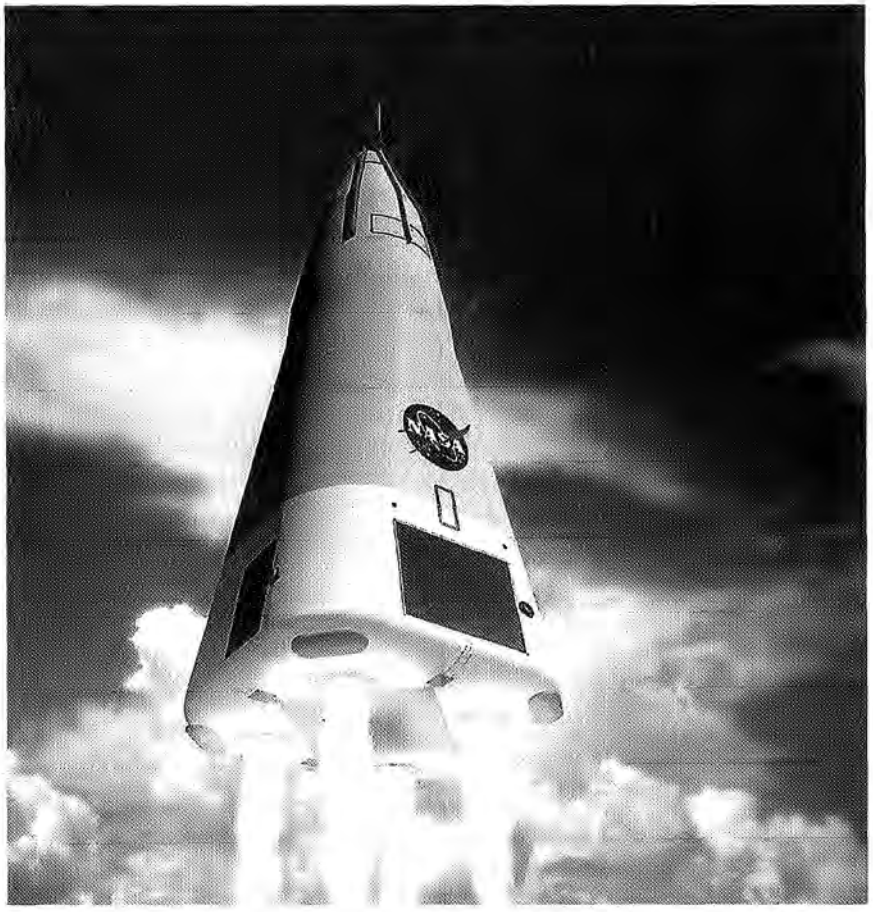
17. In 1992, during the last months of the George H. W. Bush administration, the Vice President's Space Policy Advisory Board, which advised the National Space Council, recommended the development by 2000 of an expendable "Spacelifter" launch vehicle, which would be human-rated, and also the development of a new Personnel Launch System for use with it. This would allow the government to "phase out the Space Shuttle at the earliest opportunity."[33] With the November 1992 election of a new administration, the recommendations contained in the Advisory Board's report were stillborn.

18. In 1993, both NASA Administrator Goldin and the U.S. Congress requested that the NASA staff carry out a comprehensive study of alternate approaches to accessing space through 2030. A principal goal of the study was "to make major reductions in the cost of space transportation (at least 50 per cent), while at the same time increasing safety for flight crews by at least an order of magnitude." The *Access to Space Study* examined three alternatives: 1) an upgraded Shuttle, 2) new expendable vehicles using conventional technologies, and 3) "new reusable vehicles using advanced technologies." The study concluded that "the most beneficial option is to develop and deploy a fully reusable single-stage-to-orbit (SSTO) pure-rocket launch vehicle fleet" that would allow the phasing out of the Space Shuttle, beginning in 2008.[34]

19. This conclusion of the *Access to Space Study* became formalized when President Clinton approved a new statement of National Space Transportation Policy in August 1994. That statement gave NASA the responsibility "to support government and private sector decisions by the end of this decade on the development of an operational next generation reusable launch system." NASA was to focus its research "on technologies to support a decision no later than December 1996 to proceed with a sub-scale demonstration which would prove the concept of single-stage-to-orbit." The policy envisioned that the private sector "could have a significant role in managing the development and operation of a new reusable space transportation system."[35] It was extremely unusual, if not unprecedented, for a specific technological solution such as the SSTO approach to be written into a presidential policy statement on space.

33. Logsdon, *Exploring the Unknown*, vol. 4, document IV-6, p. 550.
34. Ibid., document IV-14, pp. 585–586.
35. Ibid., document IV-16, p. 628.

20. Given the White House policy directive, NASA, over the following two years, organized a competition among potential developers of the subscale flight demonstrator. Three companies submitted proposals. Rockwell International proposed a vehicle that was in many ways a second-generation version of the Space Shuttle; Rockwell had been the prime contractor for the Shuttle. McDonnell Douglas proposed a version of the Delta Clipper vehicle that had been developed under



The McDonnell Douglas Delta Clipper-Experimental (DC-XA) reusable launch vehicle (RLV) was originally developed for DOD. NASA assumed control of the vehicle in the summer of 1995. The DC-XA was to have been an SSTO vertical takeoff/vertical landing launch vehicle concept, whose development would significantly reduce launch cost and provide a test bed for NASA RLV technology. *(NASA MSFC image no. MSFC-9513214)*

the sponsorship of the Strategic Defense Initiative Organization to demonstrate simpler space operations techniques.[36] Lockheed Martin proposed an advanced-technology vehicle based on the use of a linear aerospike engine. On 2 July 1996, Vice President Al Gore announced that NASA had selected the most technologically advanced (and thus the riskiest) of these proposals, that from Lockheed Martin. The reasoning behind this decision has not been adequately explored.

At that time, the plan was to have the first flight of what was christened the X-33 by March 1999 and to complete a 15-flight test program by the end of that year. The goal was to demonstrate the technological foundation for a decision by Lockheed Martin to invest its own funds in a full-scale operational vehicle, which the company named VentureStar.™ The X-33 program would be a cooperative undertaking between NASA and Lockheed Martin, with NASA providing $941 million of the required funding and Lockheed providing $220 million. Once Lockheed Martin developed the VentureStar™ using private capital, the assumption was that NASA would be a major customer for its services, but also that a booming commercial space industry would emerge. The combination of government and commercial demand for access to space, it was claimed, would allow VentureStar™ to be a profitable undertaking.[37]

Although Lockheed Martin, over the following several years, promoted the VentureStar™ project as symbolic of its status on the cutting edge of future technologies, the X-33 program encountered technological difficulties almost from its inception. In November 1999, there was a major test failure of the vehicle's hydrogen fuel tank; by that time, the White House and NASA were losing confidence that the program would be able to overcome its technological hurdles. In March 2001, NASA announced that it would provide no more funding for the X-33, effectively killing it well before a flight demonstration could be attempted. At that point, NASA had spent $912 million on the project, while Lockheed Martin had exceeded its planned investment, having put $356 million into the X-33.[38]

21. Some in the Executive Office of the President and at NASA had, by at least 1998 (if not before), become skeptical that the X-33 pro-

36. See Butrica, *Single Stage to Orbit,* parts III and IV, for a discussion of the origins and fate of the Delta Clipper program.

37. NASA Marshall Space Flight Center, "Lockheed Martin Selected to Build the X-33," news release 96-53, 2 July 1996.

38. Leonard David, "NASA Shuts Down X-33, X-34 Programs," *Space.com,* 1 March 2001, *http://www.space.com/missionlaunches/missions/x33_cancel_010301.html* (accessed 5 February 2005).

gram would be able to overcome its technical challenges and would provide the information needed to decide when and how to replace the Shuttle. In 1998, the Office of Management and Budget asked NASA to fund the aerospace industry to carry out what were called Space Transportation Architecture Studies to determine 1) if the Space Shuttle system should be replaced; 2) if so, when the replacement should take place and how the transition should be implemented; and 3) if not, what is the upgrade strategy to continue safe and affordable flight of the Space Shuttle beyond 2010. Five industry teams examined these questions through 1999 and came up with a variety of approaches to meeting both NASA and commercial-sector launch requirements. Many of the suggested approaches for taking humans to space involved a capsule-type spacecraft launched on top of an expendable launch vehicle. NASA leadership viewed such proposals as not being adequately forward-looking.

22. In 1999, NASA Administrator Daniel Goldin declared a "space launch crisis" and urged the White House to add funds to the NASA budget for necessary safety upgrades to the Shuttle. Substantial funds for this purpose were added to the NASA FY 2001 budget, submitted to Congress in early 2000. However, this upgrade initiative had a short lifespan. Within a year, funding for upgrades was reduced by over one-third in response to rising Shuttle operating costs and the need to stay within a fixed Shuttle budget.[39]

23. Based on the results of the Space Transportation Architecture Studies and the increasingly evident problems with the X-33 program, the NASA FY 2001 budget also contained a new Space Launch Initiative. This effort was to provide some $4.8 billion over five years to conduct studies and technology development to identify the most promising path to replacing the Space Shuttle and meeting other launch requirements. The hope was that this effort could provide the basis for a 2006 decision on what type of Shuttle replacement to develop, with a target date of 2012 for its initial launch. Three contractor teams—Boeing, Lockheed Martin, and a joint team of Orbital Sciences and Northrop Grumman—by early 2002 had identified 15 launcher concepts for detailed study.[40]

39. CAIB, *Report*, p. 114.

40. Leonard David, "Plans for Next Generation 'Shuttle' Ends First Phase; 15 Concepts Have Emerged," *Space.com*, 30 April 2002, *http://www.space.com/missionlaunches/sli_firstphase_020430.html* (accessed 5 February 2005).

24. The Space Launch Initiative was also short-lived. By the end of 2002, White House and top-level NASA optimism that it would provide the hoped-for basis for deciding to develop a second-generation, advanced-technology replacement for the Space Shuttle had evaporated. In November 2002, NASA announced that it was terminating the Space Launch Initiative and reallocating its funding to a new Integrated Space Transportation Plan. According to this plan, the Shuttle's life would be extended so that it could fly until 2020, and potentially to 2030. The Shuttle would be used for missions requiring its cargo-carrying and orbital-operations capabilities. However, for missions carrying only crew to and from the International Space Station, a new Orbital Space Plane (OSP) would be developed, but as a complement to, not a replacement for, the Shuttle. The OSP would not be an advanced-technology vehicle; the goal was to have it available for use as an ISS crew-rescue vehicle by 2010, eliminating dependence on the Russian Soyuz spacecraft to perform this function. The OSP would also become a crew-transfer vehicle by 2012, capable of carrying four or more astronauts to the International Space Station. The OSP would be launched either in the Shuttle's cargo bay or atop an expendable launch vehicle. A third element of the plan was funding of technologies and studies for an eventual next-generation vehicle to replace the Shuttle. No date was set for such a replacement vehicle to enter service.

    The Integrated Space Transportation Plan was also a reaction to the lack of a long-term plan for U.S. human spaceflight. Without knowing how long the International Space Station would operate, it was not possible to determine how long the Space Shuttle would be needed. Without a post-ISS goal for human spaceflight, particularly given the collapse of the commercial space launch market, it also was not clear what kind of "post-Shuttle" vehicle to develop.

25. On 1 February 2003, Shuttle orbiter *Columbia* broke up over Texas, and all seven crew members aboard died. As noted at the start of this essay, the August 2003 report of the Columbia Accident Investigation Board set off, in the following months, a sweeping review of national space policy. On 14 January 2004, President George W. Bush announced a new "Vision for Space Exploration" centered on "a sustained and affordable program of human and robotic exploration of the solar system."[41] The new Vision had as a key element the decision to retire the Space Shuttle as soon as the assembly of the International Space Station was declared

41. White House, "Renewed Spirit of Discovery."

> complete, in 2010 or soon thereafter. To replace the Shuttle, the Vision calls for the development of a Crew Exploration Vehicle (CEV) to carry humans into space, first to low-Earth orbit and eventually to the Moon and Mars. This vehicle will house the crew as they travel into space and thus will indeed replace the Shuttle as the means for U.S. human access to space. The CEV is the latest of the many attempts to develop a replacement for the Space Shuttle as a human transport vehicle. One can only hope that it will be become reality, unlike its predecessors.

One cannot escape the conclusion that these 25 "snapshots" add up to a portrait of failure—failure to provide for the United States' "assured access" to space for its citizens. Since 1981, there has been only one way for the United States to send people into space—at least using U.S. hardware. That way, of course, has been the Space Shuttle, and with its two fatal accidents, the United States lost human access to space twice—first for 32 months, and then for more than 30 months. The United States will not have independent access to space for humans between the time the Space Shuttle is retired in 2010 and the CEV begins crewed operations. This interval could be as long as four years, and during that time, the only way for U.S. astronauts to get to and from the International Space Station will be on Russian spacecraft.

It is worth noting that "assured access" for key national security and other robotic payloads *has* been a stated national policy since at least 1988. In its 1988 statement of National Space Policy, the Reagan administration declared that "United States space transportation systems must provide a balanced, robust, and flexible capability with sufficient resiliency to allow continued operations despite failures in any single system." The 1991 National Space Policy of President George H. W. Bush stated that "assured access to space is a key element of U.S. national space policy."[42] This policy continues in force today. President George W. Bush, on 21 December 2004, approved a new National Space Transportation Policy which stated that "'assured access' is a requirement for critical national security, homeland security, and civil missions." To be fair, this most recent statement also suggests that assured access to space for humans is also a desired policy objective. It declares that "access to space through U.S. space transportation capabilities is essential . . . to support government and commercial human spaceflight."[43] If this objective were met, it would signify a strong commitment to human spaceflight on the part of the U.S. government. As the following analysis suggests, such a strong commitment has been missing for many years.

42. Thor Hogan and Vic Villhard, "National Space Transportation Policy: Issues for the Future," RAND Science and Technology Working Paper WR-105-OSTP, October 2003, p. 7.

43. Office of Science and Technology Policy, Executive Office of the President, "National Space Transportation Policy," fact sheet, 6 January 2005.

THE ROOT CAUSES OF THE FAILURE TO DEVELOP A SHUTTLE REPLACEMENT

There can be no one explanation for why this complex chain of developments has taken place. But certainly it is possible to suggest some of the fundamental reasons for the lack of a Shuttle replacement more than 30 years after the original commitment to the Space Shuttle program.

W. D. Kay, in his book *Can Democracies Fly in Space*, suggests that the "space program's failures, like its earlier successes, have multiple causes, all of them ultimately traceable to the way the American political process operates." Space policy is "a political outcome, a product of the discussion, debates, competition, and compromises that attend all public issues." While there could be alternate frameworks within which to examine the reasons why there has been no replacement for the Space Shuttle, this essay will adopt the political perspective suggested by Kay. He sets out a framework that provides a useful way to analyze this situation. Kay suggests that it is possible to conceptualize the creation of space policy in terms of three levels of analysis:

1. An *organizational output*, produced by the hardware, procedures, and personnel developed and trained by NASA.

2. A *political activity*, an outgrowth of the ongoing debates, compromises, votes, and other decisions involving NASA, its contractors, the Congress, various executive agencies, and a number of other loosely coordinated (and in some cases competing) individuals, institutions, and organizations, both public and private.

3. A *national enterprise*, the product of a society and a people possessing not only a certain level of technical expertise, but also a high degree of consensus and a determination expressed through its political representatives . . . .[44]

These three levels of analysis, and particularly viewing space policy as the foundation of a national enterprise, help to understand was has happened in the space sector over the past three and one-half decades.

44. W. D. Kay, *Can Democracies Fly in Space? The Challenge of Revitalizing the U.S. Space Program* (Westport, CT: Praeger Publishers, 1995), pp. 33, 26–27.

TECHNOLOGICAL HUBRIS AND ORGANIZATIONAL OUTPUTS

In the last 20 years, the aerospace community has been given two major opportunities by the national leadership to develop a Shuttle replacement; these opportunities were accompanied by significant (although not adequate) funding commitments. The first of these opportunities, the NASP program, was initially justified on national security grounds; NASA was a junior partner in the undertaking and was not able to continue it as a development effort leading to a flight-test vehicle once Department of Defense funding was withdrawn. The second opportunity was the SSTO effort initiated by NASA in 1996 in response to NASA's internal studies and then the 1994 National Space Transportation Policy.

With the benefit of hindsight, it is possible to see that these two efforts were very likely doomed to failure from their outset. In both cases, the approach selected depended on being able simultaneously to bring to an adequate level of maturity a variety of challenging technologies in areas such as aerodynamics, guidance and control, materials, and propulsion. Those responsible for both efforts within the Department of Defense, NASA, and the aerospace industry assured their leaders that they could overcome these technological challenges and move forward rapidly and with affordable costs. These assurances were at variance with what actually transpired.

As mentioned above, the reality that the NASP program was unlikely soon to result in a flight vehicle became rather quickly evident after President Reagan gave the program national visibility in 1986. By 1988, the Defense Science Board had raised major questions about the technological feasibility of the undertaking. In 1989, the RAND Corporation reported "reservations" with respect to NASP coming "anywhere near its stated/advertised cost, schedule, payload fees to orbit, etc. . . ." and suggested that the "primary NASP X-30 objective—manned single stage to orbit—is exceedingly sensitive to full success in technology maturation."[45] Ivan Bekey, a proponent of a rocket-based approach to space access rather than the NASP air-breathing approach, was less kind; he has characterized the NASP program as "the biggest swindle ever to be foisted on the country," "full of dubious . . . claims" and "hot air."[46]

When Vice President Al Gore announced in July 1996 that NASA had selected Lockheed Martin's proposal to develop an SSTO demonstrator, he made a point of noting that it was the most "technologically advanced" of the

45. Bruno Augenstein and Elwyn Harris, "Assessment of NASP: Future Options," RAND Working Draft WD-4437-1-AF, July 1989, p. 2.

46. Quoted in Butrica, *Single Stage to Orbit*, p. 79.

three competing proposals. The story of why this risky choice was made has yet to be told. But once again, an approach to replacing the Shuttle had been chosen that would require simultaneous maturation of challenging technologies.[47] And once gain, achieving that maturation, at least on the original timescale and in the face of an impatient NASA and national leadership, proved impossible.

Why were these two efforts given high-level approval to proceed and widespread publicity when, at the time of approval, their chances of success were known to be low to at least some observers? This is a question deserving of more attention than it has received to date.

In 1989, one veteran aerospace engineer wondered, with respect to NASP, "How could ideas that were so thoroughly explored thirty years ago, and so thoroughly found lacking in sufficient promise twenty years go, have suddenly become once again in vogue?" It was not technological progress that had brought the ideas to the fore, he concluded, but rather "blissful ignorance of the past." Only a few of the instigators of the NASP program had been involved in earlier efforts, and "they were the ones who not only had been infected by the dream of long ago, but who had, in the process, become addicted to it and, therefore, immune to any amount of contrary evidence."[48] One suspects that an informed independent assessment of those who advocated the X-33 program would not be much different in its conclusions.

The costs of a lack of historical perspective and unchecked technological optimism, bordering on hubris, have been high. Roger Launius has suggested that the X-33 program and the NASP program before it "have been enormous detours for those seeking to move forward with a replacement for the Space Shuttle. Expending billions of dollars and dozens of years in pursuit of reusable SSTO technology, the emphasis on this approach ensured the tardiness of development because of the strikingly difficult technological challenges."[49] The Columbia Board agreed, suggesting that one reason for the "failure of national leadership" related to the absence of a replacement for the Space Shuttle was "continuing to expect major technological advances" in a replacement vehicle.[50]

How are nontechnical decision-makers to be protected against the enthusiasm of technological optimists? That is a topic well beyond the scope of this essay, but clearly, in the case of NASP and X-33, the necessary checks and balances were missing or not influential.

47. It should be noted that although X-33 and then VentureStar™ were widely perceived as a path to Shuttle replacement, the original designs were for an automated, cargo-carrying vehicle. Presumably, humans could be carried as "cargo," i.e., passengers, as the reliability of VentureStar™ was demonstrated.

48. Carl H. Builder, "The NASP as a Time Machine," RAND Internal Note 25684-AF, August 1989, p. 1.

49. Launius, "After *Columbia*," p. 291.

50. CAIB, *Report*, p. 211.

THE POLITICAL PROCESS AND THE STRENGTH OF THE PRO-SHUTTLE COALITION

As noted by the CAIB, the Space Shuttle is "an engineering marvel that enables a wide variety of on-orbit operations."[51] The Shuttle is also a program with a multibillion-dollar annual budget which employs thousands of people in various locations and is the focus of much of the activity at the Johnson Space Center, with a large astronaut corps located there; the Marshall Space Flight Center; and the Kennedy Space Center. Major and smaller aerospace firms across the United States work on the Shuttle program.

It is not surprising, then, that throughout the Shuttle program's history there has grown up a politically active coalition of government, contractor, local, and congressional supporters who argue that the Shuttle is a vehicle that continues to be superior in capabilities to any technologically feasible replacement, and who therefore have suggested that the preferred course of action is to invest scarce funds in upgrading and modernizing the Shuttle rather than seeking an early replacement. From the time when President Jimmy Carter (in 1979) considered terminating the Shuttle program, through the conflicts in the early 1980s with the Air Force on one hand and foreign and domestic competitors on the other, to the aftermath of the *Challenger* and *Columbia* accidents, and perhaps even to the current time, this coalition has argued that it would be a mistake to rush towards a Shuttle replacement. Ten years ago, a report from an advisory group headed by NASA veteran Christopher Kraft argued that the Shuttle was "a mature and reliable system . . . about as safe as today's technology will provide."[52] At the time of the 2003 *Columbia* accident, after the failure of the X-33 program and the Space Launch Initiative, NASA was planning to keep the Shuttle in operation until at least 2020 and potentially beyond.

The existence of an organized coalition of public and private interests with a stake in the Space Shuttle program is an entirely legitimate phenomenon. The whole system design of the American political process is intended to allow organized interests to contend for a favorable policy outcome. In this case, however, there was no organized alternative interest group pushing for an early Shuttle replacement, and thus the default outcome of annual policy debates was likely to favor the pro-Shuttle position, or, at a minimum, not result in outcomes opposing it. While, for example, there was opposition from the scientific community and some members of Congress in the 1980s and 1990s to the space station program, there has been no similar consistent opposition to the Space Shuttle.

51. Ibid., p. 25.
52. Quoted in ibid., p. 118.

There were, however, limits to the political strength of the Shuttle support coalition. Although it may have been powerful enough to raise questions about the wisdom of proceeding rapidly towards a Shuttle replacement, it did not have enough power within the political process to influence decision-makers to allocate adequate resources for upgrading the Shuttle and its associated infrastructure. The Shuttle program budget was cut by more than 40 percent in purchasing power between 1991 and 2000. Although some upgrades were introduced into the system, more were not funded or canceled soon after being approved, and the Shuttle's ground infrastructure was "deteriorating."[53] Especially in the decade before the *Columbia* accident, uncertainty about when the Shuttle might be replaced, as the politically weaker and not well organized advocates of such replacement contended with the pro-Shuttle coalition, created an ambivalent policy attitude towards the Shuttle program. This policy outcome was perhaps the worst possible situation—not enough funding for successful operation of the Shuttle, but also inadequate political commitment behind an effort to replace it. It was most fundamentally a reflection of the place that human spaceflight held, and perhaps continues to hold, in the list of national priorities—something that most Americans want to see continue but are unwilling to invest enough resources in to do well.

This is an attitude criticized by those committed to human spaceflight. Launius notes that "if the United States intends to fly humans in space it should be willing to foot the bill for doing so." He suggests that "if Americans are unwilling as a people to make that investment, as longtime NASA engineer and designer of the Mercury capsule spacecraft Max Faget [who died in 2004] recently stated, 'we ought to be ashamed of ourselves.'"[54] These are noble sentiments but do not reflect the long-standing reality of how the space program has been seen in terms of national priorities.

HUMAN SPACEFLIGHT AS A NATIONAL ENTERPRISE

Kay, writing a decade ago, observed that "three decades ago, the United States government made a decision to support space exploration—including human flight—on a rather large scale." He questions whether "our present institutional arrangements and political practices prevent us from carrying out that decision effectively," and thus there may be a need to "rethink our original policy decision."[55]

This essay asserts that at the national leadership level, the decision "to support space exploration—including human flight—on a rather large scale"

53. Ibid., p. 114.
54. Launius, "After *Columbia*," p. 295.
55. Kay, *Can Democracies Fly in Space?* p. x.

was rethought soon after it was made and that the outcome of that rethinking was a much more muted commitment to the civilian space program overall, including human spaceflight. The people of the United States and their government have been willing, over the past 35 years, to continue a human spaceflight program, but only at a level of funding that has forced it to constantly operate on the edge of viability. The lack of a replacement for the Space Shuttle is a symptom of this larger reality. In this context, the assertion that the lack of a Shuttle replacement is a "failure of national leadership" is the logical result of the halfhearted U.S. commitment to human spaceflight. If there is a "failure," then, it is the failure to reconcile the reality of limited support with this country's continuing commitment to sending people into space. Human spaceflight may indeed be a "national enterprise"—but it is one that for many years has not been central to important American interests, at least as they are expressed through the political process.

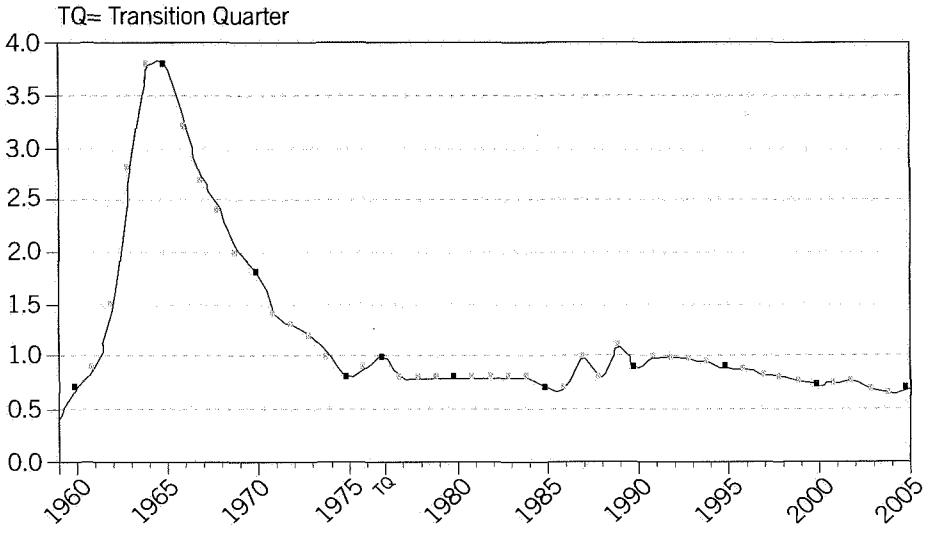
Kay ends his book with the question, "Can democracies fly in space?" His answer to this question is another question: "How badly do they want to?"[56] What will be argued below is that the answer to this second question is "not very badly."

Perhaps the single most convincing piece of evidence in support of this conclusion is the pattern of resources allocated to NASA over its history, as seen in the familiar figure repeated on the following page. Two things are remarkable about this pattern of resource allocation. The one most usually remarked upon is the rapid buildup of resources in the early 1960s in support of Project Apollo. This indeed was a peacetime mobilization of financial (and human) resources on a wartime scale. The Apollo buildup created an image of what a successful space program should be—one developing large-scale, expensive technology to take people into space.

Equally remarkable, however, and more fundamental to the argument of this paper is the rapid builddown of resources allocated to NASA between 1965 and 1974, and even more so the stability of that allocation over the past 30 years. It is impossible to escape the conclusion that, whatever the specific content of the NASA program at a particular time, the American public and their leaders, through the political process, have consistently decided to allocate less that 1 percent of the annual federal budget to the civilian space program as a national enterprise. This decision has been made, and reinforced, as the federal budget for each successive fiscal year has been assembled in the White House and approved or modified by the Congress. Within that allocation, national leaders have expected NASA to carry on a successful program of human spaceflight as well as its other activities. The result, as the CAIB

56. Ibid., p. 193.

NASA Budget as a Percentage of Federal Budget



observed with respect to the *Columbia* accident, has been an agency striving to "do too much with too little."

The basic decision that the United States, after succeeding in being first to land humans on the Moon, would not continue an ambitious program of human spaceflight in Earth orbit and beyond was made in 1969–1970 as the administration of President Richard Nixon formulated its post-Apollo policy for the civilian space program. It is a decision that has been reinforced by Presidents Ford, Carter, Reagan, and Clinton.

Up to 2004, only President George H. W. Bush (in 1989) suggested a reinvigoration of the human spaceflight program. Between President Bush's 1989 proposal for a "Space Exploration Initiative" and the time he was defeated in the 1992 election, it became clear, through the operation of the political process, that the country was not interested in a higher priority, more expensive human spaceflight effort.[57]

The first step in the process of formulating a policy to guide the space program after the end of the Apollo program was the creation in February 1969 of the Space Task Group, chaired by Vice President Spiro T. Agnew. This group was charged with preparing "definitive recommendations on the direction

57. See Thor Hogan, "Mars Wars: A Case History of Policymaking in the American Space Program" (Ph.D. diss., George Washington University, 2004), for a careful account of the origins and fate of the 1989 Space Exploration Initiative.

which the U.S. space program should take in the post-Apollo period."[58] In its 15 September 1969 report, the Space Task Group set out several options for the future and, "as a focus for the development of new capability," recommended that "the United States accept the long-term option or goal of manned planetary exploration with a manned Mars mission before the end of the century as the first target." This recommendation was actually a watered-down version of what the Group intended to recommend. President Nixon's advisers had intervened at the last minute, as the report was going into print, to make sure that the report did not contain the Group's planned recommendation that the initial mission to Mars be carried out in the 1980s, a recommendation that was politically unacceptable. The report proposed that whatever option was chosen by the President, the NASA budget by 1980 should be anywhere from the same as to twice that at the peak of the Apollo program.[59]

Accepting the Space Task Group's recommendations would have meant accepting a long-term national commitment to a robust program of human spaceflight, with repeated trips to the Moon and, eventually, forays to Mars. This was not at all what Richard Nixon and his advisers had in mind for the post-Apollo space effort. Rather than reward NASA for the success of the Apollo 11 landing, between October 1969 and January 1970, the NASA budget for fiscal year 1971 was severely reduced. In October, NASA requested White House approval of a $4.5-billion budget which would allow it to begin to implement the recommendations of the Space Task Group; by the time the President's budget was sent to Congress the following January, that amount had been reduced to $3.3 billion, a cut of over 25 percent from NASA's request and even $400 million less than the previous year's budget.

This outcome was not just the result of the Nixon administration's desire to submit a balanced budget; it reflected a major space policy choice. As Nixon's top adviser on space policy Peter Flanigan told the President in a 6 December 1969 memorandum:

> The October 6 issue of *Newsweek* took a poll of 1,321 Americans with household incomes ranging from $5,000 to $15,000 a year. This represents 61% of the white population of the United States and is obviously the heart of your constituency. Of this group, 56% think the government should be spending less money on space exploration, and only 10% think that the government should be spending more money.[60]

58. Logsdon, *Exploring the Unknown*, vol. 1, document III-22, p. 513.
59. Ibid., document III-25, p. 524.
60. Ibid., document III-27, p. 546.

NASA Administrator Thomas Paine, who had been touring both the United States and foreign countries to promote a post-Apollo space program as set out in the Space Task Group report, met with President Nixon on 22 January 1970 to make one last attempt to keep NASA on a path towards the approach laid out in the report. He had no success; Nixon told Paine that although he regretted the severe cuts to the NASA budget, "they were necessary in view of the overall budget situation—the reduced revenues and inflation." Nixon discussed "the mood of the country," which in the President's judgment "was for cuts in space and defense." Paine, ever an optimist, felt that the President "honestly would like to support a more vigorous space program if he felt the national mood favored it." But that was not the case, and Nixon wanted to make sure that he was not put in a position where "the opposition could invidiously compare his positive statements on space to problems in poverty and social programs here on Earth." Nixon did not want to appear to be "taking money away from social programs and the needs of the people here to fund spectacular crash programs out in space." Paine also noted that in their meeting, "the President didn't mention the Space Task Group Report."[61]

On 7 March 1970, the White House released a presidential statement on the future of the U.S. space program; Richard Nixon never addressed the subject in a public address. The statement was cast both as a response to the Space Task Group report and as an evaluation of where space fit into the country's future. Its message was clear:

> Space expenditures must take their proper place within a rigorous system of national priorities. What we do in space from here on in must become a normal and regular part of our national life and must therefore be planned in conjunction with all of the other undertakings which are important to us.[62]

The 1969–1970 interactions between NASA and the Nixon White House have been given detailed attention because they reflect a fundamental policy decision that has not been given adequate historical attention. In the months following the apex of U.S. success in human spaceflight with the Apollo 11 mission, the American President decided that it was neither in his political interest nor, more important, consistent with the desires of the American public to continue with a well-funded program of human spaceflight. This was not, as has been suggested, a case in which "the budget begat space policy

61. Thomas Paine, "Meeting with the President, January 22, 1970," memo for record, 22 January 1970, Apollo Files, University of Houston–Clear Lake Library, Clear Lake, TX.

62. Richard M. Nixon, "Statement About the Future of the United States Space Program," 7 March 1970, in U.S. President, *Public Papers of the Presidents of the United States: Richard Nixon, 1970* (Washington, DC: GPO, 1971), p. 251.

instead of space policy begetting the budget."[63] Rather, it reflected a deliberate, purposeful reversal of the space policy adopted by the Kennedy administration that had led to Project Apollo. That policy held that success in highly visible space projects was "part of the battle along the fluid front of the cold war"; that "dramatic achievements in space . . . symbolize the technological power and organizing capacity of a nation"; that it was "man, not machines, that captures the imagination of the world"; and that "*the nation needs to make a positive decision to pursue space projects aimed at national prestige*"[64] (emphasis in original). To Richard Nixon and his advisers, this was not an acceptable rationale for a post-Apollo space program. They did not want to put an end to human spaceflight, but they were unwilling to set an ambitious goal to guide that effort. Instead, they approved development of a means—the Space Shuttle—without stating clearly the objectives it was to serve.

The decision on the future of the space program, and particularly on the future of its most visible element, human spaceflight, taken by the Nixon administration 35 years ago has remained the core national space policy until recently. That decision viewed the space program as a national enterprise, to use Kay's term, but one of secondary priority compared to other areas of national activity such as a strong defense, adequate social welfare, and, since 2001, homeland security. Based on the priority assigned to space efforts in this policy, for more than 30 years there has been a remarkably consistent share of the federal budget allocated to NASA.

That budget share has also been consistently inadequate to support the aspirations of NASA and the space community. Neither the space agency nor its supporters have adjusted their aspirations to that reality. Instead, they have continued to hold on to the hope that either a technological breakthrough on the order of NASP or VentureStar™ or a shift in the national priority assigned to space will allow them to make their dreams reality.

It is understandable that those most directly involved in the space sector harbor expansive ambitions for the future. What is not acceptable as a basis for government policy is to allow those ambitions to remain unchecked when the resources for achieving them are not, and are not likely to be, available. It is up to the leaders of NASA and to those to whom they report in the White House and Congress to steer the organization in a direction consistent with its place in the public's priorities. As suggested earlier, those leaders have failed to do so.

63. This is the argument put forth by Joan Hoff in her essay "The Presidency, Congress, and the Deceleration of the U.S. Space Program in the 1970s," in *Spaceflight and the Myth of Presidential Leadership*, ed. Roger D. Launius and Howard E. McCurdy (Urbana: University of Illinois Press, 1997), p. 106.

64. This quotation comes from the 8 May 1961 memorandum, signed by NASA Administrator James E. Webb and Secretary of Defense Robert S. McNamara, recommending that President Kennedy set a human lunar landing as a national goal. The memorandum can be found in Logsdon, *Exploring the Unknown*, vol. 1, p. 444.

This analysis seems to have wandered rather far from the focus of this essay on explaining why no replacement for the Space Shuttle has yet been developed. On the contrary—the answer to that question depends on understanding the context within which the human spaceflight program has operated for at least the last 35 years. Beginning with the Nixon administration (or perhaps even earlier),[65] the political process by which the United States sets priorities among various government activities has assigned a consistently secondary priority to the NASA space program. Operating within that priority, NASA was able to develop the Space Shuttle during the 1970s only by retiring all of the systems that had been developed for Project Apollo, with the exception of using surplus equipment for the 1973 Skylab and the 1975 Apollo-Soyuz missions. With these two exceptions, NASA accepted a lengthy hiatus in human spaceflight as an acceptable price to pay for being permitted to develop the Space Shuttle.

Once the Space Shuttle started flying in 1981 and a space station was approved in 1984, NASA has had no similar opportunity to stop what it was doing and invest the funds thereby made available in developing a Shuttle replacement. Instead, it has had to try both to continue its ongoing, Shuttle-based human spaceflight program and to develop new spaceflight capabilities within an unvarying share of the federal budget. This has, to date, proven an impossible challenge to surmount. Therein lies the fundamental reason why there is, today, no replacement for the Space Shuttle; it is a product of a space policy decision made many years ago and not reversed since.

SO HAS THERE REALLY BEEN A FAILURE?

Calling the lack of a replacement for the Space Shuttle "a failure of national leadership" is based on the assumption, as stated in the CAIB report, that "America's future space efforts must include human presence in Earth orbit, and eventually beyond."[66] If the United States is to continue human spaceflight, so this line of argument goes, it is essential to develop a Shuttle replacement rather than continue to rely on the aging and expensive Shuttle. To have come so far in space and not to have such a replacement ready or on the horizon must indeed be the result of a failure on the part of those responsible for allocating national resources to provide the support needed.

There is an alternative perspective: that a program of continuing human spaceflight, eventually leading to travel beyond Earth orbit, does serve the national interest. The rationales in support of human spaceflight are diffi-

65. The NASA budget actually began its rapid decline from the 1965 peak of spending on Apollo while Lyndon B. Johnson was President. Although Johnson was committed to completing Apollo, he apparently gave post-Apollo spaceflight lower priority in the context of the other issues facing him in the 1965–1968 period.

66. CAIB, *Report*, p. 210.

cult to articulate to the unconvinced in convincing fashion; Launius calls the rationale for human spaceflight "highly problematic."[67] For example, one member of the space community recently commented that taking "as axiomatic that space's highest and true calling is achieving societal goals of research and exploration into the unknown" is the "burdensome baggage of an aristocratic calling, now bankrupt both ideologically and financially."[68]

What appears to be needed is some form of a national debate on the future of human spaceflight that will allow these and other conflicting perspectives to be fully articulated and the long-standing policy of assigning space efforts a secondary priority as a national enterprise to be reassessed. As suggested above, the current policy that assigns space such a priority has resulted in a human spaceflight effort that has struggled now for many years to be a viable undertaking. As one recent analysis suggests, the fact that the vision of human spaceflight, including the resumption of human voyages of exploration, has not resonated "with the American public to the point where it inspires action is a reflection of a larger problem: the U.S. currently has no larger shared vision" into which a space exploration vision can fit.[69]

The policy of assigning secondary priority to space is thus not a "failure" in a basic sense; the policy is the consistent result of a democratic political process and thus can be said to represent the will of the American public. It is also difficult to say that national leaders have failed when they have acted in accordance with the public will as expressed through established institutions and processes.

Who then—or what—has failed? As suggested above, there has been a leadership failure in the sense that space ambitions and the resources to accomplish them have not been brought into balance. But perhaps the failure also lies with those who continue to advocate the original space dream, which was based on "adventure, mystery, and exploration." To date, they have failed to convince enough others that this dream is worth realizing to make it a focus of a higher priority national (or international) enterprise. Most Americans appear not to care very much about a future that includes a vigorous space effort. Advocates have not adjusted their hopes to reflect the resources society is willing to provide them. Rather, "the dreams continue, while the gap between expectations and reality remains unresolved."[70]

67. For a discussion of the difficulty in stating a compelling rationale for human spaceflight, see John M. Logsdon, "A Sustainable Rationale for Human Spaceflight," *Issues in Science and Technology* (winter 2004); Launius, "Beyond *Columbia*," quotation from p. 308.

68. Rick Fleeter, "Contemplating Which Direction in Space," *Space News* (18 October 2004): 7.

69. Center for Cultural Studies & Analysis, "American Perception of Space Exploration: A Cultural Analysis for Harmonic International and the National Aeronautics and Space Administration," report to NASA, 1 May 2004, p. 3.

70. Howard E. McCurdy, *Space and the American Imagination* (Washington, DC: Smithsonian Institution Press, 1997), p. 243.

EPILOGUE: AN ACHIEVABLE VISION?

On 14 January 2004, President George Bush laid out what has become known as the Vision for Space Exploration. In his speech announcing this new vision, the President called for a "journey, not a race." In the formal language of the policy directive underlying the Vision, the objective is a "sustained and affordable program of human and robotic exploration of the solar system and beyond."[71]

Those planning this new approach to the U.S. space program appear to have recognized the reality described in this essay: any major new space initiative, if it is to be achievable, must be planned so that it can be carried out within a level of funding consistent with the pattern of more than three decades. The Vision gives highest priority within the NASA program to those activities related to exploration; other activities will receive lower priority and thus less funding in the future. A firm deadline has been set for retiring the Space Shuttle from service, and NASA's activities aboard the International Space Station will be gradually phased out. A replacement for the Space Shuttle in its role of carrying Americans into space, the Crew Exploration Vehicle, is a key part of the new Vision. In order to stay within a politically feasible budget, the first crew-carrying flight of the CEV is not scheduled until the 2012–2014 timeframe, and the first human mission to the Moon is planned for 2018–2020. A several-year period during which the United States will have to depend on Russia for human access to space is accepted. Cost of achieving the Vision will be minimized by substantial international and private-sector involvement. According to the Vision's financial projections, the NASA budget between 2004 and 2020 will increase only by 1.5 percent in the first five years of the new effort and not at all in constant dollars in the subsequent decade.

Is this a vision that the country will support on a stable basis? Can its objectives be achieved within the resources projected?[72] These are questions that cannot be answered now. What can be said is that the Vision for Space Exploration in its conception reflects the realities described in this essay. Whether its aspirations can become reality remains to be seen.

71. White House, "Renewed Spirit of Discovery."

72. See U.S. Congress, Congressional Budget Office, "A Budgetary Analysis of NASA's New Vision for Space Exploration," September 2004, for a skeptical response to this question.