Articles

The Space Shuttle Program: A Policy Failure?

JOHN M. LOGSDON

The 5 January 1972 announcement by President Richard Nixon that the United States would develop during the 1970's a new space transportation system—the space shuttle—has had fundamental impacts on the character of U.S. space activities. In retrospect, it can be argued that the shuttle design chosen was destined to fail to meet many of the policy objectives established for the system; the shuttle's problems in serving as the primary launch vehicle for the United States and in providing routine and cost-effective space transportation are in large part a result of the ways in which compromises were made in the 1971–72 period in order to gain White House and congressional approval to proceed with the program. The decision to develop a space shuttle is an example of a poor quality national commitment to a major technological undertaking.

ON 5 JANUARY 1972, THE WHITE HOUSE ANNOUNCED that President Richard Nixon had decided to proceed with developing an "entirely new type of space transportation system" (*1*). There were many reasons for the President's decision, among them the desire to keep the U.S. manned space flight program alive, the potential national security benefits of the shuttle, and short-term employment impacts in a presidential election year. However, public and congressional justification for the shuttle was largely in terms of the system's ability to provide easy and inexpensive access to low earth orbit and to replace all existing expendable launch vehicles. These persisted through the 1970's as primary objectives for the shuttle and were incorporated into a formal national space policy a decade later. That policy, which was approved by President Ronald Reagan and announced on 4 July 1982 as the shuttle completed its third flight, declared that the Space Transportation System (STS), of which the shuttle is the central element, "is a vital element of the United States space program, and is the primary space launch system for both the United States national security and civil government missions. . . . The first priority of the STS is to make the system fully operational and cost-effective in providing routine access to space" (*2*).

In the aftermath of the January 1986 Challenger accident, national policy for space transportation is being revised; rather than the country being almost solely dependent on the shuttle for access to space, a mixed fleet of shuttles and expendable launch vehicles will be created. The shuttle is likely to be used only for those missions for which it is particularly qualified, and any notion that it can ever be operated routinely or cheaply has been abandoned. Thus, while the space shuttle is an impressive technological achievement and gives to the United States capabilities for manned operations in space that no other country possesses, the shuttle program must be assessed as a policy failure, at least in terms of meeting the objectives that have been its articulated rationale since 1972.

A Poor National Decision

Why did this failure occur? Why did it take more than a decade for the space policy community to examine fully the implications for the totality of the U.S. space program of dependence on a single, manned launch system? How did the National Aeronautics and Space Administration get into the position of fighting attempts by other government agencies to use launch vehicles other than the shuttle, of marketing shuttle launch services globally and on a quasi-commercial basis, and of attempting to meet a demanding launch schedule, all in order for the shuttle program to be evaluated as a success? Most important, perhaps, how did the United States get itself into a situation in which a single accident, however tragic its toll in human lives, could bring the vitally important national space program, with its array of critical scientific, commercial, military, and intelligence missions ready for launch, to a halt for a year, probably longer? Many of the answers to these questions can be found in the way the decision to begin the space shuttle program was made. The system chosen for development in 1972 was, from the start, unlikely ever to meet its announced objectives, but the gap between rhetoric and reality persisted for 14 years, until the morning of 28 January 1986.

In order to get approval for shuttle development, NASA during 1971 and 1972 made a series of budget-driven design changes that have turned out to be major sources of the program's troubles in meeting its policy goals. The implications of these trade-offs for program success were not sufficiently examined before the decision to proceed was made, despite warnings from White House budget and technical advisers. That decision was a "close call," and was not accompanied by enough of a political or budgetary commitment to ensure program success as problems emerged. The shuttle was intended to be a national capability around which all U.S. space activities during the 1980's and the 1990's would be structured, but the decision to develop it was made through the "normal" political process of bargaining, compromise, and coalition-building, not on the basis of presidential leadership. Too much attention was paid to the short term, while longer range implications were inadequately considered. For all these reasons, the shuttle decision stands as a powerful example of how not to make a national commitment to an undertaking on which many other significant projects depend.

Origins of the Shuttle

The concept of a reusable space transportation system to make access to low earth orbit routine and less expensive first came to public and congressional attention in 1969 as part of NASA's very ambitious post-Apollo plans (*3*):

> The next logical step for us to take in space will be to create permanent manned space stations in Earth and lunar orbits with low-cost access by

J. M. Logsdon is director of the Graduate Program in Science, Technology, and Public Policy, George Washington University, Washington, DC 20052.

reusable chemical and nuclear rocket transportation systems, and to utilize these systems in assembling our capacity to explore the planet Mars with men thereby initiating man's permanent occupancy of outer space.

When the White House soundly rejected such proposals, NASA was left with identifying a project that could both gain enough political support for approval and be sizable enough to keep its development engineers usefully occupied during the 1970's.

The space shuttle emerged as that project because it promised a variety of capabilities, in addition to low-cost, routine transportation, that were attractive to the Department of Defense and the President's Science Advisory Committee (PSAC), as well as to NASA. These included, according to a 1970 PSAC report (*4*),

- Replacing twelve existing different launch vehicles "with a STS used jointly by both DOD and NASA as a national transportation capability"
- "Provision for national security contingencies by the ready availability of transportation to orbit on short notice, with sufficient maneuverability and cross range capability for a variety of missions."

It was these two objectives—replacing all existing launch vehicles with a more economical system and meeting DOD requirements for particular national security missions—that were the primary drivers of shuttle design during 1970 and 1971 and that led NASA to resist suggestions that a smaller manned system would be an adequate U.S. space initiative for the 1970's.

Defining the Shuttle

Once it had decided that the shuttle was its top priority program, NASA in the fall of 1970 unsuccessfully attempted to get it approved by the White House. It thus became of crucial importance to the agency to get that approval in 1971, if the agency was to remain a major force in developing space technology. A new NASA administrator, James Fletcher, was nominated in the spring of 1971; he recalled that "if the shuttle was ever going to go, it had to be that year" (*5*). NASA's leaders calculated that, in order to get White House and congressional permission to develop a new space transportation system, DOD had to agree to use the shuttle for its launch needs in the 1980's. Thus providing a shuttle that met the DOD's requirements became a key element in NASA's strategy for program approval. In addition, NASA wanted to use the shuttle to preserve the future option of developing a space station.

While meeting DOD demands implied a large, high-performance shuttle, NASA also had to try to meet a criterion of cost-effectiveness imposed by the Office of Management and Budget, which had a record of skepticism about the benefits of manned space flight, given its high cost. The shuttle was the first space project subjected to formal economic analysis. After an initial internal NASA study failed to impress OMB, NASA in June 1970 issued contracts to the Aerospace Corporation for estimating payload and launch vehicle costs, to Lockheed for analyzing the impacts of shuttle capabilities on reducing payload costs, and to Mathematica, a consulting firm headed by economist Oskar Morgenstern, for an overall economic analysis comparing the total costs of carrying out likely future NASA, DOD, and commercial space missions using the space shuttle and other launch systems. Mathematica's effort was led by Klaus Heiss, a young Austrian economist. One high NASA official later described the impact of the Mathematica analysis on the shuttle decision as "influential and unfortunate" (*6*). Although none of those closely involved in the final White House decision to go ahead with the system apparently thought that the shuttle should be justified on a cost-effectiveness basis, the existence of a public study making such claims forced NASA to maintain in congressional and public statements (not only in the early 1970's but throughout the shuttle program) that the shuttle was a good investment on economic grounds.

It became clear even during NASA's early in-house analyses that any economic justification depended crucially on the shuttle "capturing" all U.S. missions likely to be flown during the 1980's. In particular, NASA had to gain the agreement of the national security community to use the shuttle to launch all military and intelligence payloads, which were projected to be some 34 percent of future space traffic. Thus DOD support of the shuttle was crucial on both political and economic grounds.

Accommodating all DOD missions required a shuttle that could handle payloads up to 60 feet long, could launch up to 40,000 pounds into polar orbit and 5,000 pounds into geosynchronous orbit (which translated into a 65,000-pound maximum payload into a due east, 100-mile orbit), and could maneuver to land at the same location from which it had been launched after only one orbit of the

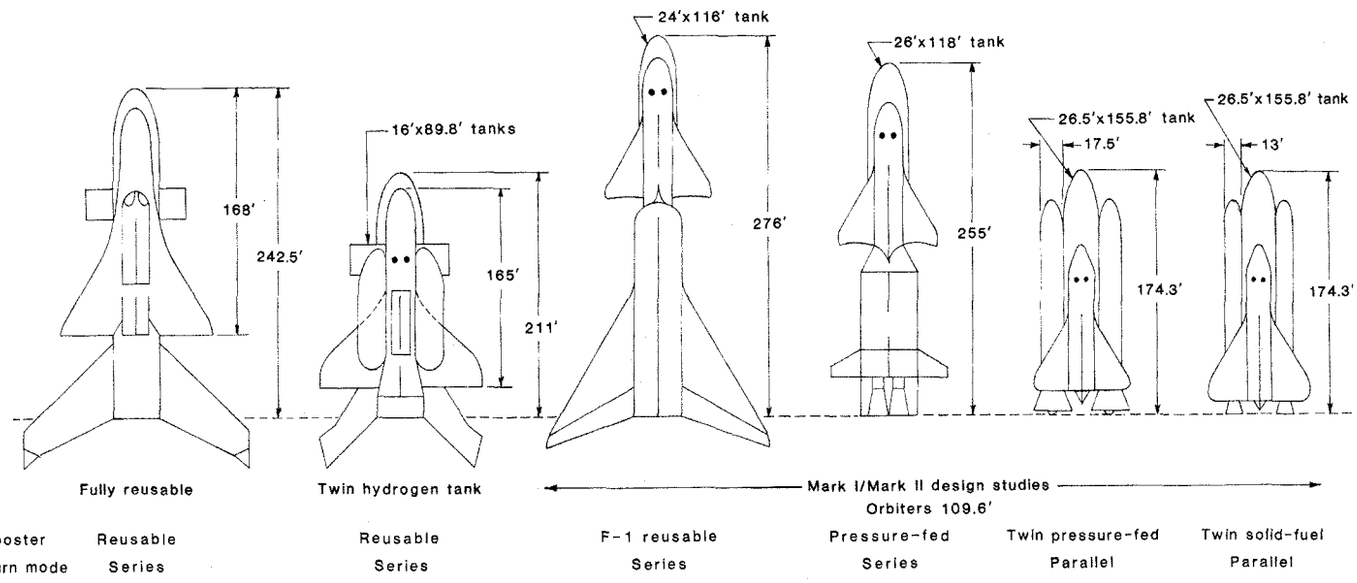

Fig. 1. Some of the shuttle designs considered during 1971. Once NASA decided to adopt a phased approach to shuttle development, a number of alternatives to launching the partially reusable orbiter were considered. These included modified Saturn V rocket stages, new pressure-fed liquid fuel boosters, and solid fuel boosters (*38*). [Drawing by Eleanor Warner]

earth. Of the crucial design parameters of the shuttle, only the maximum payload width, 15 feet, was based primarily on a NASA requirement, to be able to launch manned space station modules, although NASA as well as DOD had projected a need for 60-foot long and 65,000-pound payloads (*7*).

Perhaps the military requirement with the most impact on shuttle design was that for high cross-range, the ability to maneuver upon reentry to either side of the vehicle's ground track. The Air Force wanted 1100 to 1500-mile cross-range capability; this allowed a quick return from orbit to secure military airfields and removed the need for overflying hostile areas in crisis situations. In particular, the Air Force wanted to be able to launch the shuttle into polar orbit from Vandenberg Air Force Base on the California coast, have it rendezvous with an already orbiting payload (probably a reconnaissance satellite), and return after a single revolution to Vandenberg. The landing strip would have moved east some 1100 miles as the earth rotated during the 110-minute shuttle orbit.

In order to achieve this cross-range capability, NASA adopted a delta-wing configuration for the shuttle, which made the vehicle heavier. Maneuvering during high-speed reentry also exposed the shuttle to high temperatures for longer periods of time than a "straight-in" approach; this doubled the weight of the thermal protection system required. These increases in orbiter weight made it difficult to meet payload weight-lifting requirements and placed extra demands on the shuttle's propulsion systems (*8*).

Even though DOD demands drove important aspects of the shuttle design, it was not clear how strong was military interest in the shuttle or how "real" were the future military and intelligence missions on which the DOD requirements were based. Secretary of the Air Force Robert Seamans saw "no pressing need" for the shuttle, but characterized it as "a capability the Air Force would like to have" (*9*). Seamans was a former top NASA official. Few high Air Force officers favored the shuttle; most were satisfied with the service's own large expendable Titan III rocket. The number of Air Force personnel directly involved in the shuttle decision was "quite small" (*8*, p. 103). Air Force support for the shuttle was thus not based on wide or deep exposure of career officers to the concept; given this, the Air Force interest in recent years in keeping its own alternative to the shuttle is not surprising. As late as October 1971, as the shuttle debate entered its final stages, Deputy Secretary of Defense David Packard told NASA head Fletcher that "he felt very uneasy about the requirements that had been laid down . . . , that the cross-range requirement might have been an artificial one, and . . . that if it were causing difficulties it could easily be modified" (*10*).

NASA officials did not request such modifications, and almost to the last day of the shuttle decision process insisted that the only shuttle worth developing was one that would meet all DOD requirements. Although the military did not offer to bear any significant share of shuttle development costs, except those to create a launch facility at Vandenberg, the Air Force did agree in 1971 not to develop any new launch vehicles of its own, and leaders of the national security community did communicate their support of the shuttle program both to the White House and to Congress. Its military potential was a key factor in Richard Nixon's decision to approve the shuttle that NASA wanted to build.

Choosing the Shuttle Configuration

In May 1971, OMB officials told NASA that it could expect to get no budget increases during the next 5 years. This was a drastic blow because it meant that the agency could not carry out the shuttle program that it had been planning for almost 2 years. Those plans called for a fully reusable shuttle that was likely to have development costs of $10 billion and a peak annual budget of some $2 billion. If limited to the $3.2-billion annual budget that had been approved by OMB for fiscal year 1972, the most that NASA could put into the shuttle development was approximately $5 billion to $6 billion, with a peak annual budget of $1 billion; the organization wanted to retain enough resources to carry out a balanced science and applications program, as well as to develop the shuttle.

NASA and its contractors searched for a shuttle configuration that would both preserve the capabilities promised the DOD and fit this budget profile. Dozens of possible approaches were examined. Between June and December 1971, according to one closely involved, "everybody was a shuttle designer" (*11*). NASA, its contractors, PSAC, and even OMB struggled with alternate concepts.

The fully reusable shuttle that NASA had been studying until mid-1971 had two components. One was a manned booster roughly the size of a Boeing 747, which would provide the initial thrust to lift the system off the earth's surface. After launch, this booster stage would be flown by its crew to a landing near the launch site. The second element, the shuttle orbiter, was the size of a Boeing 707 and carried its liquid hydrogen and oxygen fuel in tanks inside the airframe. After separation from the booster, the orbiter's engines would take it into space, where it would carry out its mission, deorbit, and return to earth.

Most ideas for lowering development costs involved substituting some form of expendable booster for the manned first-stage booster. This did not appear technically possible, however, given the large size of the shuttle orbiter. A June 1971 design breakthrough solved this problem; the concept was to move the orbiter's large hydrogen fuel tanks outside the airframe and to make them expendable. This made the orbiter smaller and lighter, with a significant reduction in development costs, but with a corollary increase in costs each time the orbiter was launched. Further study showed that even more money could be saved if both oxygen and hydrogen tanks were placed in a single external disposable structure.

Further refinements in orbiter design reduced development costs even more. NASA next proposed developing first a first-generation Mark I orbiter, with subsystems such as thermal protection, electronics and engines based on existing technology, and then several years later phasing in new technology in a Mark II, full capability, version of the orbiter.

Trade-offs between development and operating costs characterized the rest of the design process, but with much more attention being paid to lowering investment costs than to the downstream consequences for those who would use the system. OMB Assistant Director Donald Rice, who headed the part of the budget office that reviewed NASA's programs, later remarked that "what needed more attention and never got any more attention was a good careful scrubdown of the operating costs. The number that NASA was carrying around was absurd" (*12*).

Once an orbiter small enough to be launched on an expendable booster had been identified, the question remained of what booster to use. This decision too was driven primarily by budget considerations and remained open for 2 months after President Nixon announced his approval of shuttle development. Among the alternatives examined (Fig. 1) were a winged but unmanned recoverable liquid fuel booster based on the first stage of the giant Saturn V rocket that had been used for Apollo moon missions; new, simpler liquid fuel boosters, also recoverable, that used gas pressure rather than large pumps to feed fuel to their rocket motors; or expendable solid rocket boosters, a technology with which NASA had had little experience. (It was not until early 1972 that the concept of attempting to recover and reuse the solid rocket boosters was

Table 1. Shuttle cost comparisons, December 1971 (*36*).

Characteristic	Payload bay size (feet)		
	10 by 30	14 by 45	15 by 60
Payload weight (pounds)	30,000	45,000	65,000
Development costs (billions of dollars)	4.7	5.0	5.5
Operating costs (millions of dollars/flight)	6.6	7.5	7.7
Payload costs (dollars/pound)	220	167	118

adopted, again as a cost-saving measure.) Also in question was whether the shuttle orbiter would be launched on top of a large booster, with the orbiter's engines not being ignited until after the first stage had accelerated it to a staging velocity, or whether the orbiter's engines would be fired from the start in parallel with smaller and cheaper "strap-on" boosters.

As late as the end of November 1971 NASA was still undecided on which shuttle configuration to favor, although it was tending toward a "parallel burn" design with either liquid or solid boosters. Mathematica, the firm conducting the shuttle economic analysis for NASA, argued that "among the many space shuttle configurations so far investigated, and which are determined to be technologically feasible, a thrust-assisted orbiter shuttle (TAOS) with external hydrogen/oxygen tanks emerges at present as the economically preferred concept." Mathematica suggested that a full capability shuttle embodying new technology and based on the TAOS approach could be developed for approximately $6 billion, with a cost per launch of $6 million or less (*13*). In December NASA decided to adopt the TAOS configuration, with the choice of liquid fuel or solid booster held open for further study.

The final choice of using solid rocket boosters attached to the orbiter's external tanks, rather than a new liquid fuel booster, was not announced until March 1972. It was based on "a trade-off between future benefits (at the time the shuttle becomes operational) and earlier savings in the immediate years ahead: liquid boosters have lower potential operating costs, while solid boosters have lower development costs." Fletcher told OMB that "from the budgetary point of view, perhaps the most important consideration is that we have selected the configuration which, for a given payload size and weight, entails the lowest development cost" (*14*). This decision placed a large share of the burden of paying for the shuttle program on its future users.

The Decision Process

While the shuttle configuration finally approved was not the one NASA had wanted to build, it did give the agency a major development program for the 1970's. The willingness of the top levels of the White House to support a large shuttle program, despite the vocal opposition of the OMB staff and the skepticism of the President's Science Adviser Edward David, was in doubt until 3 January 1972. On that day, NASA was told that President Nixon had given the project his go-ahead. In the end, the decision to approve the shuttle was made on grounds very different from those that had been so vigorously debated between NASA and OMB. The issues that had so concerned the Executive Office staff—the scope of the U.S. space program, and thus the demand for space transportation, and the validity of NASA's cost projections—went unresolved, only to reemerge once the shuttle began operation.

A few months earlier, approval of shuttle development had seemed unlikely to NASA Administrator Fletcher. The space science community in 1970 and 1971 congressional hearings had been vocal in its opposition to the shuttle, but NASA's leaders, oriented toward manned space flight, had largely ignored that criticism. In a July 1971 letter to a leading shuttle critic, space scientist James van Allen, Fletcher suggested that "the political cards are so heavily stacked against this program . . . that no opposition from the scientific community is necessary. I think you are shooting at a dead horse." Fletcher's pessimism was based both on the skeptical attitudes of key White House personnel on the political benefits of a large post-Apollo space program and his reading of an anti-technology mood in the country (*15*).

The process of developing the President's fiscal year 1973 budget took place between October and December 1971. Because OMB Director George Shultz spent most of his time as one of President Nixon's closest policy advisers, day-to-day supervisor of OMB was Deputy Director Caspar Weinberger. It was the interactions among Rice and his OMB staff and NASA Administrator Fletcher and NASA Deputy Administrator George Low that provided the major arena for the NASA–Executive Office debate on the shuttle. Also closely involved was Science Adviser David, supported by an ad hoc PSAC panel chaired by Alexander Flax, head of the Institute for Defense Analysis.

Throughout the decision process, OMB pushed NASA to examine alternatives to the space shuttle, and NASA resisted most of this pressure, on the grounds that only a highly capable system would attract critical DOD and congressional support. In July 1971, OMB told NASA that the emphasis in its studies "should be placed on defining approaches which will substantially reduce the overall investment cost of the future space transportation system" (*16*). NASA's 30 September budget submission requested approval of the space shuttle, even though Fletcher admitted that "it was kind of a fuzzy shuttle—all the details weren't worked out" (*5*). Initial decisions on the NASA budget request were made at an OMB director's review on 22 October. In advance of the meeting, Fletcher wrote Weinberger, presenting NASA's arguments for a positive decision on the shuttle (*17*): (i) "The United States urgently needs the space shuttle to provide 'routine' access to near-earth space." (ii) "The shuttle provides the capability for a continuing U.S. manned space flight program, a capability we believe to be essential—without flying men just for their own sake." (iii) "The aerospace industry will be hurt by continuing indecision. . . . A firm go-ahead, on the other hand, will quickly create jobs in this industry." (iv) "It will not be possible to sustain the momentum now built up in the shuttle program much longer."

These points found a receptive audience in Weinberger, who thought that "it was a proper thing for the government to do at that time, and that we needed some forward-looking new activities." Thus, Weinberger overruled his staff's recommendation that the shuttle effort be canceled. However, he did accept their advice that, if he wanted to approve a shuttle program, there was "an opportunity to do it at a lower cost upon additional analysis" (*18*).

The fact that Weinberger had approved some sort of shuttle was

Table 2. Shuttle cost estimates, March 1972 (*37*).

Factor	Estimate
Development	$5.15 billion
Facilities	$300 million
Cost per orbiter	$250 million
Cost per flight	$10.4 million
Cost per pound (in orbit, fully loaded)	$160

not communicated to NASA; rather, Rice asked the agency to provide detailed analyses of alternatives to the full capability shuttle. Rice's preferred concept seemed to be some sort of small unpowered manned "glider" that would be launched atop an expendable rocket. In late November, the OMB staff was suggesting that "since the shuttle is not economic anyway, intangible benefits should be given serious attention (for example, national prestige, manned space flight)" and that "a 10′ × 20′ glider would provide virtually the same, intangible benefits as a 15′ ×60′ orbiter for less than half the investment cost." The staff (*19*) proposed:

> in the light of the innovative shuttle designs which have been forthcoming over the past several months, we believe that the best procedure would be to provide NASA with a constraint in terms of total investment cost rather than have us try to define a preferred configuration. If NASA's resourcefulness to date in changing the Shuttle's design is any guide, we have not yet begun to see what they could achieve if they really tried to optimize a system for **$3–4** [billion].

Rice did not totally accept this advice. On 11 December, he, David, and Assistant to the President Peter Flanigan, who was handling space issues for the White House, met with Fletcher and Low and told the NASA leaders that the President had decided to go ahead with the shuttle provided that it was a smaller orbiter with a 10 by 30 foot payload bay carrying a 30,000-pound payload and costing less than $4 billion to develop, with a per flight cost of less than $5 million. After considerable and heated discussion, Fletcher said that he could not accept such an edict on shuttle size and performance, and that he wanted to see the President (*6*). This never happened; Fletcher was persuaded that to confront President Nixon with the controversy would be counterproductive.

Apparently, the President had indeed decided to go forward with some sort of shuttle but had not specifically addressed the issue of shuttle size. Flanigan told Fletcher that "there was no written directive from the President" and that the specifics of a shuttle size were "not set in concrete" (*20*). It seems that Rice and David were trying to use the carrot of presidential approval to get NASA to agree to the smaller, less expensive system without actually having Nixon's decision on a specific shuttle in hand.

NASA did not respond to OMB until late December. After intense discussions within the agency, NASA decided to abandon its hopes for a 15 by 60 foot payload bay, 65,000-pound shuttle. NASA communicated its decision to OMB, saying that "we have concluded that a full capability 15′ × 60′–65,000# payload still represents a 'best buy,' and in ordinary times should be developed. However, we are recommending a somewhat smaller vehicle—one with a 14′ × 45′–45,000# payload capacity" (*21*). The smaller shuttle required the Air Force to maintain a Titan III capacity to launch the largest DOD and NASA payloads but meant that NASA could use the shuttle to launch modules for the manned space station it still hoped to build (*21*). Maintaining that option seems to have been a primary NASA objective throughout the shuttle debate. Table 1 shows NASA's comparison of the smaller shuttle it was now proposing with the full-size system and the "mini-shuttle" that had been suggested by OMB. (These costs were based on the use of liquid fuel strap-on boosters. Further study showed that development costs for these boosters would be higher than estimated in December. This led to a final choice of solid fuel boosters. Table 2 shows estimated costs for the configuration finally chosen for development.)

Fletcher and Low discussed NASA's proposal in a 29 December meeting with Shultz, Weinberger, Rice, and Flanigan. While Shultz seemed willing to approve the full-size 15 by 60 foot shuttle, Rice insisted that even the 14 by 45 foot shuttle was still too large and too expensive. NASA was told to take one more look at smaller alternatives.

Fig. 2. On 5 January 1972, NASA Administrator James Fletcher briefed President Richard Nixon on the shuttle program. After the briefing the White House announced that the President had authorized development of the shuttle. [Courtesy NASA]

By now, however, those that favored a smaller shuttle were fighting a rearguard action. Science Adviser David told Shultz that he was "disturbed" by the prospect of approval for a large shuttle, because "the large space program implicit" in such a decision was "not consistent with the best interests of the nation. . . ." David "strongly" recommended a decision to proceed with a limited shuttle program (*22*). On 3 January 1972, he told Shultz that "the decision on the space shuttle will involve a long-term commitment of R&D funds during the mid-1970's to achieve a set of hoped for benefits during the decade of the 1980's and beyond. Our studies have raised considerable doubt that these benefits will justify the costs of this investment" (*23*). Rice seconded David's points, arguing that "we should limit our investment to the smallest amount that will give us a new manned space flight capability and some additional capability for delivering unmanned payloads," and "there is a high degree of uncertainty in NASA's current cost estimates" (*24*). Both David and Rice recommended delaying a decision on the shuttle for at least several months.

NASA officials knew nothing of the trend in its direction within the White House and had been struggling over the New Year's weekend to develop answers to yet another set of detailed OMB questions. When Fletcher and Low arrived on 3 January for a 6 p.m. meeting in Shultz's office, they carried a letter reiterating that the 14 by 45 foot shuttle was still "the minimum acceptable option" (*25*). To NASA's pleasant surprise, Shultz told them that the President had approved development of the full-size 15 by 60 foot payload bay shuttle. When this was reported back to NASA's offices, the head of the shuttle program remembers that he was "amazed" (*26*).

The Politics of Approval

While NASA and OMB were haggling over shuttle size and costs during November and December 1971, the agency had also been attempting to marshal top political support for its proposals, particularly at DOD and the White House. In October, Fletcher met with Deputy Secretary of Defense Packard, who told the NASA head that the agency's approach to selling the shuttle was "all wrong." Packard apparently did not believe that "the shuttle should

ever be sold on the basis of the cost savings that might result, or even the flexibility in payloads." Rather, Packard noted that "the real point has to do with national security and an intangible thing which might be called 'man's presence in space.' " He also said "that it is not surprising that it is the Defense Department and the State Department together with Henry Kissinger who offer the most support for the shuttle." He suggested that NASA and DOD assemble a top-level team to develop a rationale for the shuttle and communicate it to the President and Congress. Fletcher agreed, but later told Low that it was important that the rationale "doesn't become unduly military in its flavor" (*10*).

Conversations between NASA and DOD continued into December; DOD research chief Johnny Foster, originally a shuttle skeptic, had become a supporter of the concept, although he said that NASA and DOD were not yet able "to identify military or civilian payloads to justify the large expenditures required to make the shuttle operational in the 80's" (*27*). Low suggested to Foster that a major lack was "an imaginative military space program taking advantage of the new capabilities that the shuttle would represent" (*28*).

Although DOD never came forward with such a program, NASA had its own list of military missions that the shuttle might perform. For example, one suggestion was (*29*):

> the shuttle could be maintained on ready alert, making possible rapid responses to foreseeable and expected situations and greatly increase flexibility and timeliness of responses to military or technological surprises, such as: (a) rapid recovery and replacement of a faulty or failed spacecraft essential to national security; (b) examination of unidentified and suspicious orbiting objectives; (c) capture, disablement, or destruction of unfriendly spacecraft; (d) rapid examination of crucial situations developing on earth or in space whenever such events are observable from an orbiting spacecraft; and (e) rescue or relief of stranded or ill astronauts.

It apparently was shuttle capabilities such as these that were attractive to President Nixon. Top Nixon adviser John Erlichman remembers that "a strong influence was what the military could do with the larger bay in terms of the uses of satellites" and "the capability of capturing satellites, or recovering them." These factors, said Erlichman, "weighed into my attitude toward the larger shuttle, and . . . also weighed into Nixon's" (*30*).

Another argument in favor of the shuttle that NASA spent some time in developing was the program's employment impacts, particularly in view of the then-depressed state of the aerospace industry and the upcoming 1972 presidential election. Fletcher told the White House that "an accelerated start on the shuttle would lead to a direct employment of 8,800 by the end of 1972, and 24,000 by the end of 1973" (*31*). This was "a very important consideration in Nixon's mind," according to Erlichman, who remembers joining the President in a review of the employment impacts of various federal programs in states crucial to the President's reelection. The White House found that "when you look at employment numbers and key them to battleground states, the space program has an importance out of proportion to its budget" (*30*).

Perhaps the single key in gaining Nixon's support was the leadership aspect of maintaining a vigorous U.S. manned space flight program. Fletcher argued that "the United States cannot forego its responsibility—to itself and to the free world—to have a part in manned space flight. . . . For the U.S. not to be in space, while others do have men in space, is unthinkable, and a position which America cannot accept" (*31*). This kind of argument reportedly appealed to the President, who saw astronauts as representing the very best of American values, and who had "died very hard on the SST," which had been defeated in Congress earlier in 1971, because of "a commitment that had to do with chauvinism. We had to be at the leading edge of this kind of applied technological development" (*30*).

It was considerations such as these that led the President to give final approval to the full capability shuttle over the 1971–72 New Year's weekend. According to Erlichman, "it was Nixon's decision. During that time there wasn't anyone else making those final decisions. In defense, space, certain kinds of domestic problems, he was the final arbiter" (*30*).

Fletcher and Low flew to San Clemente to brief the President on the shuttle program and to be present when the White House announced the decision on 5 January. Nixon was "fascinated" by the shuttle model that Fletcher had brought along (Fig. 2), according to Erlichman. "He held it and I wasn' t sure that Fletcher was going to be able to get it away from him" (*30*). Nixon told Fletcher and Low that NASA "should stress civilian applications, but not to the exclusion of the military applications as well." Nixon "liked the fact that ordinary people would be able to fly in the shuttle." The President was pleased to be assured by the NASA leaders that the shuttle was indeed a good investment, but "he indicated that even if it were not a good investment, we would have to do it anyway, because space flight is here to stay. Men are flying in space now and will continue to fly in space, and we'd best be a part of it" (*32*).

Concluding Observations

There were a number of long-term effects of the confused process through which approval to develop the shuttle was obtained. These were negative in the main, and their impacts have remained to trouble the nation's space program 14 years later. As the United States debates how best to reconstitute its space efforts and whether to make continued investments in new capabilities such as a space station and an aerospace plane, some of the lessons from the shuttle experience bear remembering.

For one thing, even though other considerations were ultimately decisive, NASA allowed itself to be trapped into making the primary public and congressional justification of the shuttle its cost-effectiveness. Even though all close to the program realized from the start that achieving that objective was not likely and required an improbably high level of space activity, NASA told Congress, the public, and later presidents that the shuttle could be operated on an economical basis. The problem with overselling a program is that advocates may later be expected to deliver on the promises made to gain approval and may find it difficult to back off from their public commitments. Further, the expectations created by program advocates influence the policy framework by which program success will be judged. Unrealistic expectations obviously lead to later policy failures.

NASA and the White House failed to gain widespread understanding of the fundamental reasons that the shuttle program was approved: U.S. leadership in manned space flight and advances in technological capabilities with both military and civilian implications. President Nixon gave little attention or visibility to the program after it was initiated; other matters were occupying his attention. The shuttle program was not begun in response to any external threat or challenge and did not engage what public interest in space remained after a number of Apollo missions to the moon. By using the shuttle's cost-effectiveness as a public justification, the harder task of portraying the program for what it was was avoided.

The decision to proceed with the shuttle was made over the vigorous objections of OMB, and it was not accompanied by a strong presidential directive to give the program high priority. This allowed OMB to chip away at the program's budget from the start. NASA officials thought that, along with the shuttle go-ahead, they had gotten an OMB commitment to a level budget through the period of shuttle development; such a budget would have allowed a number of other projects as well as the shuttle to go forward. Even

as the final decisions on the shuttle configurations were being made in March 1972, however, NASA and OMB were engaged in a debate over whether the commitment had been at the level of NASA budget authority, $3.4 billion, or budget outlays, $3.2 billion (*33*). In the first two budgets after shuttle approval, NASA did not get all the funds it requested for the program, causing early stretch-outs in schedule; later budget restrictions forced NASA to divert money from other space efforts to shuttle development.

Decisions to make capital investments in major facilities or capabilities require more than an initial approval. To be effective, they must be accompanied by a political commitment to provide the resources required over the lifetime of the program on a timely basis. Further, it makes little sense to invest in a capability intended to enable a wide range of scientific and technological activities if adequate support for those activities is not also provided. Striking an appropriate balance between creating infrastructure and developing experiments appears to be a particular problem as NASA begins the space station program.

Because it is difficult in the pluralistic U.S. policy-making process to reach consensus on policy goals, debates about means to achieve those goals often are used as surrogates (*34*). Substituting choices of means for choices of ends produces effective public policy only when agreement on means implies a decision on goals. This was not the case in the shuttle situation. Going ahead with the shuttle did not commit Richard Nixon or subsequent presidents to an active NASA program of scientific and application missions. The head of the PSAC space shuttle panel, Alexander Flax, told Science Adviser David in October 1971 (*35*):

> most of the members of the panel doubt that a viable shuttle program can be undertaken without a degree of national commitment over the long term analogous to that which sustained the Apollo program. Such a degree of political and public support may be attainable, but it is certainly not now apparent. Planning a program as large and as risky (with respect to both technology and cost) as the shuttle, with a long-term prospect of fixed ceiling budgets for the program and NASA as a whole does not bode well for the future.

This admonition eloquently summarizes the fundamental problem with the decision to build a space shuttle—that the national commitment required to make the program a policy success did not accompany that decision. Without such a commitment, the shuttle program became a victim of normal, year-by-year politics, and the space shuttle has not lived up to many of the expectations placed on it. As the nation considers its future course in space, the need for such a commitment continues, if the full benefits of space exploration are to be achieved.

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39. The research on which this article is based has been carried out over a number of years, including periods spent at the Woodrow Wilson International Center for Scholars and the National Air and Space Museum. See also J. M. Logsdon, *J. Contemp. Bus.* 7, 13 (1979). Copies of most of the interview transcripts, documents, letters, and memoranda cited are in the NASA Historical Archives, Washington, DC. The papers of J. Fletcher are on deposit at the library of the University of Utah.