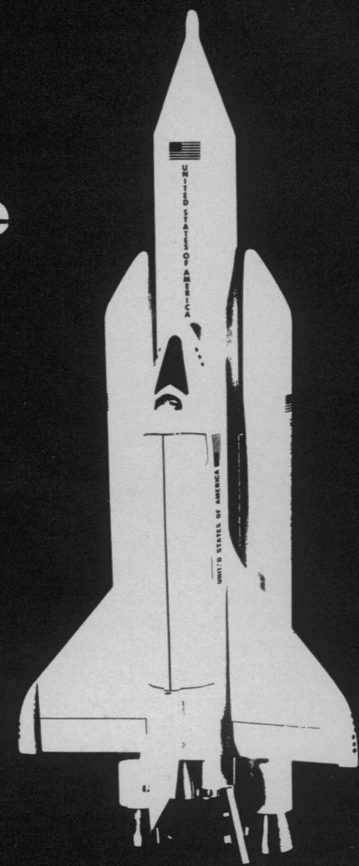
The story of an evolving shuttle



Studies have caused a major turnabout in concepts of how the space shuttle would save money

by Everly Driscoll

In 1969 the National Aeronautics and Space Administration, still exhilarated from the spectacular Apollo success, set forth a plan for the United States in space in the 1970's and 1980's that sounded like a science fiction writer's dream. The plan included a low-earth orbit space station, a space base, a space shuttle, a synchronous orbit station, a nuclear shuttle, a space tug, a lunar orbit station, a lunar base and a manned Mars spacecraft.

The space shuttle was only a small part of the visionaries' world, a world where interplanetary man would live and work as routinely as he lives in the suburbs and takes a bus to the office. But even before the first men to walk on the moon had returned to earth that world began to fade. Some of the visionaries left NASA; those who remained assumed a low profile.

What was left by December 1969 was the space shuttle, but it was a luxury liner compared with today's proposed model. It was a fully reusable two-stage vehicle. Both the booster and the orbiter had the design of an airplane. Both were launched vertically, the orbiter atop the booster. Both landed horizontally, like an airplane. The booster more often than not was manned (SN: 8/29/70, p. 179). NASA said it would cost $6 billion to build the shuttle.

What happened to the space world of the 1960's is a political story. But what has happened to the space shuttle in the 1970's—according to one Government economist not associated with NASA—"will go down [in history] as a classic in cost-effectiveness study." While the shape, size and eventual cost of the shuttle have been undergoing continuous scrutiny and change for the last two years, the rationale for the shuttle has remained the same: reduce the high cost of space activity by developing an economic space transportation system that can be used by all customers—commercial, NASA and Department of Defense. ("After all," says George M. Low, deputy administrator of NASA, "space is not as far as Cuba from the United States.")

NASA's decision two weeks ago to build a shuttle using solid rocket boosters assisted by an expendable liquid booster reflects the extent of the turnabout (SN: 3/25/72, p. 198). Instead of reusable boosters, NASA chose to use a part throwaway, part reusable system. And instead of pressure-fed liquid boosters, NASA chose less expensive solids. The new shuttle has less pizzazz, but more economy.

Changes in the concepts about how to achieve this economy are the key to the evolution of the space shuttle.

In January 1970 the Office of Management and Budget (OMB) requested that NASA do a thorough economic analysis of the space shuttle. NASA selected Mathematica Inc., a Princeton, N.J., economic analysis firm, to do the cost study. Aerospace Corp. and the Space Division of Lockheed Corp. contracted to supply the raw data to Mathematica. DOD and NASA fed Aerospace the projected shuttle traffic models and size requirements. Lockheed worked on a new concept—payload effects. All this was then fed to Mathematica for the economic analysis.

In May 1971 the first study of the two-stage, fully reusable shuttle was completed (SN: 7/24/71, p. 56). The report estimated that the space tug (which would take shuttle satellites from low to high orbit), ground installations and the two-stage shuttle would cost about $12.8 billion (instead of $6 billion) in nonrecurring cost at a 10 percent social discount rate. (The social discount rate is the interest assigned by OMB to Government projects. Many Government projects are assigned zero rate; others five; the higher the rate, the more a project has to do before the private sector sees a return on its tax investment.)

The study used as a traffic baseline, 736 launches by DOD and NASA between 1979 and 1990, or about 63 launches total per year. (The average number of launches for DOD and NASA per year has been 55 over the last 10 years.) The nonrecurring costs—research, development, testing and evaluation (RDT and

E) ranged from $12.8 billion for 500 flights up to $20 billion for 850 flights between 1979 and 1990. The recurring costs were low—$4.6 million per launch (the smallest expendable or nonreusable booster NASA and DOD now use is the Scout, which costs $2 million per launch; the largest is the Saturn 5, more than $200 million per launch).

Lockheed and Aerospace had the real winner, however, in payload effects (the effects the shuttle would have on satellites or spacecraft launched). Lockheed showed that billions of dollars would be saved in that satellites could be built cheaper because the orbiter would take them into space. There would be further savings because the satellites could be retrieved, refurbished, repaired and then reused.

The 1971 report recommended that NASA study "other systems" (other than the fully reusable two-stage). It concluded that the "economic justification of a reusable Space Transportation System (STS) is not tied to the question of manned versus unmanned space flight. Space programs used and analyzed [in the study] are in line with the activity and funding levels of the unmanned U.S. space program [DOD and NASA] for the 1960's."

In June 1971 NASA announced it was extending the shuttle studies and would be looking at alternatives to the two-stage, fully reusable design. More than nine configurations would be studied in the six months from June 1971 to January 1972. They included manned orbiters with a variety of unmanned boosters, single orbiters with parallel burn and rocket assist, single-stage-to-orbit concepts and the stage and one-half concepts. There was brief talk of a "Mark 1, Mark 2" shuttle—phasing in new technology in both the orbiter and booster.

In January 1972, President Nixon announced his support of the space shuttle (SN: 1/15/72, p. 36). He said that the RDT and E costs of the shuttle would be only $5.5 billion.

On Jan. 31, Mathematica completed its second study, released in February. The new proposed shuttle would not have a reusable booster. The boosters recommended as "cost effective" were the good old expendables. The study concludes that "a thrust-assisted orbiter shuttle (TAOS) with external hydrogen/oxygen tanks [on the orbiter] is the economically preferred choice among the many space shuttle configurations so far investigated. . . . The main economic alternatives are the pressure-fed boosters and solid rocket motors, . . . [but] a minimum nonrecurring cost program and a minimum technological risk program for the 1970's will favor a solid rocket motor, thrust-assisted shuttle system." In other words, it recommends a reusable orbiter placed into space with an expendable or only partially reusable solid rocket booster. Mathematica says this can be built for about $5 billion, half the development costs for the earlier proposed two-stage version. With the space tug and the Western Test Range site added, the RDT and E costs rise to $7.5 billion (NASA is hoping that the European Space Community will build the space tug). While nonrecurring costs are cut in half, costs per launch are double for TAOS—$7 million to $10 million per launch.

The 1972 study differs from the 1971 one in other aspects. As a traffic model for DOD and NASA, the study uses 514 launches instead of 736. It compares the total space costs (boosters and satellites for both DOD and NASA) of 43 unmanned launches per year using current expendables (Scouts, Deltas), new expendables, and the TAOS shuttle. The cost between now and 1990 for the nation to continue to use the current systems would be $42 billion (a little over $2 billion for DOD & NASA per year). The total cost to use new expendables would be $40 billion. The total cost to use the TAOS shuttle would be $35 billion.

According to Mathematica, TAOS will "break even" in costs (launches and payloads) with an average of 30 flights per year for DOD and NASA; if there is an average of 43 flights per year, TAOS will save $10.2 billion. If there are 52 flights per year, it will save $13.9 billion.

Mathematica's analysis indicates that the TAOS version will not cause the NASA budget to peak at $4 billion or more during the development phase, as did the 1971 version of the shuttle.

"Literally hundreds of different space shuttle systems have been studied," the report notes. "Seldom, if ever before has a single investment program of the scope and size of the Space Shuttle System been studied in such detail—both technical and economic—as to alternative approaches to achieve the objectives listed." It concludes that the shuttle is economically feasible assuming a level of space activity equal to the average of the U.S. unmanned program of the last eight years.

Several questions immediately occur to anyone who has been following the day to day odyssey of the shuttle. The most obvious is why didn't NASA come up with TAOS to begin with instead of the two-stage. Then, is there a possibility that NASA will find an even more efficient and less expensive system by studying the shuttle for two more years? And finally, whatever happened to the concept that the way to save money in space is not to throw away boosters?

The answer to all of these may lie in the new concept of space economy that has been emerging since the first Mathematica study. "Back in 1969 and 1970," says one aerospace official, "we were still operating under the old-fashioned mode of 'what does it cost to launch a satellite?' Each user—DOD, commerical or NASA—was trying to find the cheapest and smallest booster that would fit the satellite or spacecraft." Thus the rationale of the reusable shuttle booster of 1970.

What NASA says it has learned as a result of this two-year, often excruciating, study period is that saving money in space has little or nothing to do with the kind of booster used. Thus the shuttle couldn't pay for itself on transportation cost savings alone. The saving comes from a new way of thinking about, building, operating, using and reusing the satellites and scientific payloads placed into space. As Aerospace concludes in its summary, "Launch costs are the least sensitive elements of the analysis. RDT and E costs for the shuttle and payloads and refurbishment costs of payloads are the principal drivers."

Lockheed estimates that 25 percent can be saved in RDT and E in payload costs and operations. About 35 percent of the cost of a new replacement payload can be saved by refurbishing the old payload. (For example, when the current Orbiting Solar Observatory 7 wears out, it could be repaired rather than replaced.) And it estimates that more than a billion dollars will be saved by standardizing the subsystems and the spacecraft themselves, although this aspect of payload effects was not considered in the latest Mathematica study.

Justifying the economics of the shuttle by its effects on payloads may prove to be an even greater challenge to NASA than the booster dilemma. The payload savings assume that most satellites need to be replaced or updated, and that the scientific or defense market can handle all the data that such a system will be able to supply. The assumptions may be difficult to defend.

"How many satellites really need to be repaired or reused? asks one Rand Corp. research analyst who has studied both Mathematica studies. Many satellites, at the end of their lifetime, are obsolete."

The problem of handling the voluminous data is a perennial one. It is common knowledge that two satellite models —the orbiting solar observatory and the orbiting geophysical observatory—have already returned more data than will ever be analyzed. "There just aren't enough scientists around to do the job," says the research analyst.

"All of this is not to discount the Mathematica methodology," he adds. "It is excellent. The study covers all of the basic ingredients needed. If there are any problems in the report, it is in the numbers and statistics fed to Mathematica." □