BRIAN O'LEARY

"The most serious problems with the space shuttle can be summarized as follows: its questionable role in competing national priorities and internal NASA priorities; the lack of a clear definition of NASA's goals for shuttle use; the uncertainties in the recurring cost of the use and possible reuse of solid-fueled boosters; the questionable need for extensive payload subsystem refurbishments; the secondary social and economic costs of the shuttle; and the probability that the Department of Defense will become the primary shuttle customer and principal cost-driver in the shuttle design." Portions of this article are based on a statement presented before the U.S. Senate Committee on Aeronautical and Space Sciences on the NASA authorization for fiscal year 1973, Bill S3094, April 12, 1972. Several science, engineering and law students at the University of California at Berkeley and at San Francisco State College participated in the assessment of the space shuttle. Brian O'Leary, a former astronaut, is assistant professor of astronomy and science policy assessment at Hampshire College, Amherst, Massachusetts.

THE SPACE SHUTTLE
NASA's White Elephant in the Sky

NEWS RELEASE: PROJECT JUMBO ORBITS
(Cape Kennedy, Fla., Feb. 29, 1984)

Four white elephants were successfully fired into orbit this morning aboard NASA's space shuttlecraft Hercules.

Shuttle pilots Vic Poster and Karl Dye report "all is well" after the first orbit of this six-day sortie mission, the first of several planned flights under Project Jumbo. The program has been slated to "test the physiological reaction of large mammals under zero gravity conditions."

Dr. Raymond White, the veterinarian-experimenter attending the elephants in the shuttle bay, reports after the first 90 minutes of flight, "The animals responded surprisingly well through the three g's during the launch environment (one g is the normal pull of gravity on Earth). We should be ready to proceed with the tests as soon as the drugs wear off."

When asked about the cabin environment White said, "It smells pretty bad up here but we were prepared for that. I'm sure we'll get used to it."

The elephants are named Ramar, Babar, Millicent and Bump, each weighing 5,000 pounds. They are on loan from the government of India which is collaborating with the United States on the project. According to one NASA official, the unusual-looking Asian species, distinguished by a whitish-grey color, "is particularly well-suited for physiological experiments in space. We hope to obtain useful information in the spirit of international cooperation which has marked many of our shuttle flights."

Today's Project Jumbo launch makes this the 117th flight for NASA during the three-year lifetime of its $20 billion space shuttle program. This launch is also the first civilian use of the shuttle since the Spacebird disaster last September.

For the past two years the National Aeronautics and Space Administration (NASA) has been actively promoting a reusable space shuttle system which they claim would reduce the space transportation costs for a variety of space programs projected for the 1980s and beyond. Thus far more than $400 million has been spent or appropriated on early shuttle development. If Congress continues to approve this program, the annual expenditure will increase rapidly to about $600 million in Fiscal Year 1974 and more than $1 billion in Fiscal Year 1975 and thereafter. The total nonrecurring costs for a shuttle and tug system are estimated to cost $5 to $15 billion, or more than ten times that requested for the Supersonic Transport (SST). The space shuttle is the largest civilian technological project now under development in the United States. It is clear that the scale of the space shuttle program is enormous.

What is the space shuttle and whom will it serve? The space shuttle is a large winged rocket-plane (about the size of a McDonnell Douglas DC-9) which would be launched into space atop a booster, go into earth orbit, deliver and pick up men, experiments and other payloads in orbit, and return to the earth, landing on a runway like an airplane. Each shuttle could be reused about 100 times. Shuttle flights would be piloted by two men, and the large cargo bay (a cylinder 60 feet long and 15 feet in diameter) could carry up to 65,000 pounds of men and equipment into low earth orbit due east at about 100 miles altitude. NASA has designed another rocket called the space tug to boost payloads to much higher orbits; for example, communications satellites are put into "synchronous" orbits 22,300 miles over selected spots on the equator. Both NASA and the Pentagon believe that the

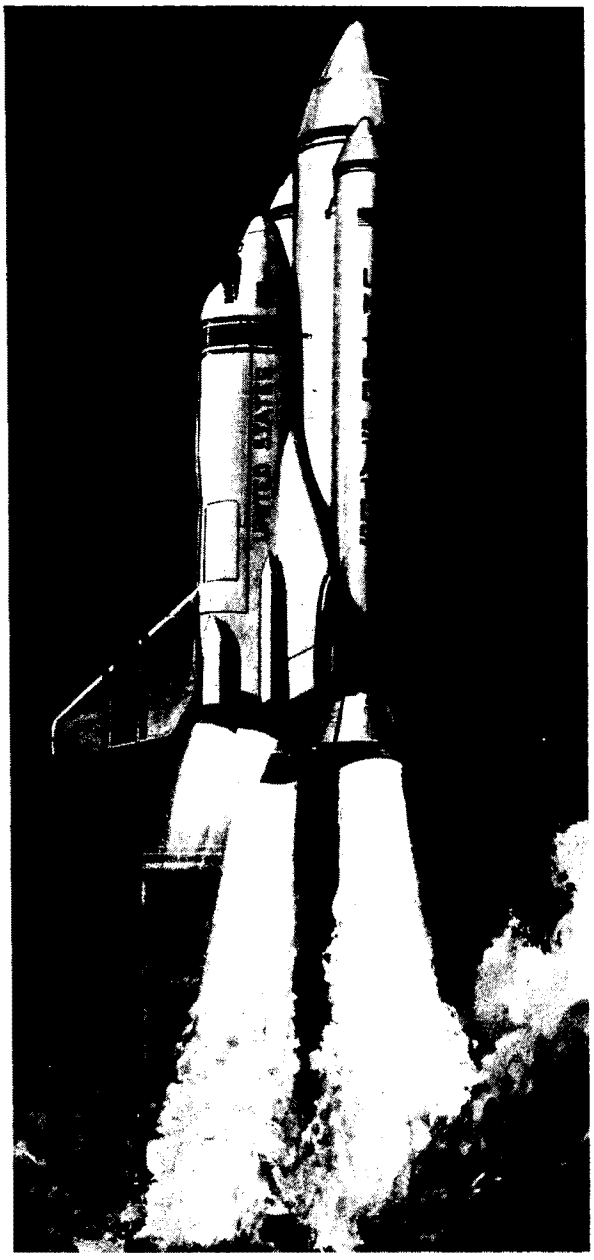
shuttle and tug would solve most of their space transportation problems.

In many minds the space shuttle program is a fait accompli. President Nixon has authorized it, Congress has quickly approved it, bases have been selected, contractors have been selected and thousands of people are being hired. From a public relations point of view the feeling seems to be unanimous: "The space shuttle will drastically lower the cost of space transportation," state the Associated Press, CBS and virtually all media. Spoon-fed by NASA, the media and hence the people have accepted this as a fact, as a foregone conclusion. Yet this statement could turn out to be one of the most controversial ones in American technological history.

I believe that the shuttle debate has only begun. Although the $400 million so far committed seems like a lot of money, it is less than 5 per cent of the estimated development costs. By comparison $1.45 billion was spent on the Air Force's manned orbiting laboratory (MOL) before it was cancelled. As NASA asks for more money, and as we begin to acquire some time to rationally assess the program, doubts will arise which might bring to the space shuttle the same fate as the MOL, the Dyna-Soar (an Air Force orbital airplane project) and the SST. It might turn out that the wide acceptance of the shuttle will have been merely a brief election-year pork barrel flurry.

I think it can be shown that economic arguments for developing a space shuttle are neither convincing nor sufficient to justify a commitment to such large expenditures at this time. The most serious problems with the space shuttle can be summarized as follows: its questionable role in competing national priorities and internal NASA priorities; the lack of a clear definition of NASA's goals for shuttle use; the uncertainties in the recurring cost of the use and possible reuse of solid-fueled boosters; the questionable need for extensive payload subsystem refurbishments; the secondary social and economic costs of the shuttle; and the probability that the Department of Defense will become the primary shuttle customer and principal cost-driver in the shuttle design.

Perhaps the most significant problem in assessing the space shuttle program has been the extremely rapid fluctuations in NASA's rationale for promoting the shuttle. These quick changes come dangerously close in time to an apparent commitment to the program. Three years ago, on the heels of the success of Apollo 11, NASA linked the shuttle concept with a permanent manned space station as a stepping stone for manned flight to the planets. In 1971, when this approach appeared unpopular, the shuttle became an end in itself—a $12.8 billion two-stage fully reusable system which, at capacity, could hoist more than two million pounds of manned and unmanned payloads into earth orbit each year. This can be compared to the present rate of approximately



Artist's concept of space shuttle at liftoff.

10,000 pounds per year of manned nondefense satellites and space probes, barely sufficient to comprise 15 per cent of the capacity of one shuttle flight.

Budgetary pressures have now forced NASA to propose a less expensive space shuttle and tug system; the shuttle orbiter would still be winged and reusable about 100 times whereas the booster would use tanks containing solid propellant which would be dropped into the ocean and could hopefully be reused a few times. The nonrecurring costs are now estimated to exceed $5 billion, but the marked increase in recurring costs make this alternative less attractive to NASA than the fully reusable system. It is clear that committing large amounts of money to a system when its configuration significantly changes at frequent intervals is unwise. Once a configuration has been decided

upon, and thorough studies from several quarters have been carried out, presumably a national decision can be made as to whether or not to build a new space transportation system.

During the last two years NASA let contracts worth $2.2 million to 3 companies to perform a cost benefit analysis of the space shuttle: Mathematica, Inc., carried out the economic analysis based on space traffic data provided to them by Aerospace, Inc., and Lockheed Missiles and Space Company. They concluded that the shuttle would be more economical than existing space transportation systems after several years of operation. They found that this conclusion applies even for the present day unmanned defense and nondefense traffic rate. Because these findings conflict with numerous other studies by the Office of Management and Budget (OMB), by a panel of the President's Science Advisory Committee (PSAC), by the Rand Corporation, by Senator Walter F. Mondale, and by several independent scientists—the economics of the space shuttle has caused considerable controversy. This fact is contrary to what NASA and the Nixon administration would have us believe.

However, a balanced presentation to decision-makers of technical information bearing on the costs and benefits of the shuttle cannot be accomplished without some degree of honest effort outside NASA and its contractors. Such effort is now almost entirely missing and is badly needed before a national decision can be made.

National Priorities

Since the triumphant moment of Apollo 11 when Neil Armstrong set foot on the Moon, protagonists and participants of the space program have suffered a series of frustrating setbacks through no fault of their own. Public interest and support have waned rapidly. The perspectives of the 1950s and 1960s have shifted radically. Then we had confidence in feeling we had virtually unlimited resources and the technological teamwork to carry out adventures at home, on the battlefield and in outer space. Now we are starting to focus on solving the problems of the everyday lives of millions—poverty, crime, disease, crowds, pollution, noise and future shock. Arguments that all technology is beneficial and will result inevitably in spin-offs for practical human needs no longer have the same degree of acceptance among the populace.

Right or wrong, the public consciousness is moving away from accepting large technological enterprises which in their opinion do not have tangible application toward improvement of the quality of life. These trends cannot be ignored. If asked for $200 to support the research and development of a space shuttle, most families would refuse—yet that will be the amount the average taxpayer would have to contribute to the shuttle before the first one is launched.

I feel that arguments involving national security and prestige are relatively inconsequential. It has not been demonstrated that the additional capacity and capabilities of the shuttle provide a significant improvement in the strategic military posture of this country. A similar argument would apply to prestige. If the Soviet Union were to develop a shuttle first, it is highly doubtful that any Sputnik-like repercussions would arise. A reusable earth-orbit vehicle does not have nearly the same public impact as a manned lunar landing, even if we assume that the United States were to feel that the space race has as high a priority in the 1980s as in the early 1960s.

In summary, the atmosphere in this country is such that the shuttle should have a demonstrably strong justification, not just a marginal one, among competing space transportation systems before any commitments are made. It is highly unlikely that large cost overruns, miscalculations and misuses of the program will be tolerated by the people. It would be a serious mistake to spend billions of dollars for a boondoggle, creating another credibility gap between government interests and the public interest.

NASA's Priorities

The Office of Management and Budget has set $3.5 billion as a ceiling to the annual NASA budget. Since much of this must be spent on NASA administrative and fixed costs and more than $1 billion would be spent on shuttle research and development each year during the latter half of this decade, there would be little left for other NASA programs such as space sciences, applications and advanced research and technology.

The pinch has in fact already been felt. The Grand Tour of the planets (a gravity assist flyby of all the outer planets)—an opportunity which presents itself once every two centuries, with a chance coming up in the late 1970s—has been cancelled in favor of modestly-funded studies of Mariner Jupiter-Saturn missions. The opportunity to visit the planets Uranus, Neptune and Pluto might have to wait for decades and would have to be done less economically on separate missions. Various long lead-time advanced technology programs like the Nerva nuclear rocket program have been severely cut. The 1973 Mariner 10 mission to Venus and Mercury will fly only one spacecraft; so in the event of a catastrophic failure like those which befell three of eight previous Mariners, the entire mission will be lost and a new opportunity may not present itself for decades. The launch of a duplicate spacecraft at 20 per cent more cost would have gone a long way to ensure success in the same way that the spectacular results from Mariner 9 last year rescued us from the catastrophic failure of its twin, Mariner 8, which ended up in the Atlantic Ocean just after launch.

The priorities which NASA has chosen to follow raise an important philosophical question with regard to the agency's mission—Have space trans-

portation systems become an end rather than the means of space exploration? Have we become so obsessed with developing space hardware that the business of exploring space for science and practical applications has become a secondary goal for NASA? Experience with the Apollo program suggests that this is indeed the case: the full potential of lunar exploration with the Apollo capability was never fulfilled. It appears that the development of the space shuttle will perpetuate this emphasis.

Nobody has explicitly stated the goals of the space shuttle. Vague comments are advanced to the effect that the shuttle will save space transportation costs because of its reusability and the capabilities of refurbishment and maintenance of payloads. These projected savings are enthusiastically promoted within the several volumes issued by the NASA contractors who have studied the costs and benefits of the shuttle, yet they admit many uncertainties in their analyses. Nowhere is there an explicit program-by-program account of projected savings by shuttle use and a coherent plan to ensure such savings. Nowhere is there a statement as to which space program would be most desirable in the 1980s. It seems ludicrous for us to commit several billion dollars to a program whose goals are so uncertain.

The Mathematica reports said:

> Any investment can only be justified by its goals. This applies to business as well as to government, hence also NASA. A new, reusable Space Transportation System should only be introduced if it can be shown, conclusively, what it is to be used for and that the intended uses are meaningful to those who have to appropriate the funds, and to those from whom the funds are raised, as well as to the various government agencies that undertake space activities.

I agree with this statement. Until NASA can explicitly state its goals, we can only assume that the space shuttle is a mission looking for a science or application rather than a science or application looking for a mission.

Shuttle Launch Costs

NASA's three-year budget for fiscal 1970-72 totals $10.4 billion. Of this the launch vehicle procurement costs add up to less than $0.4 billion or only 4 per cent of the total budget. It therefore comes as a surprise that NASA wishes to develop a space transportation system partly to save the "staggering expense" for launch vehicle procurement.

Moreover, it is claimed that the recurring launch costs per pound of payload would decrease considerably because of the shuttle. First, this assumes that the booster can be reused, which, at present, is an unknown and unproven concept. If the booster cannot be reused, each new shuttle booster could cost more than that of the Titan III-C which can launch up to 27,000 pounds of a large military payload into low earth orbit. This becomes a fundamental roadblock to shuttle development: Why invest $5 to $15 billion in a system whose launch costs might turn out to be greater than most existing systems?

In its study, Mathematica makes the optimistic assumption that the shuttle boosters can be reused. Moreover, in its summary of the analysis of the shuttle vs. expendable systems (Table 1), Mathematica uses recurring costs for a reusable pressure-fed liquid booster, where the cost per mission would be several million dollars less than that of the solid-fueled booster which NASA now intends to use (even assuming the solid booster is reusable). Finally, the analysis leaves very little room for continuing the use of expendable systems once the shuttle becomes operational. These factors combined suggest that Mathematica's stated recurring launch cost of $4.8 billion for the shuttle is low by an uncertain several billion dollars.

Table 1 reveals another fallacy in the trade-off study. Mathematica estimates $1.62 billion to be spent on nonrecurring costs for current expendable systems. In regard to this figure, Mathematica states the "research and development costs basically concerned the development of a space program to maintain the option of manned space flight in the 1980s." It is misleading to use the data from Table 1 to support Mathematica's basic conclusion that "the development of a space 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."

Table 1

Space Transportation Systems Cost Summary
(billions of undiscounted 1970 dollars)

	Current Expendable Systems	New Expendable Systems	TAOS [a] Space Shuttle and Tug
Expected Launch Vehicle Costs			
Nonrecurring Costs (FY 1972-87)	1.62	2.0	7.45
Recurring Costs (FY 1977-90)	10.6	8.76	4.8 (or $9.3 M/flight)
Total Launch Costs	12.0	11.0	12.0
Expected Payload Costs (Satellites)			
RDT&E (FY 1975-90)	11.0	10.6	9.88
Recurring Costs (FY 1976-90)	18.8	18.4	12.7
Total Payload Costs	30.0	29.0	23.0
Expected Total Space Program Costs	42.0	40.0	35.0

Source: Mathematica, Inc., Executive Summary, Report of Jan. 31, 1972, Table 0.1. This summary is based on contractor data and "Modified NASA and Department of Defense, Baseline, 515 Space Shuttle Flights (1979-1990)."

[a] Thrust Assisted Orbiter Satellite.

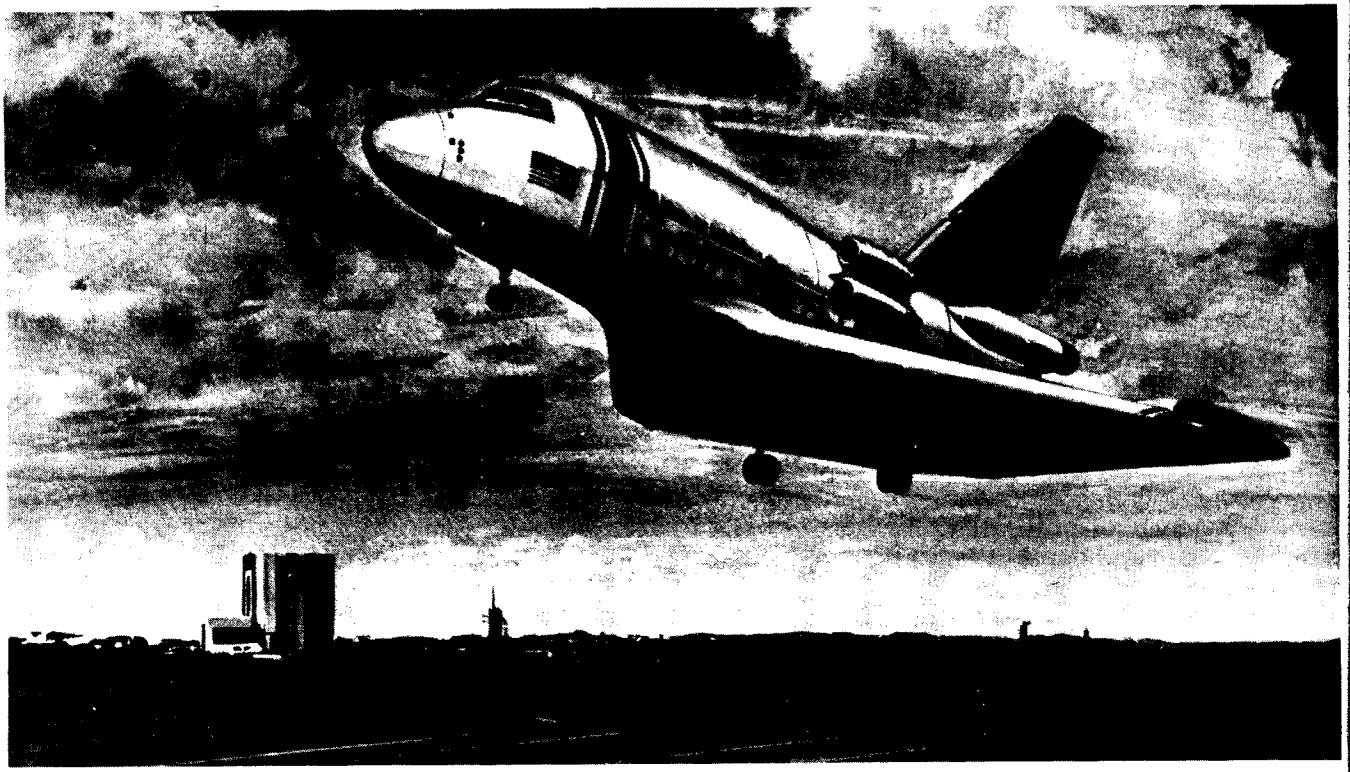
NASA and its contractors have underplayed the role of new expendable systems in the trade-off analysis. Not considered are such programs as a West German "pre-feasibility study of a low-cost, pressure-fed booster system theoretically able to deliver payloads into earth orbit for less than $200 per pound" (Aviation Week & Space Technology, Jan. 24, 1972). Such a system could thus reduce recurring launch costs by a factor of 3 or more from the Titan III-C and other boosters, and would certainly be less expensive than the recurring shuttle launch costs even if we were to accept Mathematica's figures in Table 1. Not considered are the Air Force's plans to develop a solid-fueled Titan III-D booster which would pare 30 per cent off the launch costs of the Titan III-C and yet have a greater payload capacity. Further savings could result from reusing the Titan boosters. The Mathematica reports do state that "the study of new expendable concepts has received too little attention." William A. Niskanen, who headed the evaluation division of the OMB at the time they investigated the space shuttle last year, said, "There were and are a number of people who think [expendable systems] always looked better than either NASA or Mathematica were willing to admit."

Even when compared with current boosters the shuttle fares poorly. Taking $8.1 billion as the initial development cost and assuming NASA's model of 514 shuttle flights during the 1980s, an independent scientist, Ralph Lapp, obtained $15.75 million per flight which, when added to NASA's operational cost of $10.5 million per flight, gives a total of $26.25 million for each shuttle flight without considering cost overruns. Dividing 5,000 pound average payload per shuttle flight estimated by Mathematica into $26.25 million, Lapp obtained a launch cost of at least $5,250 per pound of payload. This is more than five times the rate of Titan III-C and other present launches and 70 times the rate claimed for the shuttle by NASA and Mr. Nixon.

Current expendable boosters represent a broad spectrum of payload-launching capabilities which can be tailored to the needs of a given experiment. In the case of the shuttle an experiment might compete with several others aboard the spacecraft and therefore must be tailored to the needs of the aggregate and of the shuttle launch schedule. Spending $26 million each time to transport experiments is not trivial.

Purported Savings

NASA and its contractors have argued that payload maintenance in orbit and refurbishment either in orbit or on the ground would save an enormous amount of money, because shuttle maintenance flights are "cheap" and because large portions of payloads might be reused. These payload savings constitute the bulk of the purported shuttle economy. It is curious, however, that estimates of these savings over current expendable systems have gone down drastically from a margin of $18 billion (Scenario 1, 736 shuttle flights, Mathematica report, March 31, 1971, Table 0.1) to $7 billion (Modified baseline, 514 shuttle flights, Mathematica report, Jan. 31, 1972, Table 0.1—see



The shuttle lands like an airplane.

Table 1 in this article).

Though part of this apparent reduction results from a scaled-down baseline case, a significant portion can be attributed to the recognition that payloads can be designed to last 5, 10 or more years and that the point of obsolescence is reached before the need for refurbishment.

Why the savings of $7 billion? Even a careful examination of contractor reports reveals considerable uncertainty and speculation in the analysis. Mathematica's figures are explicitly based on the data inputs of Aerospace Corporation and Lockheed Missiles and Space Company. Looked at in this light, the Mathematica reports provide no more information about the actual dollar costs of the space shuttle than the bids received through the ordinary government procurement mechanism. Mathematica's economic analysis might be impeccable but there is no way of determining the accuracy of the data supplied by Aerospace and Lockheed. The people from these corporations working on these projects knew that in order to justify the shuttle their data had to show the shuttle cheaper than current or new expendable systems; it is not surprising that they did. Similarly it is not surprising that Table 1 shows the total shuttle launch costs to be exactly the same as the present expendable total launch costs. This is because the contractors knew what costs they were aiming toward, as expressed in what Mathematica, Inc. calls the "cost effectiveness frontier."

Shuttle Payload Costs

The uncertainties in the payload analyses are enormous. For example, Lockheed analyzed only three payloads: an orbiting astronomical observatory, a synchronous equatorial orbiter and a small research satellite. Highly approximate subsystem cost factors for these not necessarily representative satellites were extended to determine the costs of all proposed shuttle payloads. The contractors found that redesigning and modularizing subsystems for all spacecraft would result in considerable payload savings, but this procedure would not be unique to the shuttle. The primary projected savings for shuttle use would be the ability to replace or repair deficient or potentially deficient modules.

Whereas the idea of standardization may in fact lower the cost of space exploration, the refurbishment concept does not lead to the enormous savings claimed for the shuttle. The costs for refurbishment were determined with a "refurbishment factor," of a questionable nature and magnitude which makes the results essentially speculative. Even a recent Lockheed analysis indicates that the use of a shuttle and tug for refurbishment of a satellite in synchronous orbit would be, at best, marginal for a lifetime of five years or less. In other words, it would be just as expensive in terms of payload costs to launch an identical new satellite with an expendable system (if it is desirable to do so) as it would be to revive the old one with a shuttle and tug.

As for satellites in near earth orbit, we confront the problem of obsolescence. Most satellites have served their useful function after a year or two of operation. Why are maintenance and refurbishment necessary if such satellites can be designed to last 5 or 10 years? The refurbishment models of Lockheed and the extension of these models to the space traffic of the 1980s by Aerospace become unrealistic from this point of view. Yet another problem is the need to develop standard, modularized satellites capable of being refurbished. NASA will have to radically change its thinking about satellite design to derive any benefits from refurbishment. Furthermore, by refurbishing satellites with short lifetimes, NASA would be committed to a "high maintenance" program, with inevitable expensive delays and scheduling problems.

It is possible that certain expensive satellites planned for the 1980s, such as the large space telescope and the high energy astronomical observatory, may occasionally benefit from revisits in order to replace experiment packages. Obviously these isolated, infrequent operations alone cannot justify the multi-billion dollar investment in the shuttle. Nor is it clear that these programs, which are quite expensive in themselves, will be authorized or funded. It is debatable whether the cost of payloads conducive to shuttle use can be reduced by much.

Department of Defense Involvement

Said Niskanen, who headed the OMB's space shuttle evaluation, "A large part of the presumed savings come from relaxed design, repair and refurbishment of satellites. I was struck, however, with the fact that payload design is so far down the road—in miniaturization, sophistication and reliability—that you wouldn't get manufacturers or users to go for much relaxation."

As for high orbit missions, he said, "NASA never talks about it but more than half of the shuttle missions will end up in orbits beyond near-earth shuttle operating orbit. This means you need expendable rockets or the space tug. Nobody ever explained the tug technologically or economics satisfactorily. How many satellites, for instance, would you really want to retrieve or repair?"

Clearly a careful impartial study of alternative expendable systems and payload effects for each particular payload proposed for the 1980s is required before hundreds of millions more dollars are spent on the space shuttle. "My impression," said Niskanen, "is that the mission models that NASA is projecting for the 1980s are unrealistic. They start at a number that strains credibility and go up from there."

In terms of funding and total weight of unmanned payloads placed into earth orbit during the past 10 years, the Department of Defense has dominated

the traffic. The launch and payload costs of surveilance satellites have consistently surpassed 70 per cent of the total. There is little reason to believe this situation will change appreciably in the future.

Moreover, the cargo bay specifications for the space shuttle are defense-determined to accommodate maximum size surveillance satellites. The enormous engine thrust and wings projected for the shuttle respond largely to an Air Force request for sufficient cross range to land after one orbit. The shuttle cost could be reduced considerably by removing these constraints. One NASA source estimates that a ballistic reentry shuttle could be developed for $3 billion, or one-half the presently estimated cost.

The defense emphasis of a system developed by a civilian agency must be brought into question. Why haven't we been told about this? The Department of Defense involvement may also deter international cooperation in future space activities. To reiterate, during the past several years only 12,000 pounds of civilian (NASA) unmanned payload have been placed into earth orbit each year. This is barely sufficient to fill 20 per cent of one shuttle flight. How can it be argued that the shuttle is essential to NASA's needs unless one were to expand its space traffic and costs manyfold? This question needs addressing honestly and without obfuscation before more funds are committed to the space shuttle. It is conceivable that NASA will have no money left to make use of the space shuttle. One can imagine nearly empty flights, or flying elephants as experimental animals.

Secondary Costs

Only the primary costs of the space shuttle have been investigated. What of the secondary costs? Although there would appear to be no obvious environmental damage anticipated from weekly shuttle operation, certain potential problems such as atmospheric contamination by fuel exhaust, sonic booms and excessive noise in the launch area should be more thoroughly investigated than NASA has in its hastily assembled and woefully inadequate Environmental Statement filed last year. Indirect environmental costs would include the expansion of launch, manufacturing and support facilities and the use of resources and manpower that could be allocated toward more ecological purposes.

There are enough uncertainties in shuttle development to indicate a high risk of enormous cost overruns. Overruns in the development of the shuttle engines and heat shields, the uncertain number of reuses of the booster, and the possible subsequent phasing in of a fully reusable manned booster are some of many factors which may significantly raise the cost of the shuttle.

Alexander H. Flax, president of the Institute for Defense Analysis and chairman of a panel of the President's Science Advisory Committee which was asked to investigate the space shuttle program, concluded, "Prudent extrapolation of prior experience would indicate a 30 per cent to 50 per cent overrun," making the shuttle cost $8 to $10 billion to develop. Flax also estimated that additional overruns might occur after development had ended and that total nonrecurring costs of the systems might reach $15 billion.

Table 2

Comparison of Cost Estimates and Projected Cost Overruns of Space Transportation Systems [a] (billions of undiscounted 1970 dollars)

	Mathematica's Estimate [b]	Lapp's Estimate [c]
Current Expendable Systems	$42	$25
New Expendable Systems	$40	-$25
Space Shuttle with No Cost Overrun	$35	$44.50
Space Shuttle, with Expected 40% Cost Overrun	$49	

[a] Based on 514 space shuttle flights between 1979-1990.
[b] Mathematica, Inc., Executive Summary, Report of Jan. 31, 1972, Table 0.1.
[c] Ralph Lapp, Statement to U.S. Senate Aeronautical and Space Committee, April 12, 1971.

This assessment is consistent with a preliminary analysis performed by the General Accounting Office (GAO) last June: "Despite determined efforts during the 1960s to improve the outcome of major systems acquisition programs . . . typical programs continued to exhibit an average cost growth of 40 per cent." Table 2 indicates that a 40 per cent cost overrun would destroy the economy of the space shuttle. With regard to the space shuttle, the GAO concluded that the program could not be economically justified with cost overruns of between 20 per cent and 25 per cent.

Moreover, Mathematica's assessment exaggerates the project cost of space transportation using existing or new expendable systems. In his statement before the U.S. Senate Aeronautical and Space Committee in April 1972, Ralph Lapp estimated that, by 1990, total shuttle costs would exceed $44 billion or about $20 billion greater than using conventional launch vehicles (Table 2).

Many observers allege that the major reason for having a space shuttle is to restore employment and economic vitality to NASA and a crippled aerospace industry. Some have gone so far as to say that NASA would collapse without its shuttle. But projects of little value to society can only provide temporary relief for those who would otherwise be out of work. As in the case of the MOL, SST and ABM, workers are all too likely to find government forced to respond to real priorities and aborting a shuttle program of dubious value.

The highly controversial space shuttle seems to be prematurely creating jobs which may suddenly get cut off at any time; obviously the later

that happens the more severe will be the effect. It is no favor to an American worker, or to the corporate employer, to mortgage his future to a project of doubtful utility.

In order to alleviate unemployment resulting from the phasing out of the Apollo program and the possible cancellation of the space shuttle project, the federal government—in conjunction with local and state governments and those aerospace industries affected by shifts in national priorities—must begin to provide the long range plans required for conversion to civilian pursuits. Legislation such as the Kennedy-McGovern National Science Policy and Priorities Act (S. 32) must precede full conversion, providing the seed capital to revitalize America's civilian research and development efforts. Moreover, the President must act on a host of other conversion bills designed to cushion the impact of those workers, industries and communities most heavily affected by altered federal spending.

Space Policy

I do not oppose a space program per se. I believe many valuable activities can continue to be carried out in space sciences and applications; for example, in the areas of planetary exploration, communications, meteorology, resource surveillance, aeronautics, advanced research and technology transfer. These activities could even be augmented within the context of a relatively modest civilian space program funded annually at less than $2 billion.

Within the past decade, remote sensing and in situ measurements from space vehicles have resulted in tremendous increases in our knowledge about the terrestrial planets. With our eyes now opened up to the Moon and Mars—and soon to other planets—we suddenly find ourselves confronted with phenomena having no clear terrestrial analogue; for example, extensive impact cratering, enormous circular basins, mascons, chaotic terrain, featureless terrain, dry ice polar caps, planetwide dust storms and seasonal changes in the brightnesses of dark areas. On the other hand, results recently obtained from Mariner 9 show us that at least portions of the Martian surface are geologically active and earthlike. In the Mariner 9 pictures we see huge canyons and volcanoes, as well as evidence that liquid water flowed in rivers in geologically recent times. Yet this mission cost us barely one per cent of the potential space shuttle expense.

The enormous implications of these findings are only beginning to be felt. With the suggestion that liquid water once existed on Mars there is an increased probability of life having evolved on that planet. This country should vigorously pursue its efforts in exploring Mars and the other planets with unmanned spacecraft. Presently these programs comprise less than 10 per cent of NASA's budget and one-half the Soviet planetary exploration budget. Several cutbacks in planetary programs in this country—primarily because of the space shuttle's enormous demands—indicate the need to inject new life into NASA's plans. The Grand Tour of the Planets has been cancelled. Programs to study lunar rocks returned by Apollo are being threatened. Other projects, now only marginally effective in potential scientific return, could prove to become many times more useful with relatively small amounts of additional funding.

Further exploration of the planets will inevitably uncover new surprises and will help to answer some of mankind's most basic curiosities: How man came into being? How the earth was formed and evolved? How other planets developed, and whether and how life has had a chance to appear on other planets? Such space policy emphasizes the importance of space exploration for scientific knowledge and for the practical benefits available from applications satellites. The development of a rational space program requires that we encourage science and applications looking for a mission rather than a mission looking for science or applications. We should not allow space transportation systems like the space shuttle be the end rather than the means of space exploration.

We should ask, how can we best perform a given mission, manned or unmanned, not what we can do with the man. And we should start extensive international collaboration with the Soviet Union and other nations now that the big race is over. These goals, this philosophy, would bring us a better harvest from space at far less cost to the American taxpayer.

The present rationalizations our government has about the space program and its economy urgently call for a new and open space policy which yields tangible benefits to mankind. Increases in research and development in defense and in the space shuttle account for approximately 75 per cent of the additional research and development funding in Mr. Nixon's fiscal 1973 budget. It is thus abundantly clear that this Administration is only paying lip service to the awesome challenges of improving the quality of life in the United States, while it continues to proliferate waste and overkill in the Defense Department and misguided priorities in NASA.

For the reasons enumerated in this article, it is evident that any appreciable funding of the space shuttle is foolish until and unless it can be conclusively shown to be economically and socially viable and clearly more attractive than alternative space transportation systems. Such an effort is impossible as long as those making the evaluations are beholden to NASA and the Department of Defense for their livelihoods. This case indicates to me an urgent need for the introduction of the adversary system in the decision-making process, if only to encourage debate, offer alternatives and mute the monolithic nature of decisions made to date. Otherwise this potential white elephant in the sky could become a humiliating testimony to colossal waste.

Ecological Theology

"In Defense of People," by Richard Neuhaus. Macmillan, New York, 1971. 315 pages. $6.95.

Reviewed by
MICHAEL J. BRENNER

A recent arrival in the arena of political debate and intellectual discourse, the ecology movement has swiftly succeeded in generating a level of antagonism worthy of more veteran causes. Its contentiousness is predictable since to talk meaningfully about controlling pollution and providing for communal amenities requires raising basic questions about the way we conduct our public business and the vision that will guide industrial society's future. Moreover, even beyond the issues of political will and purpose, we are forced to confront the philosophical concerns of "ecology ethics": Should we strive to replace modern man's imperial domination of nature by a more restrained, harmonious relationship? Does attentive care for our physical surroundings divert moral energy from the priorities of alleviating poverty and deprivation? Can the Judeo-Christian weltanschauung validate a "Gospel of Positive Feeling," or is the only sacred humanism that which looks along the "fault lines of society" to mitigate suffering?

Richard Neuhaus, a Brooklyn-based Lutheran pastor whose social activism has led him into the peace movement and poverty politics, has fired a polemical salvo against the philosophical naturalists in the ecology movement that promises an acrid debate on environmental theology. "In Defense of People" is orthodox gospel of Christian witness in radical packaging, and written in a style only once removed from literary free association. It combines a revelatory excursion into the radical humanist state of mind (circa 1971), with a fervent testament to a classic Christian morality of the Suffering Servant boldly contrasted to what he views as the faddish self-indulgence of the ecologists and the flower children. His targets are multiple. They are the conservative patricians of American society who exploit environmentalist sentiment to protect their privileged place while shielding their eyes from the social injustices that scar the American landscape. They are the "eco-maniacs," the potential "commissars," who in their zeal to avoid catastrophes are prepared to offend against morality by totalitarian measures of forced starvation and genetic suppression. They are, more surprisingly, the "state of consciousness" radicals whose "project of greening America is obscene so long as most areas of the world are parched by war and famine." So diverse a camp of enemies might seem to imply that the author is simply prone to literary dyspepsia. He deserves a more careful reading.

Linchpin of Morality

In Neuhaus' dire judgment of the ecology movement, they are all proper objects of contempt and criticism. For each group, in its own way, does violence to the moral principle of Christian witness that he sees as the ethical imperative of Western civilization. As he reminds us, "In Western biblical thought, the linchpin of morality is the relationship between rich and poor, strong and weak." The salvation of American society is not to be found in the groves of nature worship or in a fear-inspired crusade against man's procreative destiny. The only "hope for sharing in the future promise" is for society to hold "itself accountable to the minority of the poor" and to "redefine American power in a hungry world by developing a myth of a Covenant with the (global) poor." The slogan for Neuhaus' hirsute Christianity might well be "Reality as Slum," since in a flawed world it is only by fixing our collective gaze on the deprived that society can acquire spiritual hope. (In America the implication is that "The Touchstone is Black," to use one of the author's chapter heads.)

Easy Targets

Using this basic morality as a lance, Neuhaus moves adroitly among the ecologists from one target of opportunity to another. He unmercifully pricks the frivolous fads, excoriates the radicals' failure to reconcile their highly personal cultural rebellion with their purported revolutionary objectives (although he never uses the word, Neuhaus always appears to be on the verge of declaring the youth movement's exuberant celebration of life sinful), and more seriously, calls to account Ehrlich and Company for their greviously misconceived and outrageous solutions to the population problem. The targets are easy to come by and are subjected to a rare sarcasm. But the wit distracts from the deadly seriousness of Neuhaus' theme, one that is as unacceptable as it is daring.

To make his case, he pursues three lines of argumentation that