coveries of universal principles of physical science and great Classical artistic compositions such as John Keats' ***Ode on a Grecian Urn.*** To understand that universe, and its impact on the condition of life of man on Earth, we must proceed relentlessly to explore to the most distant events and conditions on the largest scale, and also the very, very tiniest. We must explore how the universality of a principle of life operates in even remote and strange conditions of the universe, and address the creative powers of the individual human being similarly.

Man in space presents us directly with all of these phases and their interactions in a concentrated and immediate way. We must overcome a childish fear of the imagined "bogeyman," and go out into the night to discover what is actually there. If we did not do that, we would be less than human.

The growth of brutishly anti-scientific "consumer cultures," and suppression of pro-scientific "producer cultures," during the 1964-2003 interval to date, has been the axiomatic factor which misled the world at large into the present global economic and monetary-financial catastrophe. It is time to return to attitudes on which our earlier achievements, such as the Manned Moon Landing, were premised.

7. The Common Aims of Mankind?

Back during the Fall of 1982, Dr. Edward Teller uttered the most fortunate phrase: "The common aims of mankind." The greater mastery of the conditions among the inner orbits of the Solar System, is the immediate imperative for all mankind during the remainder of this present new century. Later, we shall extend our reach to greater things.

As I emphasized in public addresses I delivered during that same past period, "If we can establish a scientific sub-surface colony on Mars, we can readily transform the Sahara Desert into a habitable region of Earth; and, generally, transform the Earth into the garden it was intended to become under our husbandry."

Shuttle 'Fix' Means a Change In Economic Policy Axioms

by Marsha Freeman

It will take some time for the National Aeronautics and Space Administration (NASA), and the independent investigating board appointed on Feb. 2, to determine what happened in the final moments of the flight of the Space Shuttle *Columbia,* and what led up to its catastrophic accident. In the immediate hours following the tragedy, however, the media have had no lack of targets of blame. Charges have been levelled at a broad sweep of suspects, from the engineers who designed the Shuttle transportation system 30 years ago, to the last man to look at the video film footage of its Jan. 16 launch. Rounding up the "usual suspects," however, will provide little insight into what happened; nor will it fix the problem.

The risk of accidents is inherent in the extreme environment of space travel, as it is in any other experimental or exploratory venture. Nothing can be made perfectly safe. But as is readily acknowledged by the astronauts who take the risk, there is no other way to further the human knowledge gained through space exploration, than to do it. While the risk cannot be eliminated, it should be minimized. One way is constantly to be examining and re-examining the physical state of the vehicle and other assets involved—especially as they age and wear—but also the assumptions made about every aspect of operation of their systems. Relying on mathematical models or data that do not take into account changes over time, will not improve safety.

A second way to minimize risk is to incorporate leading-edge technologies into space flight systems, with the goal of a high rate of technical attrition in existing assets, as they are replaced, retired, or shifted into less critical functions. The Shuttle system's problem is not its age as such, but that its 1970s technologies have been surpassed by innovations that could improve its performance, and make the Shuttles safer.

For nearly 40 years, the wrong criteria have been used to make decisions about space policy. While Presidents and Congressmen make self-righteous statements about their commitment to space exploration, especially at times like this when the public expects it, they are married to ideologies that preclude their fighting for the space program the nation requires. It is the cultural paradigm shift this country has suffered since the Kennedy years that has to be "fixed."

Space Exploration as 'Science Driver'

President Kennedy set the space agency on a clear and visionary mission—to land a man on the Moon. He told the Congress that it would be expensive, and warned them that if the Members were not willing to fund it, it should not even be attempted. He formulated an investment tax credit, and other fiscal measures, to vector private sector resources toward leading-edge high-technology R&D and manufacturing investments, that would support the exploration of space. Kennedy's space program contributed substantially to more than a decade of technological innovation, leading to dramatic growth in the economy of the United States.

The idea that the Space Shuttle program must be more "cost effective"; that accountants in the budget office should decide what the nation can afford to spend on space exploration; that these expenditures "take money from" other projects, imposing limits on NASA funding; that bringing in the private sector and the profit motive to this research and development endeavor will make things cheaper—all these are false and dangerous assumptions that have brought us to where we are today.

NASA should be a "brain trust" for the nation. Its laboratories, in collaboration with universities and other research institutions, should lead inquiries into the most vital issues of science—in astronomy and macrophysics, the life sciences, and microphysics. NASA has made steps in this direction, through the establishment of an Astrobiology Institute, and Space Biomedical Institute, to bring the best minds in academia to tackle some of the most critical scientific questions. But each NASA Center should be the nucleus of a "science city," where the frontiers of research are the focus.

Space exploration has already posed some fundamental questions. Astronomers have found evidence of solar systems around other stars, which are very different from our own. Where are today's Keplers, who will discover the universal principles that can explain these fascinating new worlds? The proposition that there was once life on Mars has led to the discovery that life can exist in the most extreme Earth environments, overturning long-held concepts of the "envelope" of requirements for life. How does the development of life on Mars challenge our fundamental hypotheses of life on our own planet? How can the exposure of life to the micro-gravity environment of space, or the partial gravity of other planetary bodies, open up new means of discovery?

In order to be able to answer such questions, the space agency is tasked with creating the transportation and other infrastructure needed to carry out missions to expand human knowledge. As the science and exploration objectives drive the development of revolutionary new technologies, NASA should be creating and spinning out into the economy new energy and propulsion techniques, new materials, medical breakthroughs, and industrial processes, at a rate at least comparable to that of the Apollo program.

The advanced fission and nuclear fusion technologies that we must develop for manned missions to Mars will bring an era of unlimited energy to this planet. The technologies to create artificial biospheres in space and terraform Mars will bring forth ways to make Earth's deserts bloom. The life support techniques to care for crews off planet will revolutionize the way we nourish human health at home.

The Jan. 16 launch of the orbiter Columbia *on the 107th flight of a Space Shuttle. There were many conscious decisions to cut NASA and Shuttle budgets, and to move toward privatization, which formed a pattern one expert called "a failure waiting to be discovered."*

We would not have record-breaking unemployment, rotted out and abandoned industries, a transportation system that is disintegrating, a population that is addicted to drugs, television, and video games, or a systemic financial crisis, were economic policy organized to invest our resources in science, technology, and infrastructure—most profitably represented by our space program. We will "fix" the space program when we have an economic policy that discards "shareholder value" and the "bottom line," and returns to national investment in great projects that uplift the population morally, physically, and intellectually.

Sabotaging Shuttle Safety

For years, NASA engineers have been well aware of the need to update the 1970s technologies of Space Shuttle systems, and to carry out upgrades to improve safety and performance. And in case they were to miss any areas of importance, the Aerospace Safety Advisory Panel, established after the 1965 Apollo fire, prepares an independent report for NASA on flight systems' safety every year.

In 1992, a decade after it started flying, NASA undertook a new initiative to assess and improve the safety and reliability of the Shuttle, compiling a list of proposed upgrades. But one year later, the Clinton Administration's agreement with Russia for the Shuttle to visit the Mir space station, required that money for the Shuttle be spent on modifications to the

orbiters to carry out that program. While NASA was lobbying for safety upgrades, its budget for the Space Shuttle program was declining. Between 1993 and 1999, the Shuttle budget was cut from $3.5 billion per year to $2.9 billion, in real-year dollars. In constant dollars, the cuts over that time were 40%. This led to the deferral of upgrades, and substantial cuts in both NASA and contractor personnel.

In 1996, all proposed modifications to the Shuttle fleet were put on hold due to the budget squeeze. Under the "leadership" of Vice President Al Gore—and with the enthusiastic support of NASA Administrator Dan Goldin, a former TRW Corporation executive—the space agency became the White House's poster boy for the policy of "reinventing government." In The White House's attempt to "balance the budget," and out-do the lunatics leading the Republican "Conservative Revolution," the nation's future in space was being sacrificed.

NASA managers, under heavy pressure from the Congress, discussed designing a future replacement for the Shuttle, which would be designed, and eventually run, by the private sector. Even though everyone was aware that designing, building, and testing a new manned space-launch system would take years, the accountant's mentality dictated that money would not be spent on the Shuttle system if it had only a limited lifetime.

But in 1999, NASA made clear the Shuttle would, and should, be flying until at least 2012. "We will not come close to the life span of the Shuttle in the next 10 years," stated former astronaut Andrew Allen, director of Space Shuttle development for industry contractor United Space Alliance. Astronaut Bill Readdy, NASA Deputy Administrator for Space Flight, stressed that the Shuttle should evolve to assure greater safety margins for astronauts and ground personnel.

The consequences of lack of investment in the Shuttle fleet were then becoming obvious. At a Congressional hearing on Sept. 24, 1999, called to discuss the cause of frayed wires and a hydrogen fuel leak in *Columbia*, Allen stated that "the Space Shuttle upgrade program has been delayed and underfunded for years" and that this was contributing to the problems. The discovery in August of the frayed wires had grounded the entire orbiter fleet.

Characteristically, members of the House Science Committee responded that there were not enough funds for all the upgrades that NASA wanted, and Space Subcommittee chairman Rep. Dana Rohrabacher (R-Calif.) said NASA should speed up the process of "privatizing" the Shuttle, and "incentivize" the industry contractors to make the upgrades! In a second hearing a month later, Allen recommended accelerating the pace of the upgrades, with 60% of the needed funds to be spent by 2003.

NASA began an internal review of needed Shuttle upgrades in the Fall of 1999, and in February 2000, in the agency's Fiscal Year 2001 budget request, identified nine critical safety upgrades to be implemented across the four-orbiter fleet. The list included the replacement of the Shuttle's hydrazine-powered Auxiliary Power Units that are vulnerable to leaks, fires, and even explosions, with electric units used in military jet fighters, costing a total of $224 million. An advanced health-monitoring system for the Shuttle's three main engines was included, for $108 million, to prevent an inadvertent engine shutdown in flight that could trigger a catastrophic explosion. NASA proposed redesigning combustion chambers and nozzles, at a cost of $400 million, using more advanced designs and manufacturing processes pioneered by Russian aerospace companies to reduce the number of welds, and potential failure points, in the Shuttle engines. The total request by NASA for Shuttle upgrades in the Fiscal Year 2002 budget came to $488.8 million.

But the safety panel NASA had convened in September 1999, warned in its report in March 2000, that efforts to reduce the cost of Shuttle operations, primarily by reducing staff, had led to an erosion of risk management. Shuttle employees were under "increasing levels of stress." The panel recommended that the size of the Shuttle workforce be increased, with additional NASA employees, rather than contractors, echoing a similar recommendation of the Aerospace Safety Advisory Panel, which cited "consistent and repeated reports . . . of critical skills shortages" in the space agency.

Between 1996 and 1999, NASA's Space Shuttle workforce shrank from about 3,000 to about 1,800 employees. The total NASA and contractor workforce perform about 1.2 million separate procedures to prepare a Space Shuttle for flight, and the NASA cuts had eroded the agency's ability to perform adequate oversight to ensure the safety of the Shuttle. Throughout NASA's Office of Space Flight, thanks to years of a hiring freeze, there were twice as many people over the age of 60, as under the age of 30.

By 1999, both the stress on the workforce and threat to Shuttle safety had already been noted, even by "market oriented" NASA Administrator Goldin, who admitted that cuts to the program had gone too far. In its FY 2001 budget request, NASA allocated money to hire an additional 2,000 workers over two years, a net gain of 550 after attrition. But this was inadequate compared to the decade of damage that had been done.

The Situation Is Deteriorating

Despite the demand by NASA to turn around the years of neglect by increasing investments in Shuttle upgrades, a Senate hearing in September 2001 revealed the continuing deep concern for Shuttle safety. Funding pressure from increased space station costs, within a flat total budget, were putting safety upgrades in jeopardy. In testimony before the Senate Subcommittee on Science, Technology, and Space on Sept. 6, 2001, Richard Blomberg, Chair of the Aerospace Safety Advisory Panel, stated that "little effort was being expended on the long-term safe use of the [Shuttle] system." The "long-term situation has deteriorated," he said, as "budget constraints imposed on NASA's human spaceflight programs have forced the Space Shuttle program to adopt an even

The STS 107 crew on their way to lift-off. NASA Administrator Sean O'Keefe has made a point of appointing veteran former astronauts to key management positions; but at the same time, the continuing pattern of underfunding and moves toward privatization, has led some, like Robert Crippen, to resign.

shorter planning horizon in order to continue flying safely." As a result, Blomberg continued, "more items that should be addressed now are being deferred," adding to the backlog of restorations and upgrades, and "postponing many risk reduction benefits."

"The Panel does not believe that safety has been compromised at present," Blomberg said, as "the defined requirements for flying at an acceptable level of risk are always met. Increasingly, though, these requirements can only be achieved through the innovative and tireless efforts of an experienced workforce." But "as hardware wears out and veterans retire, the program will inevitably lose some of this compensatory ability."

Blomberg warned that "improvements to the orbiter and the other Space Shuttle elements are being delayed in order to accommodate current budget needs." The situation becomes worse each year, he said, and if restoration of basic infrastructure continues to be delayed, "it will reach a point at which it may be impossible to catch up. Safety is an intangible whose true value is only appreciated in its absence," Blomberg counseled. "The boundary between safe and unsafe operations can never be well defined. As a result, even the most well-meaning managers may not know when they cross it. . . . As equipment and facilities age and workforce experience is lost, the likelihood that the line will be inadvertently breached increases."

At the same hearing, the Chief Operating Officer of United Space Alliance—the industry consortium responsible for flight planning, astronaut training, and preparation of hardware and software for launch, employing 10,000 people in Texas and Florida—also testified. Mike McCulley, a former astronaut with 17 years of experience in the Space Shuttle program, told the Senators that in his opinion, the "drive toward efficiency has moved us below sufficient funding for the many years of Shuttle operation ahead of us. . . . One half of annual maintenance budgets are spent band-aiding systems that are failing and then maintaining the band-aids."

The unfunded critical infrastructure projects, McCulley reported, had led to a situation where Launch Control Center operators had to change firing rooms for each of the previous two launches because of computer interface failures. The Vehicle Assembly Building had to be shut down while a Shuttle was being assembled, due to antiquated assembly equipment failures. Some ground infrastructure, he said, is literally falling apart.

Sen. Bill Nelson (D-Fla.), who flew on the Shuttle *Columbia* in the flight just before the *Challenger* accident, had requested the hearing, to evaluate the impact of the $500 million shortfall in Shuttle funding. The budget, Nelson said, "fails to adequately protect these astronauts." Safety upgrades that NASA considers critical "are now discretionary projects subject to available funding. All but one of the Shuttle's pending safety upgrades have been targetted for cancellation or deferral," Nelson reported.

"Decisions about NASA priorities are coming not from NASA, but from bean counters at the President's budget office," Nelson said. "We've got accountants making life and death decisions for our astronauts. . . . We're starving NASA's Shuttle budget, and thus greatly increasing the chance of a catastrophic loss."

Just nine months ago, after the Aerospace Safety Advisory Panel's 2002 annual report was released, Blomberg stated before Congress, again, that "the Panel believes that safety has not yet been compromised," but that the report contains "the strongest safety concern the Panel has voiced in the 15 years I was involved with it." As the Shuttle ages, he warned, "the well-established characterization of the system is no longer fully valid." Blomberg also warned that "any plan to transition from the current operational posture to one involving significant privatization would inherently involve an upheaval, with increased risk in its wake."

Longer term, more expensive fundamental changes to the Space Shuttle design—such as liquid fly-back boosters, to

eliminate the more dangerous solid-fueled boosters, or increased on-orbit crew rescue capabilities—were never seriously even begun.

The Invasion of 'Shareholder Value'

The Shuttle had barely finished its initial test flights in the early 1980s, before President Ronald Reagan and his budget balancers ordered NASA to try to find a buyer for the orbiter fleet. The idea was that privatizing the Shuttle would decrease the amount of Federal funds for the program, cut costs, and enable it to run "like a railroad." No company was foolish enough to take the bait, however, despite the rhetoric.

But as Space Shuttle budgets were declining in the early 1990s, NASA managers worried about flying the Shuttle safely with less money. NASA Administrator Goldin dismissed their concerns. "When I ask for the budget to be cut," he told a meeting of NASA employees in September 1994, "I'm told it's going to impact safety on the Space Shuttle and it'll destroy reliability on these other [unmanned] flights. I think that's a bunch of crap." Three months later, astronaut Robert Crippen—the pilot of the first Shuttle flight in 1981—abruptly announced his decision to resign as director of the Kennedy Space Center, saying it was prompted in part by concern about continuing budget cuts.

In November 1994, NASA announced that an independent team, led by former Johnson Space Center Director Chris Kraft, would review "innovative concepts," and new "management options" for dealing with the continuing budget cuts in the Shuttle program. The report, released in March the following year, included the recommendation that NASA consolidate its 20 Shuttle prime subcontractors and 59 major subcontractors, as a "stepping stone" to the full privatization of the Shuttle. The report contended that the program, to "meet the challenge of reducing costs," should do away with "expensive habits." "Safety is one of those terms that can be used to hide behind and prevent necessary change and innovation," the report claimed. It complained that "ground testing is routinely performed on much of the hardware, even if it performed flawlessly on its previous mission."

Although the report's call for commercializing the fleet was immediately embraced by the Administration, in the person of Dan Goldin; and the Congress, led by House Science Committee Chairman Robert Walker (R-Pa.), many were alarmed. John Pike, then of the Federation of American Scientists, called the Kraft report "close to hallucinatory," and described changes in the philosophy on safety procedures as foolhardy and dangerous. He predicted that the recommendations would one day be considered "the turning point that led to the next Shuttle accident." The Aerospace Safety Advisory Panel warned that such a radical restructuring of the program was having a serious impact on safety.

The impact of the growing budget cuts was already leading NASA managers to propose drastic manpower cuts. In order to meet the projected $5 billion cut in Shuttle funding over the coming five years, NASA said in 1995 that no further upgrades would be initiated. Over five years, the workforce at the Marshall Space Flight Center, which clears the Shuttle's main engines for flight, would be reduced from 220 to 50. Those involved in clearing the External Tank for launch would go from 134 to 23, while those working on certifying the solid rocket boosters would drop from 126 to 26.

'A Failure Waiting To Be Discovered'

At the Kennedy Space Center, civil service workers who do engineering and development of the orbiter would decline from 395 to 184 by 1999. Those in launch processing and safety would be cut from 880 to 450 by the turn of the century. NASA oversight of contractor work would be cut significantly. The NASA director of Space Shuttle operations, astronaut Brewster Shaw, said this would mean abandoning NASA's guiding assumption about Shuttle safety: that "you've got a generic failure waiting to be discovered."

Administrator Goldin vowed to reduce the manpower deployed in Shuttle safety operations, in line with the Kraft panel's privatization recommendations. "We had 183 people signing off on flight readiness for the Shuttle," Goldin said in June 1995. "To me, that represents a threat" to safety, rather than a guarantee of it. In contrast, NASA's most experienced astronaut, John Young, told Associated Press, "you can't reduce people without introducing a lot of risk, because you just work people too hard."

Much of the work that had been done by civil service employees was to be contracted out to the industry management entity, United Space Alliance, a joint venture of Lockheed Martin and Rockwell International (which built the orbiters, and was later taken over by Boeing). This shift of Shuttle operations to management by the private sector was sold to nonbelievers as the only way to cut costs and still fly. United Space Alliance (USA) signed a $7 billion contract with NASA at the end of September 1996. One month earlier, Kennedy Center director Jay Honeycutt, who had taken over when Bob Crippen resigned, warned that the hundreds of layoffs planned for the launch center would leave many jobs undone, including safety inspections. In October, Honeycutt, who had worked for NASA since 1960, announced that he was retiring.

The level of Shuttle funding continues to be determined by the White House and Congress, and with NASA approval, USA makes the decisions as to where and which of its contract employees will be eliminated when budgets are cut. And although United Space Alliance brought in astronauts to manage its operations at both the Kennedy and Johnson Space Centers, they are in business to make money. USA insists that safety, which is the criterion used to determine incentive payments in its NASA contract, will always come first, but there is little doubt that downgraded NASA oversight has had an impact on safety.

By 1997, United Space Alliance was pushing for in-

creased commercialization, as a way for it to make more money from its Shuttle operations. It lobbied for dropping the 11-year-old ban on flying commercial (non-government) payloads on the Shuttle, which had been implemented by the Reagan Administration after the *Challenger* accident. This would have required adding more flights to the orbiter schedule. Johnson Space Center Shuttle manager Tommy Holloway summed up NASA's negotiations with USA on the proposed changes, stating, "We have different objectives." USA's objective "is to fly the program and make money. Our objective is to reduce costs, but we don't worry so much about them making money."

At the same time, the Aerospace Safety Advisory Panel, testifying before Congress on March 13, 1997, warned that even though it could find no additional safety risk arising from the contract with USA, it noted "that the rewards and penalties of the incentive [contact] may motivate the contractor to actions which are unanticipated by either party today, and which may pose additional risks to safe operations in the future." This increased potential risk was introduced for no other reason than to cut costs.

Four years after USA began managing much of the Shuttle program, a March 2000 report by an independent safety analysis team stated that there was too little government oversight of contractors working on the Shuttle. The team said it was troubled by increased risk due to a desire by the contractors to cut corners and costs to meet the schedule, which provides bonuses for the company. All new hires at the Kennedy Space Center, it advised, should be NASA employees, because NASA needs more hands-on involvement in maintenance and safety.

There is no place in manned space programs for the "profit motive," to begin with. The very nature of the effort means that it is impossible to know far in advance how much anything will cost. The level of funding support for the program must be determined by the mission to be accomplished, not the other way around. The space program has always depended upon private industry for the development of new technologies, manufacturing, and development of the payloads that use the space transportation system. But the infrastructure must be provided by the nation as a whole, for the benefit of all.

Previously technology-proud corporations have long ago become more wedded to their "bottom line" and dividends to stockholders, and controlled by Wall Street financiers rather than engineers. They should not be entrusted with management of the nation's space program.

Where Do We Go From Here?

When the Bush Administration came into office, Dan Goldin finally left. But in came Sean O'Keefe, fresh from the Office of Management and Budget. A political protégé of Vice President Dick Cheney, O'Keefe was Comptroller of the Department of Defense under Cheney in the first Bush Administration. While still at OMB, O'Keefe told Congress that he would not support an increase in NASA funding, because "technical excellence at any cost is not an acceptable approach." But at least, O'Keefe admitted he knew nothing about NASA, or the space program. To his credit, the new Administrator has brought some of the agency's most experienced astronauts into NASA management positions.

At his confirmation hearing in the Senate, O'Keefe admitted that he had no vision for NASA, and said that his plan for the space agency was to "get back to basics, reinvigorate the entrepreneurial" spirit there, and "infuse prudent management." He sounded more like the bankruptcy judge in the Enron case than the leader of NASA. This did not sit well with many of the senators.

"The leader of NASA cannot just be a budget cutter," Sen. Kay Bailey Hutchinson (R-Texas) stated at the hearing on Dec. 7, 2001. "I don't think you can precisely budget a war, and I don't think you can precisely budget innovative research." In this kind of work, she said, "you are going to have mistakes, and miscalculations. You're going to learn from those. . . . NASA is one of the economic engines of America," she stated.

Disregarding Senator Hutchinson's advice, the first policy decision made by the new administration, in July 2001, was to propose a reduction in the Space Shuttle program's funding by about $1 billion from 2003-07. This was designed to make up for the cost overruns in the space station program. A second decision was to emasculate the International Space Station, by refusing to increase NASA's budget to provide the funds needed to complete the space laboratory.

Last year, under White House orders, O'Keefe commissioned the systems-analysis RAND Corporation to look into options for introducing more "competitiveness" into the Shuttle program. This was guided by the Bush principle that "government should be market-based"—the current version of Al Gore's "reinventing government." The September 2002 report called for more competition among suppliers, and for eventually selling the fleet of orbiters to the highest bidder. Money for things like safety upgrades would be raised from private capital. The RAND report pointed out that about 92% of NASA's $3.2 billion per year Shuttle funding already goes to private contractors, but wanted more. The reaction to the report by Kennedy Space Center Director Roy Bridges, a former astronaut and retired Major General, was that some commercial concepts could end up "with a Shuttle being flown into the water." Sen. Bill Nelson compared the proposal to the Pentagon handing over its forces to a private company to fight a war.

But with the Feb. 1 loss of *Columbia*, all of the cards have been thrown up into the air.

Immediately after the accident, the Administrator and President Bush pledged that NASA will find the problem, fix it, and return to flight. But going back to the way things were, will not fix the problem.