The Rise and Fall of the Space Shuttle: Leadership Lessons

By W. Henry Lambright

The space shuttle was a remarkable technological creation—perhaps the most complex machine ever built. It was also an extraordinary government program. It began officially in 1972, when President Richard Nixon authorized its start. It ended in July 2011 when the last shuttle landed safely. The lifetime cost of the program was $209 billion.

Was the shuttle worth the investment? There is disagreement. In my view, it was—but there are downsides to the program. There are positive and negative lessons to be drawn from the shuttle experience. The aim of this essay is to suggest lessons for leadership of large-scale, long-term technological programs that have national significance.

In an earlier article, I wrote of lessons from Apollo.[1] But Apollo was unique—a best-case example of agency and national leadership. It showed technological management at its optimum. The space shuttle presents other lessons, the kinds that come from "normal programs." In such programs, not only are lessons mixed, but they sometimes are conflicted.

Leadership of government programs always involves politics and management. Administrative leaders work at the boundary between an organization with a task to perform and a political environment of president, Congress, rival agencies, interest groups, and other forces. As with the space shuttle, certain programs encompass politics, administration, and technology. Politics and administration shape technology, but technology also shapes politics and administration, since it provides both new options and problems. The space shuttle experience illuminates how NASA leaders have sought to manage a large-scale, long-term technological program in a political environment. Their decisions have led to the shuttle's successes, as well as flaws in running the program.[2]

Birth: 1969–1972

The basic responsibility of any agency leader with a technological mission is to make sure his or her agency survives in a vigorous and productive manner. To do that, he or she must promote (i.e., "sell") the next big mission to political authorities. Otherwise, the agency loses vitality and fails to adapt to changing times. In promoting a new program, the agency leader must build support inside and outside the agency while overcoming opposition. Thus, in the wake of America's successful moon landing, NASA Administrator Tom Paine sought to sell a post-Apollo program to President Richard Nixon.

NASA/Bill Ingalls

Paine proposed a range of possible activities, such as a Mars mission, a moon-base, a space station, and a shuttle to go to and from the space station. Nixon was not interested in so huge an effort. Times had changed from 1961 when Kennedy initiated Apollo, in part because of Apollo's success. Paine failed in his post-Apollo effort and resigned. James Fletcher came on with NASA's budget in free fall.

Fletcher succeeded by crafting a program that Nixon and others, especially OMB, were willing to accept. This was the minimal human spaceflight program on Paine's menu, the shuttle. It was priced at $5.5 billion for development. Congress went along. In hindsight, Fletcher offered too much

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for too little money. The shuttle was oversold and underfinanced. Fletcher may not have had much choice, since he had to satisfy not only Nixon, who was interested in an impressive program for electoral and prestige purposes, but OMB, which demanded a "cost-effective" program.

As Michael Griffin, NASA administrator from 2005–2009, observed: "The shuttle was intended to be a robust, reliable vehicle, ready to fly dozens of times per year at a lower cost and a higher level of dependability than any expendable vehicle could ever hope to achieve. It simply didn't happen. What the shuttle does is stunning, but it is stunningly less than what was intended."[3]

Fletcher got a decision from the president to develop the space shuttle, but had to promise more than NASA could deliver in technological advancement and cost savings. But had he not achieved a go-ahead on the shuttle, the human spaceflight mission might have died, and perhaps NASA itself would have been dismantled. With anti-Vietnam war protests and domestic unrest, the atmosphere of the 1969–1972 period was toxic. The problem for NASA was that the shuttle had no real destination without a space station. Instead, its role had to be rationalized as an all-purpose launching system for satellites and planetary spacecraft. Fletcher packaged the shuttle as "the" national launching system, enlisting Department of Defense and intelligence agencies as allies in launching classified missions in addition to civilian spacecraft.

NASA

President Richard M. Nixon and Dr. James C. Fletcher, NASA administrator, discussed the proposed space shuttle vehicle in San Clemente, California, on January 5, 1972. The President announced that day that the United States should proceed at once with the development of an entirely new type of space transportation system designed to help transform the space frontier into familiar territory.

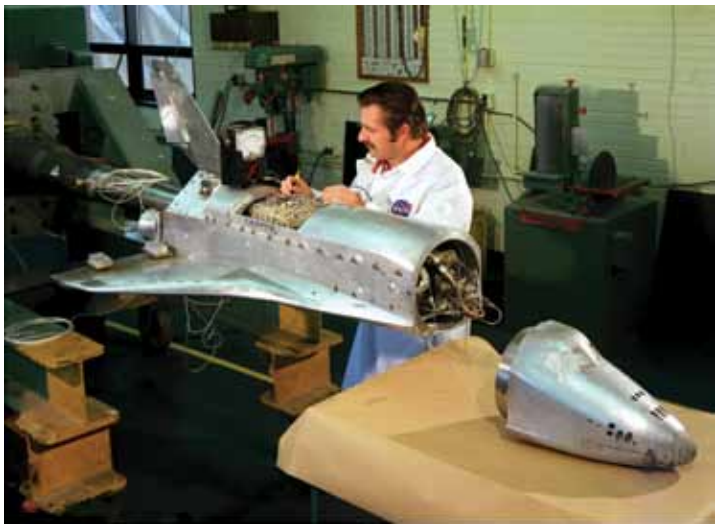
Development: 1972–1983

The development of the shuttle program followed in the 1970s. NASA was ambitious. It had promised a technological leap, a spaceplane that would launch like a rocket and land like an airplane. Griffin has argued that NASA should have developed the shuttle using a more evolutionary approach.

"What if we had not tried for such an enormous technological leap all in one step? What if the goal had been to build an experimental prototype or two, fly them and learn what would work and what was not likely to? Then, with that knowledge in hand, we could have proceeded to design and build a more operationally satisfactory system."[4] But that approach, emphasizing gradual learning, was not used. Development was pushed hard.

One result of the approach used was that by the late 1970s, overruns and delays were visible. President Jimmy Carter considered cancellation. But Fletcher had created a strong political constituency for the shuttle in DOD and the intelligence community. The NASA Administrator Robert Frosch found that the shuttle's connection with the spy satellites Carter wanted for policing nuclear non-proliferation treaties was a strong argument for sustaining the program. Carter thus decided to maintain the program and give it the funds it needed to overcome some of its emerging technical problems.

Ronald Reagan succeeded Carter and he appointed James Beggs NASA administrator. Beggs managed the shuttle through a flight testing stage and a few years beyond. In



NASA Langley Research Center

NASA model of space shuttle being prepared for testing in Langley's 16-foot Transonic Tunnel, May 3, 1978.

1983, Beggs persuaded Reagan that tests were proving that the shuttle was "operational." This term connoted a machine that was reliable and capable of routine flights. Now that the shuttle worked, argued Beggs, it was time to take "the next logical step" in space policy.

Operations: 1983–1993

In 1984 Reagan decided to take the step Beggs advocated. He called for building a space station. It might not have been possible to launch a large new development program if the shuttle had not been seen as ready to go to the next technological stage, that of operations. For the ensuing few years, it looked like the shuttle was indeed highly capable. It took not only astronauts but civilians into space. These included politicians and eventually, in 1986, a teacher.

Then came the explosion of the shuttle Challenger in 1986. This accident took the lives of seven people, the teacher included, and occurred on television, before an audience of millions. This event made clear that the shuttle was not all it was supposed to be, something that was already obvious to many NASA engineers. It was not possible for the shuttle to fly frequently; it took an army of technicians to service the shuttle between well-spaced flights. Certain safety procedures were stretched or ignored.

After the Challenger disaster, an investigation showed that the shuttle was not operational in the reliable, routine sense, and that NASA had made high-risk decisions. Beggs was not administrator at the time of the disaster: he was fighting a criminal charge later proved false. The acting administrator, William Graham, was overwhelmed. Reagan brought Fletcher back to the helm to chart NASA's recovery as an agency and return the shuttle to flight.

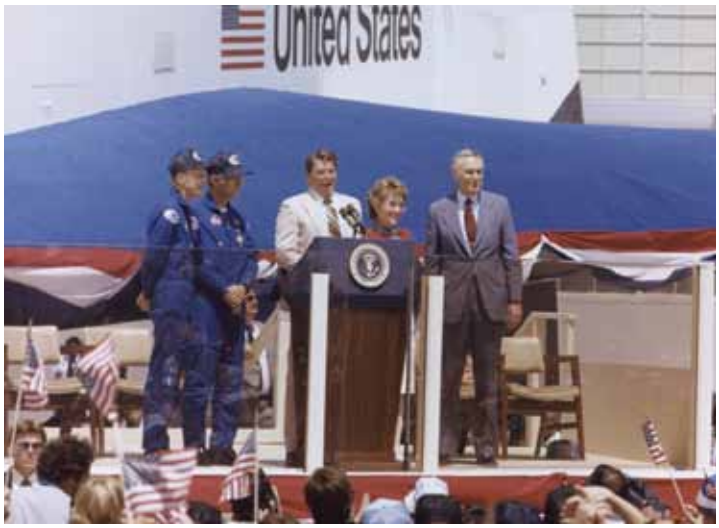
Reorientation: 1993–2003

National policy decisions were made after Challenger to reduce the stress on the shuttle manifest. NASA would not launch commercial or national security satellites. This meant fewer flights. The main task of the shuttle would be to launch certain scientific spacecraft requiring a shuttle and, particularly, to build the space station. It took 32 months for the shuttle to return to flight. When it did so, it launched the Hubble Space Telescope. There was also a program begun to develop a possible shuttle successor, which was called the National Aerospace Plane. This latter program survived only a few years.

The Space Station had its own problems and delays. It was not until 1993, when Bill Clinton was president and Dan Goldin was NASA administrator, that the Space Station's design was finalized. Following Goldin's advocacy, the president and Congress agreed that the Space Station would be an International Space Station (ISS), in which the former adversary, Russia, would join Europe, Japan, and Canada in partnership with the United States. NASA was managing partner of this vast enterprise. With ISS finally secure, given its top priority as a post-Cold War symbol of international cooperation, the shuttle's role as its builder was now equally stabilized. Also, following the astronaut repair of the Hubble Telescope in 1993–1994, the shuttle won praise for enabling great scientific discovery.

Unfortunately for NASA, Clinton constrained the overall agency budget. Goldin wanted to give more emphasis to space science. Priorities at NASA now favored the Space Station and science. The shuttle was squeezed. Goldin and the administration also launched a shuttle successor program, called the X-33. It became difficult to acquire money to upgrade the shuttle if it were destined to be soon replaced. Finally, the notion of the shuttle as operational in the routine sense crept back into the collective consciousness of NASA and its political overseers. A good deal of shuttle servicing was privatized, as NASA focused more on ISS and research and development in space science.

Near the end of the decade, the X-33 was cancelled. Goldin called for a major shuttle upgrading effort, as well as a Space Launch Initiative to research technologies that could eventually replace the shuttle. In late 2001, Sean O'Keefe succeeded Dan Goldin as NASA administrator. O'Keefe inherited a huge overrun on ISS, and gave his attention to mitigating this problem. He also called for building a complement to the



NASA

President Ronald Reagan speaks to a crowd of more than 45,000 people at NASA's Dryden Flight Research Center following the landing of STS-4. To the right of the President are Mrs. Reagan and NASA Administrator James M. Beggs. To the left are STS-4 Columbia astronauts Thomas K. Mattingly and Henry W. Hartsfield, Jr. Prototype Space Shuttle Enterprise is in the background.

shuttle called the Orbital Space Plane. This would take some of the strain off the aging shuttle by launching crew but not cargo to the International Space Station, and help extend the life of the shuttle, perhaps to 2020.

Retirement: 2003–2011

The shuttle Columbia accident of 2003, which occurred as the shuttle entered the Earth's atmosphere, killed seven astronauts and spread debris over a number of states. The investigation that followed made it clear that the shuttle was still being asked to do too much given its vulnerabilities. Moreover, as with Challenger, the accident was shown by investigators to be due not just to technology, but also to management weaknesses. O'Keefe himself came under criticism for adding to schedule pressure in his attempts to get the much-delayed Space Station on track via shuttle flights.

O'Keefe guided the shuttle recovery process, making a host of technical and managerial improvements. He even sought to change the traditional NASA culture from one of "prove to me it is unsafe to launch" to "prove to me it is safe." He also took advantage of the mood of his political masters and the public that lives should not be risked simply to go continually around in Earth's orbit. Beyond the International Space Station, there was a new mission that could be sold.

Thus, in 2004, Bush proclaimed that NASA would go back to the moon by 2020, and subsequently to Mars and beyond. NASA would end the shuttle in 2010, the point when the ISS was expected to be fully assembled. The shuttle would be succeeded by a new rocket-spacecraft system called Constellation that would reach the International Space Station and also go to the moon and deep space. With the shuttle ending, so also ended the nascent Orbital Space Plane.

In 2005, Michael Griffin became NASA administrator. Griffin returned the shuttle, grounded two and a half years, to flight and to resumed building of the ISS. Griffin set as his prime task the implementation of Constellation. He wanted to adopt the kind of rational, evolutionary approach he had *not* seen used in the case of the shuttle. Thus, Constellation would require a space capsule carrying astronauts (Orion), a rocket to do what the shuttle had done in servicing ISS (Ares 1), a heavy-lift, deep-space exploration rocket (Ares 5), and a device that could land on the moon (Altair). In addition, he launched a new program to enlist commercial firms to help launch cargo to the ISS. He began Constellation development with Orion/Ares 1.

Unfortunately, Griffin could not persuade Bush and Congress to fund Constellation adequately. When the Obama administration came to power in 2009, it found Constellation underfunded by at least $3 billion, years behind schedule, and inflicting damage on the budget of NASA's Space Science Program. In February 2010, Obama summarily killed Constellation, and called for an expanded commercial sector role—i.e., to replace the shuttle in taking astronauts along with cargo to ISS. He also proposed enhanced technology development.

NASA Administrator Charles Bolden had little role in the president's Constellation decision, but he did play the leadership role in bringing the shuttle to its conclusion in 2011, one year later than originally scheduled, and selecting the museums to which the remaining spacecraft of the shuttle fleet would be sent. It also became his role to help chart NASA's future in the post-shuttle era.

The Post-Shuttle Future: 2011–?

Congress—both parties—soundly pushed back at Obama's cancellation of Constellation. Obama had gone too far for lawmakers in a way that was ineffectively communicated. By mid-April 2010, the President backtracked and later that year the White House and Congress struck a compromise policy. Under the compromise, set in an authorization bill signed by Obama, Ares 1 was killed. A version of Orion would be built called the Multi-Purpose Crew Vehicle (MPCV). The development of a heavy-lift, deep-space rocket akin to Ares 5 would be accelerated and named the Space Launch System (SLS). With Ares 1 gone, the role of the shuttle would be

performed by commercial firms, and new technology would be developed.

The prime interim deep-space goal, which Obama announced in April 2010, was not the moon but an asteroid, to be reached by 2025. Mars, perhaps a decade later, was the ultimate destination. The post-shuttle future is uncertain, especially because the shuttle's demise has placed the U.S. and other spacefaring nations in a dependency relation to Russia in launching astronauts to ISS. Russia's recent failure of an unmanned cargo-supply rocket has caused worry about this dependency. Also, the commercial firms have yet to prove themselves in providing shuttle-like services.

The point of relying on commercial firms and Russia to get to ISS, under Obama policy, was to free up NASA to return to deep-space exploration. On September 14, NASA announced its new deep-space rocket design. It resembled plans for the aborted Constellation heavy-lift rocket and was in part "shuttle-derived." NASA said it would devote $3 billion a year to building the new deep-space transportation system. With money going to SLS rocket development, the MPCV, and associated costs, NASA would spend $18 billion for the system over the ensuing six years. Its aim would be to launch the first unmanned vehicle in 2017.

NASA planned the rocket to be "evolvable." It could be made more powerful over time. The initial version would potentially have more lift-potential than the shuttle or even the Saturn 5 moon rocket. What was being proposed was an ambitious space system for exploration.[5]

The $18 billion cost figure was just the beginning. The policy question is whether in these hard times anything as big as this can make it through the political system and be sustained. For that to happen, there are critical implications for leadership, many of which are also "shuttle-derived."

Conclusions and Lessons Learned

The space shuttle was a magnificent flying machine. As its design intended, it launched like a rocket and landed like an airplane. It resembled a spaceplane that visionaries after Apollo imagined, but with such severe limits in capability that the resemblance was superficial. In spite of those limits, it performed remarkably well over three decades, with 133 successful flights.

For years, the space shuttle was the nation's prime launch vehicle for satellites, planetary spacecraft, and human beings. It enabled the awe-inspiring Hubble Space Telescope to attain orbit and then be serviced several times. It made it possible to build the International Space Station. It pioneered U.S.-led international connections upon which the ISS has expanded. It was a symbol of U.S. leadership in the world. It inspired young people who saw heroic astronauts living and working in space.

NASA

Anchored on the end of orbiter Endeavour's remote manipulator system arm, astronaut Jeffrey Hoffman (foreground) prepares to install the new wide field planetary camera into the empty cavity of the Hubble Space Telescope (HST). Astronaut Story Musgrave works with a portable foot restraint.

Of the 135 flights, two failed—Challenger and Columbia. Because the shuttle was a national icon, those failures were especially devastating to NASA and America. They graphically revealed technical weaknesses and managerial failures.

There are many leadership lessons, both positive and negative, to be learned from the shuttle experience. The emphasis here is on NASA leadership, but such leadership cannot be separated from national leadership. The shuttle was not only a NASA technology; it was a national technology. As leaders, NASA administrators stand uncomfortably between the managerial tasks of a complex organization and the often capricious political requirements of Washington, D.C. These lessons are about launching programs, developing them, sustaining them, coping with crises along the way, transitioning to next-generation technology, and integrating components of the leadership role.

1. **Launching.** Leaders of science and technology agencies like NASA have to be entrepreneurial, taking advantage of technical windows of opportunity—and political necessity—to advocate new missions to keep their agency viable for the next decade and more. Unless

they extend the technical frontier, their agency can lose its edge and fail to adapt to changing times. NASA is an organization geared to engineering development, not routine operations. While pursuing the next technical generation, leaders must protect ongoing missions. What is perceived as routine may yet be experimental. Also, in pursuing the new, the leader should be optimistic but realistic. Overselling can lead to credibility issues and disappointment later. The leader should fight hard for resources for new and existing missions, and if resources are not available, bring ambition in line with what is technically and fiscally possible.

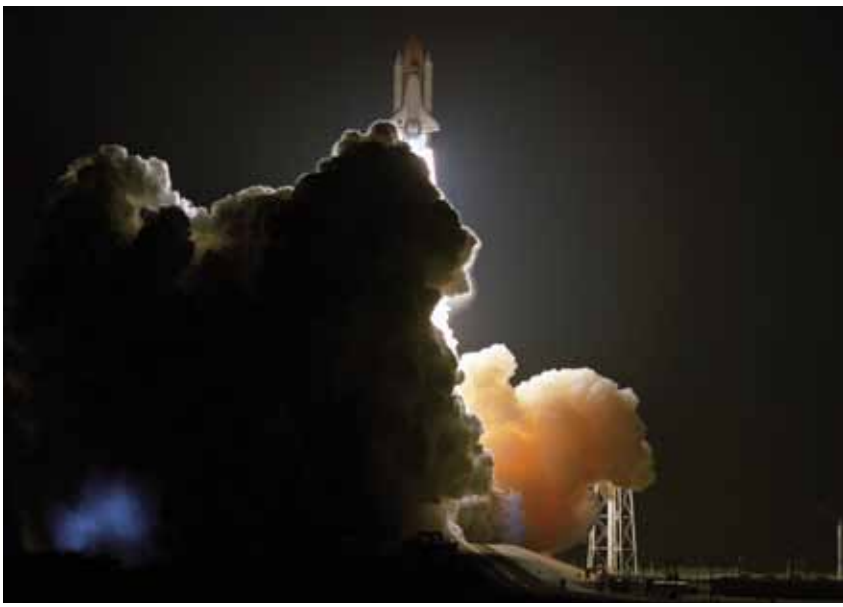
2. **Developing.** Leadership in developmental projects entails balancing pace, cost, and risk. It is best to manage a new technology, especially a large-scale new technology, in an aggressive but evolutionary manner. There is learning and confidence-building along the way to increased complexity. Great leaps forward work best if money is ample. But with great leaps come increased technical and managerial risk. Even in a great leap forward or crash project like Apollo, there can be a sequence: Mercury, Gemini, and finally Apollo itself. The point is to look and learn before leaping.

3. **Sustaining.** The leader can't just sell a new program once. He or she must engage in continual advocacy, especially early in the development process. Programs begin under one president and Congress and have to be readopted under succeeding political masters. Funds come in yearly appropriations. Leaders must make alliances with politicians, other relevant agencies, and international allies. The DOD/intelligence agency partnership NASA had with the shuttle paid off when Carter was president in maintaining the program. Once a program has influential constituents and significant sunk costs, it is likely to survive. However, survival cannot be assumed. For long-term programs, rationales have to adapt.

4. **Crisis Decision-Making.** The best way to cope with a crisis is not to have it. The two shuttle accidents were as much about management errors as technology. It is clear, in hindsight, that there were warning signals and negative trends. NASA deviated from its own best practices. Once a crisis occurs, the leader has to deal with technical and managerial recovery—finding what went wrong and who was to blame, and fixing the technical and organizational malfunctions. There are also huge public relations and Congressional issues to deal with in winning back credibility. The two crises affecting the shuttle point up that agencies (and political authorities) can be in denial. The leader typically is focused on the external pressures facing the agency. He or she can't forget to look "down and in" as well as "up and out." Disasters with the shuttle shut down the program for years. Leaders have to be vigilant as technology managers.

5. **Transitioning.** It was clear at least since the Challenger disaster that the shuttle had serious technical issues and that it would need to be replaced as it aged. Various false starts were made to launch and develop shuttle successor programs. Billions were spent and all efforts died prematurely, yet the prospect of a successor helped justify not investing in service upgrades in the shuttle. Shuttle-successor decision-making thus reveals how *not* to transition technology. This is not only a case of NASA failure. It is also an instance of failure by national policymakers to anticipate and plan for inevitable change.[6]

6. **Integrating components of leadership.** A leader has to deal with politics, management, and technological choices simultaneously when a program like the space shuttle is at issue. Leadership entails having capable associates to help in decision-making. This is especially true if the leader is not technically trained. However, the shuttle history shows that leaders with technical backgrounds may not necessarily be adept in building alliances and acquiring needed resources from the president and Congress. Leaders need teams at the top that embrace relevant political, managerial, and technical skills. Further, the long life of the shuttle shows that leadership takes a relay form. A sequence of leaders have to carry the baton in a marathon. Some may be abler



Against a black night sky, the Space Shuttle Discovery and its seven-member crew head toward Earth-orbit and a scheduled linkup with the International Space Station (ISS). The P5 installation was conducted during the first of three space walks, and involved use of both the shuttle and station's robotic arms.

than others in one respect or another, but all have to do their part in keeping the program going. They also have to pave the way for the eventual ending of the program to be as smooth as possible, so as to minimize disruption for the organization, its employees, contractors, and others that have depended on it. Knowing when and how to terminate a program can be as important as when and how to get it underway.

In conclusion, the rise and fall of the space shuttle provides important lessons that are positive and negative. The shuttle did not achieve its early goals, but still was an amazing machine. It was the key to human spaceflight for three decades. What comes after the shuttle is the leadership challenge ahead.

The proposed NASA space transportation system that has been announced differs from the shuttle. It is an exploration system—bolder and more ambitious than the low-Earth orbit shuttle. But so was Constellation, and it failed to survive a change in presidents. The only way the present plan can be sustained over the long haul is for the political constituency to match the scale of the technology. Big technologies require large-scale political coalitions. The proposed exploration system is very large-scale. Hence, NASA leaders and their allies have to base the new system on rationales that go well beyond jobs in a few "space states." One of the champions of this new technological system is Senator Kay Bailey Hutchison (R–TX). She is assuredly conscious of jobs. However, she also has said that even conservative budget-cutters will support the new space mission "because they see that as part of the American spirit and most certainly part of the American economy and America's national security where we cannot afford to be in second place."[7] Creating a constituency that sees space in those terms is the key to sustaining a program that aspires to the stars.

NASA

Artist concept of SLS launching.

1 W. Henry Lambright, "An Apollo Project for Climate Change/Energy? History Lessons for Future Success," *The Business of Government,* Fall/Winter 2008, 66–69.

2 For the history of the Space Shuttle, a useful source on which the author relied is *Columbia Accident Investigation Board (CAIB) Report,* Vol.1 (Washington, D.C.: NASA and Government Printing Office, 2003).

3 Michael Griffin, "Operationally Fragile: Space Shuttle was Oversold at the Beginning," *Aviation Week and Space Technology,* July 18/25, 2011, 72–73.

4 Ibid.

5 Kenneth Chang, "NASA Unveils Giant Rocket That Might Someday Go To Asteroids and Mars. " *New York Times,* September 15, 2011, A23.

6 This point is made clear in the CAIB report, p.211.

7 Quoted in Chang.