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Decided in the Affirmative, For Now

Our Society's 44th Robert H. Goddard Memorial Symposium was held March 14-15 with the theme "80 Years after Robert Goddard's First Rocket Flight: Engineers, Scientists, and the Vision." The Symposium garnered record attendance because of the relevance of the theme to our community, the strength of the program to address it, and the commitment and hard work of the planning team.

A highlight of the Symposium was the keynote address by Dr. John Marburger, the President's Science Advisor and Director of the Office of Science and Technology Policy. Dr. Marburger took us to altitude to establish exploration vision context, to articulate the key to its sustainability and, ultimately, to grasp its grandeur.

"As I see it, questions about the vision boil down to whether we want to incorporate the Solar System in our economic sphere, or not," Marburger said. "Our national policy, declared by President Bush and endorsed by Congress last December in the NASA authorization act, affirms that '*The fundamental goal of this vision is to advance U.S. scientific, security, and economic interests through a robust space exploration program.*' So at least for now the question has been decided in the affirmative." For now. But how do we ensure that it is always decided in the affirmative, across administrations and across the Iraq's and Katrina's of the future? How do we make the exploration vision sustainable?

Dr. Marburger clearly stated the often-sought and even more often unappreciated answer. "The [vision policy] … subordinates space exploration to the primary goals of scientific, security, and economic interests. Stated this way, the 'fundamental goal' identifies the benefits against which the costs of exploration can be weighed." Benefits. Exploration vision sustainability is based on scientific, security and economic benefits worth the cost. Creation of benefit worth the cost does not occur by serendipity, or simply by flawless mission execution, or bold assertions, or compelling videos, or outreach. Creation of benefit worth the cost requires deliberate management - management of its definition based on researched customer need, management of its creation by profoundly shaping programs, and management of its delivery to customers.

Having articulated benefit worth the cost as the source of sustainability, Dr. Marburger hit the thrusters and went yet higher. "President Bush's vision also declares the will to lead in space [like Apollo], but it renders the ultimate goal more explicit. And that goal is even grander. The ultimate goal is not to impress others, or merely to explore our planetary system, but to *use* accessible space for the benefit of humankind. It is a goal that is not confined to a decade or a century. Nor is it confined to a single nearby destination, or to a fleeting dash to plant a flag. The idea is to begin preparing now for a future in which the material trapped in the Sun's vicinity is available for incorporation into our way of life."

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Mark Craig
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ON THE COVER

FRONT: The Space Shuttle *Columbia* on Launch Pad 39A prior to the launch of STS-1, April 12, 1981. (Source: NASA) **BACK:** The Space Shuttle *Columbia*, piloted by astronauts Crippen and Young, on Rogers Dry Lake Bed at Edwards Air Force Base after landing to complete its first orbital mission on April 14, 1981. (Source: NASA)

Space Shuttle: The First 25 Years

Twenty-five years after its first flight, the space shuttle remains the most sophisticated spacecraft ever built. As a technology demonstrator and operational platform, its performance is unmatched. However, given the shuttle's failure to meet its initial cost and flight-rate goals, its ultimate legacy, and that of the Agency which flies it, remains to be seen.

by Dennis R. Jenkins

As Apollo was reaching its climax in the late 1960s, NASA began planning for the future. Incredibly ambitious plans included large orbiting space stations, Moon bases, trips to Mars, and reusable spacecraft to service them. The price tag of some these plans reached $10 billion per year, more than five times what was being spent annually to support the Apollo program. Early concepts for the reusable spacecraft showed huge fully-reusable, two-stage vehicles that could drastically reduce the cost of space access by making it routine, flying dozens or more flights per year. Most of these concepts involved a hypersonic first-stage larger than a 747 that would launch an orbital stage at Mach 8. However, the largest hypersonic aircraft ever flown was the 50,000-pound X-15, and the development risks for such a large vehicle were enormous, assuming the technology even existed. Given the economic and political climate of the era, none of these plans were taken seriously by the White House or Congress.

Main engine exhaust, solid rocket booster plume and an expanding ball of gas from the external tank is visible seconds after the Space Shuttle Challenger *accident on January 28, 1986. (Source: NASA)*

By 1971, NASA finally conceded that it needed a new plan. The fully-reusable, two-stage vehicle slowly gave way to a variety of partially reusable concepts that traded near-term development costs for long-term operational costs. In addition, the size, and attendant risks, of the vehicle came down to manageable proportions. When the White House finally approved the space shuttle on 3 January 1972, it dictated a ceiling of $5.15 billion for development costs, including manufacturing of the first two orbiters.

The NASA officials who began space shuttle did so with grand ambitions. However, the exercise must be looked at with the perspective of the time. When the initial space shuttle studies began, the United States had completed fewer than two dozen space flights; indeed, when *Columbia* made her first flight in 1981, the United States had only completed 30 orbital missions. The electronics revolution that would ultimately change the world had only begun when space shuttle was being developed. The use of satellites was increasing, but their reliability was not, leading most to expect the need for dozens of flights per year to launch or repair the satellites upon which the industrialized nations were increasingly dependent. Much of this would change before shuttle began to fly, but by then it was too late. Too much prestige had been placed on the need for a high flight rate.

After several years of studies and competitions, North American Rockwell was awarded the space shuttle development contract on 26 July 1972. Martin Marietta, Rocketdyne, and Thiokol were subsequently selected to develop the External Tank (ET), Space Shuttle Main Engine (SSME), and Solid Rocket Motor (SRM); United Space Boosters, Inc. (USBI) would integrate the SRMs with NASA-provided non-motor parts to form Solid Rocket Boosters (SRB). The Apollo launch site at the Kennedy Space Center and the Manned Orbiting Laboratory launch site at Vandenberg Air Force Base would be modified to launch space shuttles.

Four years later, on 17 September 1976, the first "Orbital Vehicle," OV-101, was rolled-out of the assembly plant in Palmdale, California, and trucked overland to Edwards Air Force Base. *Enterprise* was loaded on the back of a modified 747 Shuttle Carrier Aircraft for a series of aerodynamic flight tests that would ultimately prove that the Orbiter could successfully land like a (mostly) normal aircraft – a first for a spaceship since all previous capsules had returned under a parachute. After the Approach and Landing Tests, *Enterprise* was supposed to be modified into a space-rated orbiter, but cost estimates grew too high and the orbiter was instead relegated to a series of test duties. These included vibration tests at the Marshall Space Flight Center, use as a pathfinder to verify the readiness of Launch Complex 39 at the Kennedy Space Center, and similar duties at the Vandenberg Launch Site. Along the way OV-101 excited the crowds during a European tour that included a stop at the 1983 Paris Air Show, and later at the 1984 World's Fair in New Orleans. Ultimately, *Enterprise* was added to the collection of the National Air and Space Museum and is the centerpiece of the McDonnell Space Hangar at the Steven F. Udvar-Hazy Center near Dulles International Airport in suburban Washington, D.C.

The first orbiter to fly into space was *Columbia*, rolled-out under unfortunate circumstance on 8 March 1979. The program was running behind schedule, and one of the most troubling areas was plainly obvious on the new orbiter – the unique ceramic thermal protection system tiles that were supposed to cover the exterior of OV-102 were largely missing.

In December 1998, the crew of STS-88 began construction of the International Space Station by joining the US built Unity module to the Russian built Zarya *module. (Source: NASA)*

The tiles themselves were performing mostly as expected during testing, but Rockwell was having a difficult time figuring out how to affix them to the orbiter. Later there would be unexpected trouble with waterproofing, and some question about damage tolerance in some locations.

At the same time, Rocketdyne was having even more trouble with the SSME, which was well behind its ambitious development schedule. The First Manned Orbital Flight originally scheduled for mid-1979 soon slid into 1980, and then into 1981. Finally, on 12 April 1981 *Columbia* was launched as STS-1 on the first of four Orbital Flight Tests. This was undoubtedly the most ambitious maiden flight in the history of aviation, and the first time that astronauts had ridden on the initial flight of a new launch vehicle. Despite losing some tiles during launch, John Young and Bob Crippen successfully completed the flight and brought *Columbia* back to a pinpoint landing at Edwards. Post-flight inspection revealed that the orbiter had received only minor damage during its flight, although there was a need to modify the launch pad to minimize a potentially dangerous overpressure problem. Three more orbital tests would follow over the next year, and with the return of *Columbia* from STS-4 on 4 July 1982, President Reagan declared the space shuttle "operational."

It appeared that the ambitious hopes for space shuttle might be realized. Over the course of the next three years, the orbiters would fly a series of highly-publicized, and in many ways, astounding missions. Satellites would be launched, and for the first time, objects would be retrieved from space and brought back to Earth. A science module called Spacelab was first flown on STS-9 in November 1983, acting as a surrogate for the space station that NASA hoped to build one day. The astronaut corps was expanded to include women and people from many races and nationalities. The space shuttle was recognized around the world as a symbol of American technology.

A second orbiter, OV-099, *Challenger*, joined the fleet in 1983. Originally built as a structural test article, NASA decided that it was less expensive to convert *Challenger* into a space-rated orbiter than to modify *Enterprise*. The new orbiter was rolled out in Palmdale on 30 June 1982, and would make its maiden flight as STS-6 on 4 April 1983. As part of the same contract modification that begat *Challenger*, Rockwell was authorized to build two additional orbiters – OV-103, *Discovery* and OV-104, *Atlantis*. These were rolled out on 16 October 1983 and 6 March 1985, respectively. A great deal had been learned during the manufacturing process, and *Atlantis* was 7,000 pounds lighter than *Columbia* and had taken only half the man-hours to build. Attempts to get Congress and the White House to authorize the construction of a fifth orbiter ultimately failed, although NASA built a set of structural spares that could be used to repair damage to an orbiter.

Things were looking up. Despite launch delays with almost every flight, the publicity surrounding the space shuttle program was generally positive and the public was amazed by the sight of the space shuttle thundering into the sky from Kennedy Space Center. NASA maintained its faith that the flight rate would eventually build to more than two dozen missions per year, although this was considerably less than the 60 missions per year originally proposed. In reality, there were simply not enough payloads to justify that number of missions, even given the 1978 National Space Policy that dictated space shuttle would be the only American launch vehicle by the end of the decade.

Beginning with the launch of STS-20 (51-C, as it was publicly called) in January 1985, the space shuttle program had ramped up to a launch rate of almost one per month. Unfortunately, the eleventh mission on 28 January 1986 would shatter all of the dreams. Seventy-three seconds after launch, *Challenger* was destroyed during STS-33 (51-L) when hot gases from a breached joint in the left SRB impinged on the ET liquid hydrogen tank and caused an explosion. The crew of seven was lost.

It took a long twenty-eight months to recover, and addressing the non-technical issues raised by the Presidential Commission that investigated the accident caused a great deal of soul searching within NASA, and especially within the space shuttle program. When flights resumed with the launch of STS-26R on 29 September 1988, many of the rules were different. No long would space shuttle be the only American launch vehicle – expendables such as Atlas, Delta, and Titan were back in business and would bear the brunt of the satellite business. Space shuttle would be limited to launching national defense satellites and scientific payloads that could not easily be accommodated on other vehicles. These included the *Galileo* and *Magellan* planetary probes, Hubble Space Telescope, and Chandra X-Ray Observatory. The orbiters, however, continued to demonstrate their unique capabilities by conducting the servicing missions to Hubble and carrying Spacelab modules. *Challenger* was replaced by OV-105, *Endeavour*, built largely from the set of structural spares the program had manufactured. Nevertheless, any thought of flying two dozen missions per year vanished.

> "Despite widespread press coverage in the late 1970s claiming shuttle was seriously over budget, the final development numbers appear to be on the order of $6 billion (in constant FY71 dollars), only 16 percent over the original target."

Despite the apparent setback, the space shuttle had a new mission, one it had always been intended to fulfill – building a space station. In 1995 the orbiters began visiting the Russian *Mir* space station, a prelude to the international cooperation necessary to construct a large, orbiting outpost. *Discovery* made the ninth and final *Mir* docking in 1998, five months before the Russians launched *Zarya*, the first International Space Station (ISS) module. A month later, astronauts aboard *Endeavour* initiated the assembly of the ISS, linking the *Unity* module to *Zarya*. In 1999, the *Discovery* crew accomplished the first docking of an orbiter with the ISS during a mission to supply the two modules with tools and cranes.

During the 1990s, space shuttle demonstrated that even routine spaceflight is hardly easy. A series of problems haunted the program, including hydrogen leaks that grounded the fleet for several months while engineers determined their cause. Nevertheless, in the first decade after the return-to-flight of *Discovery* the space shuttle flew 66 missions, mostly carrying the Spacelab science module or ISS assembly flights.

The string of successes came to an abrupt halt on 1 February 2003. Eighty-eight missions after *Challenger*, the program experienced its second major accident when *Columbia* broke apart during reentry on STS-107, killing the crew of seven. This time the accident board pulled no punches, criticizing the NASA leadership and the program management for serious lapses of judgment. Much like *Challenger*, the underlying technical cause of the accident – insulating foam falling off the ET – had been known for years, but had not been adequately categorized as a threat. Unlike the first accident, however, the technical cause of this one proved much more difficult to remedy.

When *Discovery* lifted off as STS-114 on the second return-to-flight mission, the program breathed a sigh of relief until it was realized that foam was still shedding from the ET in unacceptable quantities. Instead of fulfilling an ambitious ISS assembly manifest, the program found itself grounded again while the engineers continued to investigate the anomalies. At the time of the twenty-fifth anniversary of the first space shuttle launch, many are wondering when the next mission will be. Officially, the window for STS-121 opens on 1 July 2006 – only time will tell.

Tracking down exact expenditures within the NASA budget is an impossible exercise, but most researchers agree that space shuttle came remarkably close to its development cost targets. Despite widespread press coverage in the late 1970s claiming shuttle was seriously over budget, the final development numbers appear to be on the order of $6 billion (in constant FY71 dollars), only 16 percent over the original target. Compared to many cutting-edge programs, this was remarkable cost performance. The program did not fare as well on its schedule estimate. At program approval in 1972, it was estimated that the First Manned Orbital Flight (what became STS-1) would take place in mid-1979, roughly 90 months from authority to proceed. In reality, STS-1 did not launch until April 1981, which was 112 months after ATP – a 24 percent overrun.

The cost per mission, however, has been nothing like expected. By the time of STS-1, expectations were for the cost of a shuttle flight to be about $50 million (FY81), based on 26 flights per year. (The estimated cost per flight and number of missions per year varied widely and, as said earlier, included flight rates as high as 60 per year.) In reality, of course, the program never came anywhere near 26 flights per year (the best being 11 flights in a 12 month period just before *Challenger*). And taking the simplistic approach of dividing a $3.5 billion annual budget by 6 flights (the average in a good year), you end up with $583 million per flight ($260 million in constant FY81 dollars), not attempting to recoup the original R&D expenses.

Despite not living up to its original, unrealistic, billing as an economical space launch system, the space shuttle has proven to be a remarkably capable vehicle and has served well for 25 years. Reagan's proclamation that the vehicle was "operational" notwithstanding, the space shuttle has always been a development vehicle charged with an operational mission, much like the later X-15 flights. Unfortunately, at times the space shuttle program began believing its own propaganda and forgot that it is, and should be, primarily an engineering organization, not an airline. It appears that the pendulum may have swung too far the opposite way after the flight of STS-114. As Harrison Storms, the legendary head of the Apollo spacecraft program for North American, once observed: "There is a very fine line between stopping progress and being reckless…[and] the necessary ingredient in this situation of solving a sticky problem is attitude and approach. The answer, in my opinion, is what I refer to as 'thoughtful courage.' If you don't have that, you will very easily fall into the habit of 'fearful safety' and end up with a very long and tedious-type solution at the hands of some committee. This can very well end up giving a test program a disease commonly referred to as 'cancelitis,' which results in little or no progress." Perhaps the space shuttle program should look inward and see if Stormy was right. ■

***Dennis R. Jenkins* has worked in the space shuttle program for over twenty years in a variety of technical and managerial positions. He was a technical consultant to the *Columbia* Accident Investigation Board and is the author of numerous books on aerospace history, including *Space Shuttle: The History of the National Space Transportation System: The First 100 Missions*.**

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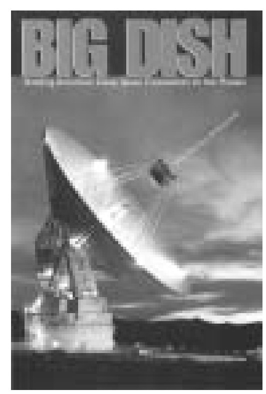

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The End of an Era

The top priority of NASA and the space shuttle program is to safely complete assembly of the International Space Station and, if possible, fly a final servicing mission to the Hubble Space Telescope before the shuttle fleet is retired in 2010. But this focus on safe mission execution has not stopped the Agency from planning for the day when shuttles will no longer blast off from the historic Launch Complex 39.

by Robert Lightfoot

When President Bush announced the *Vision for Space Exploration* in January, 2004, with it came the direction to retire the space shuttles in 2010 following the assembly of the International Space Station. Prior to this announcement, the space shuttle program had been focused on flying through 2020. Space shuttle retirement and transition planning became a new area of focus and will remain a significant activity long after the last shuttle flight. Today, NASA has created an initial structure to facilitate this undertaking and has actually begun the transition process of addressing the transition and retirement of a workforce of over 17,000 and assets valued at over $17 billion located at government and contractor-owned facilities across the United States.

While it is vitally important that NASA ensure that the assets of the shuttle program are drawn down or transferred to other programs as efficiently and effectively as possible, the Agency's top priority is safe mission execution. Right now, the three shuttle orbiters *Discovery*, *Atlantis*, and *Endeavour* are scheduled to fly up to sixteen missions to the International Space Station between now and 2010. This manifest will complete assembly of the unique orbiting laboratory and preposition enough supplies and hardware onboard the station so that the U.S. and its international partners can fully utilize the facility after the shuttle is retired. Assuming that the STS-121 mission scheduled for this summer validates the fundamental improvements made to the shuttle since the launch of STS-114 last July, the shuttle program may also conduct a fifth servicing mission to the Hubble Space Telescope some time in early 2008. These missions are essential first steps in the *Vision* and for a strong, healthy U.S. space science program through the next decade.

Following the President's announcement, NASA commissioned a space shuttle transition panel headed by Lesa Roe of the Langley Research Center as part of the 2005 Integrated Space Operations Summit (ISOS). Like the two Service Life Extension Program (SLEP) summits which preceded it, the ISOS also addressed the long term investment strategies required to safely fly the shuttle mission until the end of the program. The summit process utilized panels made up of representatives from government, industry, and academia to address areas such as mission execution, safety enhancements, infrastructure, and technology. The concept of the summit was borrowed from the Air Force, which occasionally used this kind of mechanism in areas like munitions development to tap a broad community of experts and users in order to get the "buy in" needed to make these efforts successful. In the case of the 2005 ISOS summit, the addition of a panel to address shuttle transition provided the shuttle community with the opportunity to take a first look at the magnitude of the undertaking that lay ahead.

The ISOS transition panel gathered data through internal and external benchmarking of programs which had been retired and developed three primary recommendations based on those findings. First, the transition panel recommended that NASA should develop an Agency-wide transition plan that included inte-

Space Shuttle Discovery*, Seen here docked to the Pressurized Mating Adapter 2 on the ISS, safely delivered crew and supplies to the space station after the* Columbia *Disaster. (Source: NASA)* gration, implementation, management and schedule. Second, the panel recommended that the Agency should create a transition manager position outside the space shuttle program to oversee implementation of this plan, authorize funds, lead the NASA transition team, and advise Agency boards during the decisionmaking process. Finally, the panel recommended that NASA develop an Agency-wide transition process through which shuttle program assets are evaluated for future needs and dispositioned appropriately. These recommendations became the initial foundation of the Agency planning effort.

Space shuttle program planning was further influenced by the announcement in September 2005 that NASA was choosing an architecture for the future exploration vehicle derived from the existing shuttle systems. With this announcement, a significant amount of the shuttle workforce and assets had a direct link to the future vehicles. The question, then, became one of identifying assets that would be "transitioned" to these new projects and those that were no longer needed and could be retired.

Today, the Agency has taken some key steps toward the 2010 milestone for retiring the space shuttle. A transition manager position has been established at NASA Headquarters in Washington, DC. Initial planning and a transition control board is in place at headquarters to address the capabilities that are no longer needed to complete the shuttle mission, but could be used by future NASA missions. This structure includes not only the Space Operations Mission Directorate (the organization responsible for managing the shuttle, International Space Station, and other programs), but also the Exploration Systems Mission Directorate (responsible for developing the new systems needed to carry out the *Vision*) as well as the ten NASA centers. A standing Headquarters-level Transition Control Board provides senior Agency managers with insight and guidance into important tactical-level transition issues, while a Joint Integration Control Board provides direction for strategic integration functions that cut across multiple operations and development programs.

This process has already been exercised for the space shuttle External Tank project, which has stopped procurement of hardware and supplies no longer needed for flying out the manifest but has continued some purchases of aluminum-lithium alloy under existing contracts for potential use on future vehicles. Consistent with Federal Acquisition Regulations, NASA is also taking advantage of other provisions in existing operations contracts to begin development work in key areas.

A key component to these decisions is developing a position on the risk associated with the disposition of a given capability. The risk of each element has to

Space Shuttle Discovery *leaves the confines of NASA's Vehicle Assembly Building as begins its slow 4.2-mile journey via the crawlerway to Launch Pad 39B on May 19, 2006. (Source: NASA)* be addressed in several ways. For example, there is a risk assessment required for the shuttle program to address the loss of a capability. Also, other potential users of the capability must address the risk of maintaining a capability for a future use versus trying to recreate it at a later time. By bringing these forward from an Agency perspective, the total risk associated with a given decision can be understood.

> "While it is vitally important that NASA ensure that the assets of the shuttle program are drawn down or transferred to other programs as efficiently and effectively as possible, the Agency's top priority is safe mission execution."

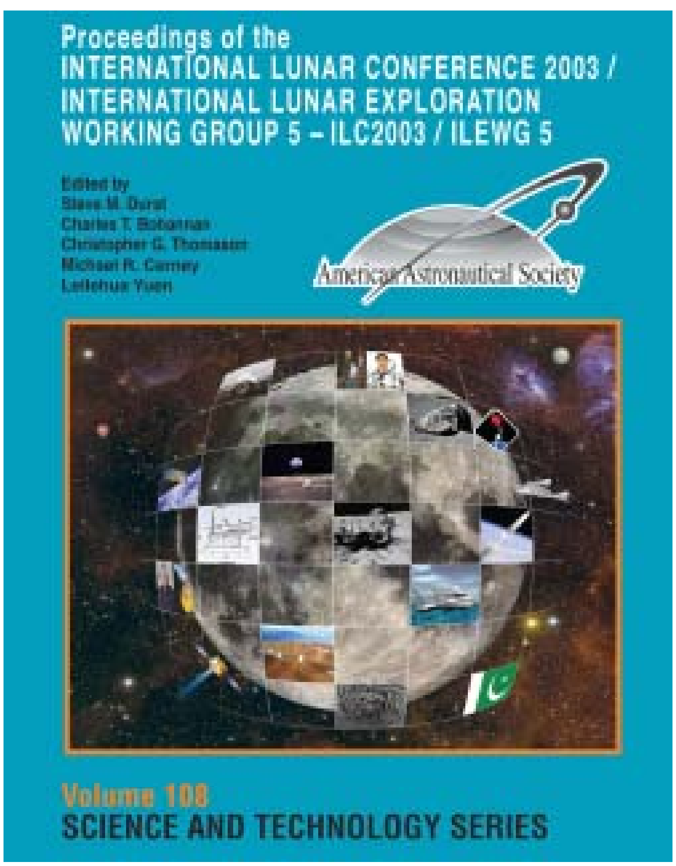
Over the past year, Space Operations and Exploration Systems have also encouraged close working relationships between operations projects (Space Shuttle and International Space Station) and development projects. Co-location of both operations and development program management at the Johnson Space Center in Houston, Texas, facilitates these relationships and ensures that both groups effectively exchange knowledge and identify and appropriately disposition assets for transition.

At the working level, the space shuttle program has also hosted two technical interchange meetings on transition to survey existing Agency capabilities in areas like human capital management, data archiving, environmental remediation, and historical preservation.

Right now, the transition team is developing a master schedule of last need dates for the capabilities and workforce within each given project. The management of this schedule over the next several years will allow for a timely and orderly transfer or disposition of these assets. Furthermore, the potential next users of these capabilities can incorporate the availability into their planning.

The transition and retirement of the space shuttle assets will be a significant undertaking. Protecting the critical agency and national assets currently used for the space shuttle program but needed for all future endeavors is critical to enabling the *Vision for Space Exploration.* ■

Robert Lightfoot **is the Deputy Program Manager for the Space Shuttle Propulsion Office and the Space Shuttle Program Transition Manager.**



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The Passing of an Engineer

by Dennis R. Jenkins

By training, and vocation, I am an engineer and perhaps unsurprisingly, my few heroes tend to be engineers. On 19 April the world lost one of my heroes. Most of the press reports called him a legendary or renowned test pilot, and they were not incorrect. But Albert Scott Crossfield was, first and foremost, an engineer.

Like many of his generation, Scott's early life was interrupted by a World War. In 1942 he put undergraduate work at the University of Washington on hold and joined the Navy as a pilot, spending six months in the South Pacific, but never seeing combat. He resumed his engineering studies in 1946 and graduated in 1949 with a B.S. in aeronautical engineering, followed by an M.S. in aeronautical sciences the next year. The timing was perfect.

The late 1940s and 1950s was a time of great advancement in aeronautics. The U.S. government was funding a variety of experimental aircraft to explore new frontiers, and Crossfield wanted to be part of the excitement. In June 1950, he joined the National Advisory Committee for Aeronautics (NACA) as a test pilot. Over the next five years, Crossfield flew most of the experimental aircraft at Edwards. Oddly, Scotty is most remembered for one of the few things he did on emotion, not engineering judgment. On 20 November 1953, Crossfield became the first man to fly at twice the speed of sound as he piloted the Douglas D558-II Skyrocket to 2,078 km/h (Mach 2.005), surpassing its design speed by some 25 percent. It was an unusual undertaking for both Crossfield and his boss, Walt Williams, since both routinely maintained that the NACA was not in the business of setting records. However, beating the Air Force – and Chuck Yeager – to Mach 2 was an opportunity too good to pass up. By the time Crossfield left the NACA to join North American Aviation in 1955, he had amassed more flight time in the rocket planes than any other pilot.

Scott Crossfield, seen here in the cockpit of the Douglas D-558-II Skyrocket, after the first Mach 2 flight on November, 20, 1953. (Source: NASA)

The move to North American allowed Scotty to help design the fastest and highest flying aircraft of the era, the X-15. Scotty's influence included championing the use of an ejection seat and full-pressure suit as an escape system instead of a heavier and more complicated capsule. His influence on David Clark during the development of a workable full-pressure suit was equally as important, as were his contributions to the physiological test program – particularly in the human centrifuge at NADC Johnsville, Pennsylvania – that led directly to the regime used during Project Mercury.

Scott flew the X-15 from 8 June 1959 until 6 December 1960, making 14 flights, including one glide flight, ten flights with the interim XLR11 engine, and three flights with the ultimate XLR99. Crossfield reached Mach 2.97, a speed of 3,154 km/h, and an altitude of 26,858 meters.

Crossfield continued with North American until 1967 when he left to become an executive at Eastern Airlines before becoming a Senior Vice President for Hawker Siddeley Aviation during 1974-75. From 1977 until his retirement in 1993, he served as civil aviation consultant to the House Committee on Science and Technology. Beginning in 2001, at age 80, Crossfield trained several pilots to fly a reproduction Wright Flyer during the 100th anniversary of the Wright Brothers' first flight.

On 19 April 2006 Scotty was returning home to Virginia after a speech at Maxwell AFB, Alabama. At 11:10 a.m., in the middle of a Category 6 thunderstorm, the FAA lost radar contact with the Cessna 210A that Crossfield had flown for years. The following day the wreckage was located in a remote area north of Atlanta, Georgia. Crossfield is survived by his wife of sixty years, Alice, six children, and two grandchildren.

I was privileged to know Scotty, and he graciously wrote the foreword for one of my books. During the many years I spent researching the X-15 program, all of the surviving pilots were happy to talk about their experiences, and I spent many hours on the phone and email with Crossfield. My admiration for him grew with each conversation. Crossfield was always willing to share his experiences, provide counsel and encouragement, and quickly point out errors in my reasoning or research. Scott was a gentleman without a truly bad word to say about anybody, unlike at least one of his contemporaries. He never regretted any of his decisions, never boasted of his contributions, and was justifiably proud of his accomplishments. Scotty is still one of my heroes. ■

***Dennis R. Jenkins* is an aerospace engineer and historian. Scott Crossfield wrote the forward for Jenkins' *Hypersonic: The Story of the North American X-15*.**

A Shelf of Indispensable Books on the Space Shuttle

A collection of the most noteworthy books yet written on the Space Transportation System.

by Roger D. Launius

When NASA began work on what became the space shuttle at the end of the Apollo program, few recognized how important a part of American life it would become over the next thirty-plus years. While not vast, the literature on the history of the space shuttle is now large enough to permit assessment.

In terms of technical history nothing is better than Dennis R. Jenkins, *Space Shuttle: The History of the National Space Transportation System, the First 100 Missions* (North Branch, MN: Voyageur Press, 2001, 3rd Edition). It presents an overview of the vehicle's development and use. It begins with a discussion of the origins of the goal of winged spaceflight in the 1920s, extends through the Dyna-Soar, lifting body, and X-plane research until the decision to proceed with the space shuttle in 1972. It then goes into great detail about the shuttle's design and development effort in the 1970s and then discusses in some detail the first 100 missions of the program since 1981. In every case, Jenkins offers an excellent technical analysis of all aspects of the vehicle. This book is the place to start in any effort to understand the history of the space shuttle. When the Columbia Accident Investigation Board (CAIB) started investigating the shuttle accident of February 1, 2003, its members read this book as background to their important work. Not surprisingly, Jenkins soon became a staff member supporting the CAIB and his expertise showed in the final report.

David M. Harland, *The Story of the Space Shuttle* (Chicester, UK: Springer-Praxis, 2004), is another solid account of the origins and development of the space shuttle. In spite of the *Challenger* and *Columbia* disasters, the author claims that the space shuttle remains the most successful spacecraft ever developed. He argues that the scientific contribution it has made to the international space program is exceptional, and that its missions to Mir, Hubble, and the International Space Station make it an indispensable vehicle whose place in the history of the Space Age is secure. This is a revision and updating of a 1999 book on the history of the shuttle.

> "Collectively, these books, as well as a few others that cannot be mentioned in a brief assessment such as this, sketch the broad contours of the space shuttle program, a program that has dominated more than half of the nearly fifty-year experience of the Space Age."

Well-known writer T.A. Heppenheimer has published two volumes on the history of the space shuttle that present important perspectives on its origins and development. The first, *The Space Shuttle Decision, 1965-1972 (History of the Space Shuttle, Volume 1)* (Washington, DC: Smithsonian Institution Press, 2002, a reprint of NASA SP-4221, 1999), reviews the shuttle's technical antecedents in the X-15 and various rocket booster technologies, and illuminates the principal personalities involved in the space shuttle decision and their motivations. He traces NASA's evolving program goals, technical calculations, political maneuvering, and fiscal constraints, and explains the myriad designs that preceded the 1972 approved shuttle concept. His second volume, *Development of the Space Shuttle, 1972-1981 (History of the Space Shuttle, Volume 2)* (Washington, DC: Smithsonian Institution Press, 2002), traces the development of the shuttle through a decade of engineering setbacks and breakthroughs, program management challenges, and political strategizing, culminating in the first launch in April 1981. The focus here is on the engineering challenges: propulsion, thermal protection, electronics, and onboard systems.

Perhaps appropriately, disasters in the shuttle program have attracted considerable attention from writers. The *Challenger* accident during launch of STS-51L on January 28, 1986, received early and persistent treatment. The most useful study is Diane Vaughan's *The Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA* (Chicago: University of Chicago Press, 1996). The first thorough scholarly study of the events leading to the fateful decision to launch *Challenger*, this book uses sociological and communication theory to piece together the story of this disaster in spaceflight and to analyze the nature of risk in high technology enterprises. Three other books take a journalistic approach to the subject. These include two early publications, Malcolm McConnell, *Challenger: A Major Malfunction* (Garden City, NY: Doubleday and Co., 1987), and Joseph J. Trento, with reporting and editing by Susan B. Trento, *Pre-*

scription for Disaster: From the Glory of Apollo to the Betrayal of the Shuttle* (New York: Crown Publishers, 1987). Both of these books use the *Challenger* accident as a window to review the NASA management and R&D system emphasizing the agency's "fall from grace" in the space shuttle era. Claus Jensen, *No Downlink: A Dramatic Narrative about the Challenger Accident and Our Time* (New York: Farrar Straus Giroux, 1996), recounts the story of the *Challenger* disaster as a symbol of American technological decline.

There are five major works offering first person accounts of space shuttle operations. The earliest of these is Henry S.F. Cooper's *Before Lift-off: The Making of a Space Shuttle Crew* (Baltimore, MD: The Johns Hopkins University Press, 1987). Written in a journalistic style without scholarly apparatus, it is an excellent first person account of the 1984 mission of STS-41G. More recently, Tony Reichhardt has edited, *Space Shuttle: The First 20 Years—The Astronauts' Experiences in their Own Words* (New York: DK Publishing, 2002). As said in the title, this work captures stories from 77 astronauts who have flown on the space shuttle since 1981 in a heavily illustrated, oversized format. Similar in format, but focused on the shuttle/Mir episode in the mid-1990s, Clay Morgan, *Shuttle-Mir: The U.S. and Russia Share History's Highest Stage* (Washington, DC: NASA SP-2001-4225, 2001), offers a large-format picture book/CD-ROM with a multimedia history of the shuttle-Mir story. It emphasizes the team members on the ground, the missions of the space shuttle to and from Mir, and the tales of the seven American astronauts who, with their Russian crewmates, worked under often challenging conditions. A searchable CD/ROM further explores the Shuttle-Mir program with historical documents, photos, biographies, correspondence, and oral histories.

One of a series of photographs showing the Space Shuttle Discovery *as taken from aboard the International Space Station during rendezvous and docking operations. The Italian-built Raffaello Multi-Purpose Logistics Module (MPLM) is in the shuttle's cargo bay. Earth, dotted with popcorn-like clouds, provides the backdrop for this image. (Source: NASA)*

Additionally, in early 2006 two memoirs of shuttle astronauts appeared. Thomas D. Jones, *Sky Walking: An Astronaut's Memoir* (New York: Collins, 2006), offers more reflectiveness and less swagger than many earlier works by astronauts and focuses attention on the working men and women who operated in Earth orbit to deploy satellites, repair the Hubble Space Telescope, and build the International Space Station. A veteran of four shuttle missions, Jones's memoir is one of only a small number of such first person accounts, and his style, penetrating insight, and wit makes it an essential book for anyone interested in the history of recent spaceflight. Another astronaut memoir that appeared at almost the same time is Mike Mullane's *Riding Rockets: The Outrageous Tales of a Space Shuttle Astronaut* (New York: Scribner's, 2006). It is an entertaining, if sophomoric, work that speaks to the pilot mentality still present in the NASA astronaut corps. Mullane was chosen as a candidate in 1978, and his memoir oozes the machismo and conceit made famous in "The Right Stuff" without the heroism and sense of mission.

Finally, the *Columbia* accident on February 1, 2003 has prompted the publication several books on the accident, none of them as thoughtful and useful as Diane Vaughan's work on *Challenger* but all suggestive of future investigation. Philip Chien, *Columbia—Final Voyage: The Last Flight of NASA's First Space Shuttle* (Chicester, UK: Springer-Praxis, 2006), and Michael Cabbage and William Harwood, *Comm Check...: The Final Flight of Shuttle Columbia* (New York: Free Press, 2004), are journalistic accounts of the mission, the accident, and its aftermath. They review the crew's training, scientific work, and the details of this mission. Mark Cantrell and Donald Vaughan, *Sixteen Minutes from Home: The Columbia Space Shuttle Tragedy* (New York: AMI Books, 2003), offers a tribute to the crew and a sympathetic look at how the tragedy affected the families of the crew and the American public.

Collectively these books, as well as a few others that cannot be mentioned in a brief assessment such as this, sketch the broad contours of the space shuttle program, a program that has dominated more than half of the nearly fifty-year experience of the Space Age. ■

***Roger D. Launius* is Chair of the Division of Space History at the National Air and Space Museum in Washington, DC.**

Contributions to Space Exploration: Global Objectives, Plans, and Capabilities

Public Seminar

November 1-2, 2006

An AAS/AIAA Initiative, Organized in conjunction with George Mason University

The American Astronautical Society (AAS) and the American Institute of Aeronautics and Astronautics (AIAA) in conjunction with George Mason University plan a series of events to highlight global space exploration objectives, plans and industrial capabilities and develop a single integrated data base of space exploration activities worldwide. The events will focus on the comprehensive range of plans, encompassing Moon and Mars programs and other missions and precursor research that contribute to space exploration overall. National space exploration objectives, plans and industrial capabilities worldwide will be reviewed and presented in relation to a standard template. The template approach will aid an independent assessment of the overall space exploration endeavor and the roles of individual national space exploration components within it. The template approach will also aid the identification of gaps, overlaps and strategic redundancies, providing useful input to discussions on and planning for exploration activities for the coming decades.

This initiative will be accomplished through a public seminar, a data synthesis working group and an invitation only follow-on workshop. It is the first activity being undertaken by AAS and AIAA under a new collaborative agreement on international activities.

Public Seminar: November 1–2, 2006

The public seminar will be held November 1–2, 2006, at the George Mason University, Arlington Campus, Virginia. It will highlight the full range of national exploration, objectives, plans and industrial capabilities (including purely commercial initiatives)

Seminar Program:

- Presentation on the important role international cooperation will play in space exploration
- Presentations by space agencies on their national exploration objectives, plans and industrial capabilities. Speakers will be provided a template so that all presentations are made in the same manner, thus allowing an "apples-to-apples" comparison.
- Panel on international cooperation (organizations' and societies' statements about international cooperation and its potential role in space exploration)
- Panels on commercial interests in space exploration
- Presentation on status of Global Space Exploration Strategy
- Presentation on possible regimes/frameworks for international cooperation in space exploration

Synthesis Group

A small synthesis group (drawn from organizers and co-sponsors) will meet soon after the Seminar to develop/refine an initial summary document of national exploration plans, objectives and capabilities and identify gaps, overlaps and strategic redundancies.

Invitation Only Workshop

Workshop participants (including seminar speakers or their representatives from government and industry, scientists, academia, former program managers, and international organizations) will review, discuss and validate the summary document and discuss implications and next steps, including the role the document will play in the future, coordination strategies and other coordination topics, and promotion of findings. The workshop will be held in early 2007.

Written Report; Promotion of Outcome

A written report containing the summary document and workshop findings will be released at public events in Washington and at non-U.S. venues in addition to being circulated within space agencies. Papers summarizing the report will be given at IAC and other relevant conferences. ■

Eileen Galloway Honored on 100th Birthday

Friends and colleagues of Eileen Galloway gathered recently at her home in Washington, DC in honor of her 100th birthday. Dr. Galloway, often called "the grand matriarch of space law," played an influential role in the development of the NASA Act of 1958 and the Outer Space Treaty of 1967. She has been involved with the development of space legal codes since the day after Sputnik went up in 1957, and helped to establish the United Nations Committee on the Peaceful Uses of Outer Space. She continues to work in the field of international space law and serves on several committees and panels related to spaceflight. Dr. Galloway was elected an AAS Fellow in 1986 and has been a member of the Society for many years. ■

On behalf of the AAS, Ian Pryke, Vice President Public Policy, presents Eileen Galloway with an AAS Fellows pin and President's Recognition Award. (Source: Ian Pryke)

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Right Stuff, Wrong Sex: America's First Women in Space Program

Reviewed by Rick W. Sturdevant

Right Stuff, Wrong Sex: America's First Women in Space Program, Margaret A. Weitekamp. Baltimore: The Johns Hopkins University Press, 2004. 256 pages. ISBN: 0-8018-7994-9 (hardback); 0-8018-8394-6 (paperback). $45.00 (hardback); $25.00 (paperback).

Recipient of the AAS 2004 Eugene M. Emme Award for Astronautical Literature, Margaret Weitekamp's *Right Stuff, Wrong Sex* contributes mightily to filling a void in the historical literature on the earliest days of human space flight. While not the first monograph on American women as astronaut candidates during the early 1960s, it nonetheless surpasses in narrative scope and analytical depth such previously published volumes as *Amelia Earhart's Daughters* (1998) by Leslie Haynsworth and David M. Toomey, *Tethered Mercury* (2001) by Bernice Trimble Steadman and Jody M. Clark, *Space for Women* (2002) by Pamela Freni, *Promised the Moon* (2002) by Stephanie Nolen, *Women Astronauts* (2002) by Laura S. Woodmansee, *Almost Heaven* (2003) by Bettyann Holtzmann Kevles, and *The Mercury 13* (2003) by Martha Ackmann. While Weitekamp's prize-winning book is predictably not the final word on this long-neglected chapter in women and space, it certainly challenges future researchers and writers by setting the bar several notches higher.

Ninth in The Johns Hopkins University Press series on Gender Relations in the American Experience, *Right Stuff, Wrong Sex* explores how the personal and business relationships among Dr. William Randolph Lovelace, renowned pilot Jacqueline "Jackie" Cochran, and her financier husband Floyd Odlum led to the Woman in Space Program within the context of the Cold War and the flourishing women's aviation culture of the late 1950s. The author explains how pilot Geraldine "Jerrie" Cobb, the first woman to undergo astronaut testing, unsuccessfully sought public and political support for the program. She describes how Vice President Lyndon Johnson's secretive opposition, combined with NASA's and, surprisingly, Cochran's statements during congressional hearings in July 1962 resulted in the Woman in Space Program's abrupt cancellation. This effectively denied women any opportunity to become astronauts in America's space program for a generation.

In addition to doctoral dissertations and published secondary works, Weitekamp delved into many previously untapped or under-utilized sources to explain the historical linkage from female pilots during the 1930s to women in uniform during World War II, thence to postwar women's aviation, the U.S. Air Force Air Research and Development Command's Project WISE (Woman in Space Earliest), and onward to the privately funded Woman in Space Program. Several women who participated in Lovelace's program consented to interviews with the author or generously supplied copies of original correspondence, newspaper clippings, and magazine articles about the program. Oral history collections at Columbia University in New York City and at the University of New Mexico's Medical Center Library in Albuquerque proved invaluable. Formal archives at the Smithsonian Institution's National Air and Space Museum, the NASA Headquarters History Office, the John F. Kennedy and Lyndon Baines Johnson Presidential Libraries, and several smaller, lesser-known repositories furnished unanticipated details.

One generally can find things to nitpick in a publication, and Weitekamp's book is no exception. Some readers might think she takes too long getting to the crux of her story. A handful will notice that she misunderstands or misinterprets the etymology of the "aerospace" term. Others could focus simply on errors that resulted from inadequate proofreading. Particularly disingenuous souls might even quibble with her feminist inclination and argue that it caused her to perceive the Woman in Space Program as inevitably doomed from the beginning. This reviewer would vehemently oppose voices in this last category, because *Right Stuff, Wrong Sex* presents a well documented, skillfully crafted perspective on the stifling political, social, and cultural milieu in which thirteen aspiring female

Continued on page 22

Ryerson University and the University of Kansas Take Top Honors in 2006 CanSat Competition

The second annual Design/Launch/Build Student CanSat Competition was held June 2-4 at Great Meadow, The Plains, Virginia. In order to experience a hands-on space program at an affordable cost, student teams had to build a payload the size of a twelve-ounce soda can for launch via rocket to an altitude of 2,000 feet. The mission required that the payload determine its altitude, range distance from deployment to landing, direction of travel and temperature. This data was both recorded and transmitted real-time to a ground station. Each team was also required to write a mission proposal, generate design documentation and present a comprehensive post-mission debrief.

The student CanSat team from Ryerson University, located in Toronto, Canada, took home the $2,500 first place prize in the Undergraduate Category, with Ohio University winning the $1,500 second place prize and the University of Kansas getting third place with $1,000. A second team from University of Kansas was honored with the $2,500 first place prize in the Advanced Category.

Conditions on the field were challenging, with stiff winds causing the payloads to drift away from the field. GPS data helped most teams recover their CanSats, and those using the smallest parachutes tended to land at a more reasonable distance from the launch site. However, with the rural setting of this year's event, most students (and volunteers) got a chance to get up close and personal with farm fields, cattle, trees, brush and water.

After a working for a semester or more at completing their projects, the student teams were glad to finally launch their CanSats and test the effectiveness of their designs. Although not every team could finish first at this unique and challenging competition, the judges were tremendously impressed by the caliber of the both the CanSats and the students, and felt that each team successfully accomplished their mission requirements.

The 2006 competition was organized by the AAS, the American Institute of Aeronautics and Astronautics, and sponsored with generous financial and volunteer support from NASA Goddard Space Flight Center, the Jet Propulsion Laboratory, Naval Research Laboratory, Swales Aerospace and Orbital Sciences Corporation. Photographs of the competition can be viewed at www.cansatcompetition.com. For sponsorship opportunities for the 2007 competition (location and dates TBD), contact the AAS business office. ■

ABOVE: *University of Ohio team with their "custom" tracking antenna.*
BELOW: *University of Michigan students with one of the rockets. (Source: Thomas Flatley)*

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American Astronautical Society

NASA's Underlying Depression?

The space shuttle program is drawing to a close. The ramifications of this fact are already being felt in the shuttle workforce, which shows some signs of growing pessimism and disillusionment. If the Vision for Space Exploration is to succeed, NASA's senior managers must do all the can to reverse this disturbing trend, keep the shuttle program focused on safe flight, and do a better job of capturing the important lessons of the shuttle era while building the next generation of vehicles.

by Roger D. Launius and Dennis R. Jenkins

There appears to be a disturbing trend within the workforce on our largest national space programs. In the more than three years since the *Columbia* accident, excitement and dedication that has traditionally permeated the program has, in too large a measure, been replaced by foreboding and concern. Many of the mid- to upper level engineers and managers that we routinely speak with have noted this trend, although from the outside it appears to have escaped the notice of senior management at NASA's Headquarters and Centers.

Some of this is understandable. NASA's major human spaceflight program, the space shuttle, has a well known and publicized end date – 2010 – and even if it slips a few years no one doubts that the program's end is near. A sustained and underlying depression cannot help but affect those who have been working in the program, some of them for their entire careers. The tragic loss of *Columbia* on February 1, 2003, was difficult enough. Like the *Challenger* accident in 1986, we have friends associated with the shuttle program who experienced an underlying depression permeating all of NASA in the aftermath of this accident. The pall of depression about this loss has burrowed into the marrow of NASA's workforce. Nonetheless, the shuttle workforce steeled itself and tried to overcome the overwhelming feeling of tragedy and failure. Couple this with the difficulties of return-to-flight and a true sense that the program is destined to end sooner rather than later, and the result is a workforce in a difficult, even desperate, situation.

This sense of ending, as well as an ever-present perception of loss and failure, may prompt many key staff to depart the space shuttle program as soon as practicable. To prepare for this inevitable ending, and to ensure preservation of as much technical knowledge as possible, several studies have urged NASA to take action to secure the inevitable brain-drain as experienced workers secure jobs elsewhere, but the agency and its contractors have not implemented a policy to reassure these essential personnel. A similar dilemma faced the Air Force and Lockheed Martin at the end of the Titan program—how to ensure that sufficient experienced personnel remained to launch the last vehicle. The Air Force took several initiatives, ranging from making sure that everybody knew the schedule and process to get to the end, to authorizing substantial monetary bonuses for those that remained through the last launch, to gathering program documentation in one location, to guaranteeing jobs on other programs after Titan ended. By all accounts that process worked well.

> "As the space shuttle program enters its home stretch, it should be remembered with both praises for its many accomplishments and criticisms for its shortcomings."

NASA has not embraced this approach, at least as yet, and the space shuttle program is proceeding largely with business as usual. The younger engineers and technicians are beginning to worry and look for jobs elsewhere. More senior people are already moving to the various new-development programs within NASA's Exploration Systems Mission Directorate. The uncertainty about future jobs is exasperated by the morale-sapping delays being encountered during the return-to-flight efforts. At some point this migration of experienced personnel will adversely affect the ability to launch the last of the projected 19 space shuttle missions.

Not that Exploration offers a panacea for those going there. To many senior people, the Exploration programs still seem tentative, as if they might disappear at any moment. Part of this is the distinct lack of support shown by the White House; other than the January 14, 2004, speech that began the return to the Moon, President Bush as not mentioned space exploration in any major way. The continual reshuffling of the designs for the Crew Exploration Vehicle (CEV) and Crew Launch Vehicle (CLV) give the impression that NASA is struggling to meet budgetary constraints. Admittedly, many of the changes are part of the normal engineering trade-off studies conducted as any major program begins, but an air of uncertainty surrounds them that is difficult to quantify and even harder to accept. And to many, the entire concept of beginning a major program already significantly over the expected budget makes little sense and is certain to drive undesirable solutions to complex technical issues.

Amid the glow of lights from the fixed and rotating service structures, Space Shuttle Discovery rests on the hardstand of Launch Pad 39B at NASA's Kennedy Space Center after completing the 4.2-mile journey from the Vehicle Assembly Building in preparation for STS-121. As the sun begins to set on the shuttle program, the challenge is to maintain the high levels of excellence needed to safely fly out the program while capturing important lessons learned for future programs. (Source: NASA)

This is not to imply that there are not still large numbers of knowledgeable and well-motivated people doing meaningful work. Although significantly behind the original internal schedules, the necessary requirements and specifications for the CEV and CLV are progressing toward a major review later in 2006. These documents attempt to quantify the lessons learned from the space shuttle, although the disdain publicly shown by NASA leaders toward shuttle makes it harder for engineers to both accept and use it as a good example, which in many ways it was. The characterization of the NASA administrator that the shuttle was a "mistake" that has haunted the Agency for more than a generation suggests that those working on the program are also degraded and unworthy of preservation. Even so, the space shuttle, for all of its faults, completed its development activities only 17 percent over budget. This was a remarkable achievement for such an advanced program.

The current challenges with the space shuttle, on the other hand, seem much harder to grasp. Some parts of the program seem to be looking for excuses not to fly. In this sense officials in the program need to be careful. Harrison Storms, the legendary head of the Apollo spacecraft program for North American, Inc., once observed: "There is a very fine line between stopping progress and being reckless…[and] the necessary ingredient in this situation of solving a sticky problem is attitude and approach. The answer, in my opinion, is what I refer to as 'thoughtful courage.' If you don't have that, you will very easily fall into the habit of 'fearful safety' and end up with a very long and tedious-type solution at the hands of some committee. This can very well end up giving a test program a disease commonly referred to as 'cancelitis,' which results in little or no progress." This seems to be the situation that the space shuttle program presently finds itself in.

The end of the space shuttle program is in sight. Without question, the vehicle will be retired within something less than a decade. To do so seamlessly will require resolve, ingenuity, and a valuing not only the next human launch system and its development team but also the longsuffering and venerable shuttle program and workforce. Preserving the knowledge and many of the personnel associated with a generation-long complex reusable spaceflight system will not be easy. Valuing the workforce's efforts and sacrifice is one step in the right direction. Seeking to raise morale and ensuring the transition of a vital core of the workforce is another.

As the space shuttle program enters its home stretch, it should be remembered with both praises for its many accomplishments and criticisms for its shortcomings. At sum, it remains the only vehicle in the world with the dual capability to deliver and return large payloads to and from orbit. The design, now more than three decades old, is still state--of-the-art in many respects, including computerized flight controls, airframe design, electrical power systems, thermal protection system, and main engines. It is also the most reliable human launch system now in ser-vice any-where in the world, with a success rate of more than 98 percent.

At the same time, it is extremely expensive to fly and has been unable to deliver on its promise of routine access to space. Costing between $400 million and $1 billion for every flight, the shuttle program should be replaced by a modern launch system that everyone believes will be both more eco-nom-ical and safer. That does not mean that the program was a mistake, or that its workforce has no value. We must recognize this fundamental reality, and seek to mitigate NASA's underlying depression arising in the aftermath of the *Columbia* accident and the demise of the shuttle program.

The inability of the space shuttle to meet the nation's long-term space launch needs is not a recent development, and has been acknowledged since at least 1990 when the Presidentially-appointed *Advisory Committee on the Future of U.S. Space Programs*, headed by Martin -Marietta CEO Norman R. Augustine, commented on the future challenge of space access. Augustine's report stated that "the most significant deficiency in the nation's future civil space program is an insufficiency of reliable, flexible, and efficient space launch capability." The commission recommended moving out on transitioning to a new space vehicle by 2000. In the intervening years little has been accomplished toward achieving that goal.

Perhaps journalist Greg Easterbrook said it best, writing eloquently about the significance of the space shuttle in *Time* just after the *Columbia* accident:

A spacecraft is a metaphor of national inspiration: majestic, technologically advanced, produced at dear cost and entrusted with precious cargo, rising above the constraints of the earth. The spacecraft carries our secret hope that there is something better out there—a world where we may someday go and leave the sorrows of the past behind. The spacecraft rises toward the heavens exactly as, in our finest moments as a nation, our hearts have risen toward justice and principle.

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It is now time for NASA and the larger aerospace community to give the space shuttle an honorable retirement and to thank those charged with its operations for their efforts. NASA must also ensure that the knowledge and expertise gained in the shuttle program is preserved and used for the future. ■

Roger D. Launius is Chair of the Division of Space History at the National Air and Space Museum in Washington DC, former chief NASA historian, and a frequent contributor to _Space Times_.

Dennis R. Jenkins has worked in the space shuttle program for over twenty years in a variety of technical and managerial positions. He was a technical consultant to the _Columbia_ Accident Investigation Board and is the author of numerous books on aerospace history, including Space Shuttle: _The History of the National Space Transportation System: The First 100 Missions._

Since the flight of Freedom 7, one thing sure *hasn't* changed: Having the 'green stuff' is just as important as having the Right Stuff. Even today's most advanced scientific, technological, and human capabilities will still only take you so far without adequate capital resources, optimally structured. As we enter this next phase of manned space exploration, we look forward to helping you—the industry elite—reach escape velocity...once again.

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Space Times Article Submission Guidelines

We accept feature articles (1500-3000 words), op-eds (500-1500 words), and book reviews (600 words or less). Exceptions to these lengths may be possible and should be discussed with the editor. The editor and author will agree on a length at the time an assignment is made.

Articles can cover virtually any topic involving space science, technology, exploration, law, or policy. We welcome articles that touch on issues relevant to the civil, commercial, and military and intelligence space sectors alike.

Articles should be written for a well-educated audience that has great interest in space topics but may not necessarily be familiar with your specific topic.

We are a magazine, not a technical journal. Articles should be written in active voice and should explain technical concepts clearly. Tone should lean more toward conversational rather than stiff and formal. We do not include references with articles.

Deadlines occur six to seven weeks before the first month of the issue in question (e.g., ~Jan. 15 for the March/April issue). Exceptions are possible if discussed with the editor.

Articles should be submitted in Microsoft Word format, Times New Roman font. No need to worry about other formatting specifics – we'll take care of the rest in the editing process.

Authors should provide with their articles: a title, a "subtitle" of one or two sentences summarizing the idea of the article, sub-heads within the article that provide separations between the major sections of the article, and an author biography of one to two sentences to appear at the end of the article. You should also send a mailing address so we can send you complimentary copies of the issue in which your article appears.

Authors are encouraged but not required to submit photos or other visual supports for their articles. Suggestions for photos or visuals are also welcome. Photos need to be of high resolution (at least 300 dpi) and can be in JPG, TIF, or GIF formats. We must receive permission from photo owners to use photos, so please provide proof of permission or contact info for the photo owner if you haven't already secured permission.

A few style pointers:

- Units of measurement should be conveyed in metric, not English, terms.
- Acronyms should be used sparingly, and only when a term is used several times.
- Names of specific spacecraft (e.g., *Columbia*) should be italicized. General spacecraft names (e.g. space shuttle, Delta) should not.
- Numbers one through one hundred should be spelled out.

Contact: Jonathan Krezel, editor (jonathan.krezel@gmail.com).

Right Stuff, Wrong Sex

Continued from page 16

astronauts found themselves during the late 1950s and early 1960s.

Ironically, as Weitekamp observes, women stood a better chance of serving aboard spaceships during the late 1940s and early 1950s when such travel remained in the realm of science fiction. As spaceflight became a reality, the portals closed to American women and remained locked until NASA's selection of the first group of female astronauts in 1978, even then only as mission specialists. Not until 1983 did Sally Ride become the first American woman in space, and not until 1995 did Eileen Collins become the first American woman actually to pilot a spacecraft. Nonetheless, as *Right Stuff, Wrong Sex* makes clear, physiological and psychological testing of women pilots under Lovelace's Woman in Space Program in the early 1960s demonstrated their equality with, in some cases superiority over, the performance of male candidates. Anyone interested in the historical relationship of women, gender, and space should consider this book mandatory reading. ■

***Rick W. Sturdevant* is Deputy Command Historian, HQ Air Force Space Command and a member of the AAS History Committee.**

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In Memoriam

Robert O. Aller, 76, a NASA administrator who held high-level positions in the Gemini, Apollo and space shuttle programs, died on May 17. Mr. Aller, who was awarded two NASA Exceptional Service Medals, left the agency in 1989 and worked as a consultant for several years. He was a longtime AAS member, Fellow, and received the AAS Space Flight Award in 1989. He had lived in Rehoboth Beach, Delaware, since 1993. Survivors include his wife of 53 years, Nancy Aller of Rehoboth Beach, two daughters, a sister, and nine grandchildren.

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