VOLUME 4 ISSUE 1 WINTER 2010

Rendezvous

Where today meets tomorrow

Onward & Upward

T&R Progress Report:
An overview of this fall's transition and retirement activities across NASA.

Space Generations — Emerging Leadership:
As the shuttle retires, the next generation is stepping forward to take the reins of the future.

Moving Forward: Orion Rising
Constellation's designs for the future are fast becoming reality.

Protecting A Culture of Safety:
How Bob Doremus and his Safety & Mission Assurance team make sure each remaining shuttle mission is as safe as humanly possible.

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TRANSITION & Retirement

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http://rendezvous.jsc.nasa.gov

October 28, 2009 — The Ares 1-X test rocket blasts off Launch Pad 39B at Kennedy Space Center in Florida while Atlantis waits in the foreground on Launch Pad 39A.

From Leadership

For many of us, a new year doesn't really hit us until we date our first check of the year or open a brand new appointment calendar. But this year is different. It's not just any old new year. It's the end of a dramatic decade. And for us, it's the last year for shuttle.

Now, in early 2010, there's no ignoring the fact that transition is being implemented across the Space Shuttle Program, and that it's affecting us and our colleagues. It's our current reality. But while we still have many post stand-down unknowns to address, we still have five missions to execute safely, efficiently and successfully.

This is the most important charter of our space program careers. Paying attention to every detail and keeping safety at the forefront of our focus are critical at this juncture. If we don't complete the shuttle manifest, we won't be able to explore. It's that simple.

When we stop for a moment and consider what we've done in the last three decades, it's clear that we've enjoyed a long and productive program. We have a right to be proud of the shuttle's considerable accomplishments and be excited at the promise of returning to the moon and exploring beyond low Earth orbit.

Closing down our program at the end of this year is a bittersweet prospect. But we're not finished yet. Our challenge is to see this through like the pros we are, keep our eyes firmly on the ball and savor every moment of our remaining missions.

The shuttle program is ending because, when the last flight lands, we will have achieved our mission. We will have done what we set out to do back in 1981 with STS-1. We were, and are, successful, and no one in the world was better prepared or qualified to do what we have done.

In fact, in many ways, our program is the most successful program in the history of Human Space Flight. Now *that's* saying something.

Be proud. You deserve it.

Dorothy Rasco
Manager, Space Shuttle Business Office
SSP T&R Lead
Johnson Space Center

From the Editor

Wow. 2010. As Dorothy Rasco said in her leadership message, this is not the same old new year. A full decade has passed since it seemed that the whole world held its breath as the clocks ticked past midnight on Dec. 31, 1999. At this time ten years ago, the program was between missions. The STS-103 mission had landed a couple of days before the new year, successfully concluding the third Hubble Space Telescope repair mission. And STS-99, scheduled to launch on Jan. 31, 2000, was up next.

Ten years and 33 missions later, we're looking at the last year of our shuttle program. Five more missions and we're done.

On one hand, we feel sad because the Space Shuttle Program has been a career for many of us. But on the other hand, there's the excitement of moving on to something new. So in this issue of *Rendezvous* we're talking about what's now, what's coming up and what comes after that.

In "T&R Progress Report," the items are less about the retirement and disposition of shuttle assets and more about the milestones rapidly appearing in Constellation's rearview mirror. In "Space Generations: Emerging Leadership," the second of our three-part series examining the differences between generations in the shuttle workforce, we look at the generation that started their careers in the 1990s and how they're dealing with their program's imminent close.

In "Moving Forward: Orion Rising," *Rendezvous* sat down with Mark Geyer, Orion project manager, to talk about the crew exploration vehicle's journey from paper to prototype to reality. And in "Protecting a Culture of Safety," Bob Doremus, manager of the shuttle program's Safety and Mission Assurance office, reminds us that safety always comes first. Especially right now.

You may notice that we've replaced our "Weighing In" column with a piece titled "Web Site" that details the features of the *Rendezvous* Web site and the various T&R information tools you'll find on it. It's designed not only as a shuttle workforce resource and a forum for discussion, but also as a repository for shuttle memories. We encourage you to visit it soon and often.

So it's 2010 and time to keep our focus on our remaining missions, but also set our sights on the future. Or as we say on this issue's cover, "Onward & Upward."

Wow.

T&R

Progress Report

An overview of this fall's transition and retirement activities across NASA.

"Ares I-X provides NASA with an enormous amount of data that will be used to improve the design and safety of the next generation of American spacefilght vehicles — vehicles that could again take humans beyond low Earth orbit. "

— Doug Cooke, associate administrator for the Exploration Systems Mission Directorate at NASA Headquarters

Pictured Above: The Ares I-X test rocket produces 2.96 million pounds of thrust at liftoff and reaches a speed of 100 mph in eight seconds.

X Marks the Spot: Ares I-X Flight Test Takes Off

NASA is one step closer to achieving the exploration goals of returning to the moon and eventually traveling to Mars and points beyond.

NASA's Ares I-X test rocket launched on Oct. 28 from the newly-modified Launch Complex 39B at NASA's Kennedy Space Center. It was in flight for approximately six minutes before the booster stage splashed down in the Atlantic Ocean, nearly 150 miles from Kennedy.

"This is a huge step forward for NASA's exploration goals," said Doug Cooke, associate administrator for the Exploration Systems Mission Directorate at NASA Headquarters. "Ares I-X provides NASA with an enormous amount of data that will be used to improve the design and safety of the next generation of American spaceflight vehicles -- vehicles that could again take humans beyond low Earth orbit."

The Ares I-X test vehicle simulated the actual Orion and Ares I vehicle systems by integrating a combination of proven spaceflight hardware with mockups of other Ares I components. The vehicle was powered by a single, four-segment reusable solid rocket booster fitted with a fifth inactive segment to simulate the Ares I five-segment booster. The test vehicle was also outfitted with mockups of the upper stage, the Orion crew module and the launch abort system, which separated from the first stage and fell into the Atlantic Ocean as planned during the test. A malfunction with two of its main parachutes led to some damage to the booster, however, after it hit the water at higher-than-planned speeds.

The first stage booster performed through a complete recovery sequence, releasing its Ares I prototype three-stage parachute recovery system, falling safely into the ocean and floating until the hardware was retrieved by recovery personnel for inspection and analysis.

The primary test objectives for the Ares I-X flight were to demonstrate the flight control system performance during ascent as well as to gather information that will aid engineers in better understanding how to control the Ares I system's in-flight roll torque, which is what causes the rocket to rotate. Additionally, the test demonstrated the flight environment during stage separation. This helps engineers better understand any possible effects on the future Ares upper stage J-2X engine. It also provided opportunities to test assembly and processing activities, launch and recovery operations and the first stage parachute recovery system.

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The Ares I-X test is just one part of a larger flight test program. Additional future tests include three tests of the Orion launch abort system to be conducted between 2010 and 2012, a follow-on to the Ares I-X test called the Ares I-Y test and a test combining both the launch vehicle and spacecraft, called Orion 1, which is scheduled for 2015.

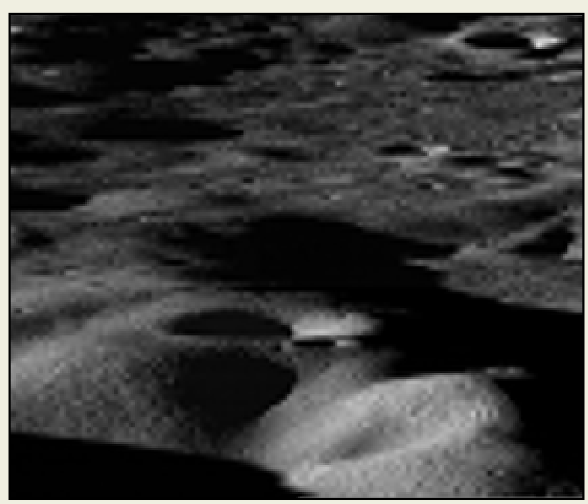
More information on Ares I-X is available at: http://www.nasa.gov/mission_pages/constellation/ares/flighttests/areslx/index.html.

Lunar Dowsing

To the world watching the morning network news shows on Oct. 9, the dual impacts of the Lunar Crater Observation and Sensing Satellite (LCROSS) and its launch vehicle's spent upper stage into the moon's Cabeus crater barely registered. Indeed, the NASA TV image of the moon broadcast across the nation showed no apparent evidence that impact had occurred. But to scientists at NASA's Ames Research Center in Moffett Field, Calif., the impacts generated a tidal wave of data to be analyzed by an eager team.

More than a month later, that data bore fruit – or, more accurately, water.

The Cabeus crater is a permanently shadowed region located near the moon's south pole. It was an educated guess on the part of Ames scientists that if there was evidence of water on the moon it would most likely be found in the bottom of a crater that hadn't seen sunlight in billions of years.



The Cabeus crater near the moon's south pole hasn't seen sunlight in billions of years.

"Multiple lines of evidence show water was present in both the high angle vapor plume and the ejecta curtain created by the LCROSS Centaur impact," reported Anthony Colaprete, LCROSS project scientist and principal investigator.

According to Colaprete, the permanently shadowed regions of the moon are "cold traps" that collect and preserve material over billions of years. Water ice discovered at the perpetually dark lunar poles could be more widespread, in greater quantity and billions of years old, which means it could shed a great deal of light on the history and evolution of the solar system.

And if the science of the discovery isn't enough to excite you, consider the implications for exploration: Water is a key ingredient in the agency's plans to eventually live off the land and establish a long-term home on the moon. In addition, the hydrogen and oxygen that water contains could also be used to fuel rockets and save weight in launches from Earth's surface.

Resource Extraction Via Kitchen Appliance

In the form of billions-of-years-old ice, the water discovered in the moon's craters isn't of much use. Luckily scientists at NASA's Marshall Space Flight Center in Alabama have devised a way to melt it.

Dr. Ed Ethridge holds his "moon in a bottle" experiment in his lab at Marshall Center.

In the culmination of a five-year study on how to extract water and unstable gases from the lunar surface, the Research Opportunities in Space and Earth Sciences, or ROSES, project at Marshall was able to cook water out of regolith, or moon dust, using a one-kilowatt microwave oven. NASA Scientist Dr. Edwin Etheridge, principal investigator for the project, and his team used a conventional microwave and lunar soil simulant in the experiment.

The extracted water can be used to meet human needs at a lunar outpost or split into hydrogen and oxygen to be used as a fuel or an oxidizer. Both uses make the moon a more viable test bed for space exploration, according to Etheridge.

"We found that if we could extract two grams of water ice per minute, we could collect nearly a ton of water per year," Etheridge reported. According to the In-Situ Resource Utilization (ISRU) Development and Planning Team, that would be enough to meet the needs of the initial manned lunar outpost.

Extra Push for Ares I

Another successful hot-fire test of the ullage settling motor – the second test in this series – was conducted on Oct. 8 at Test Stand 116 in Marshall Space Flight Center's East Test Area. All test objectives were met, wrapping up the first round of development testing for this critical element of the Ares I rocket.

The word "ullage" is taken from the French term "ouillage," which is used in winemaking to describe the space between wine and the top of a storage container. At NASA, however, it refers to the space at the top of the first stage fuel tank and the need to push the fuel, or settle it, to the bottom of the tank.

The ullage settling motor is a small solid rocket motor that serves two key roles during the launch of the Ares I rocket. During first stage separation, which occurs 125.8 seconds into flight, the motor will fire for 4 seconds, producing the forward thrust needed to push the second, or upper, stage away from the first stage. This forward thrust also ensures the rocket's liquid fuel is properly pushed to the bottom of the upper stage fuel tank prior to ignition of the J-2X engine that powers the upper stage.

The ullage motor is the first small motor to be designed, developed and tested at Marshall in decades. The ullage team includes Marshall engineers, Alliant Techsystems and the U.S. Army's Aviation and Missile Research, Development and Engineering Center at Redstone Arsenal in Huntsville.

Engineers at NASA's Marshall Space Flight Center in Huntsville, Ala., completed the first round of development testing on the ullage setting motor for the Ares I rocket.

NASA and engineering support contractors completed a demonstration test of the main parachute test equipment for the Orion crew exploration vehicle Oct. 2 at the U.S. Army's Yuma Proving Grounds in Yuma, Ariz.

Chutes, Chutes and More Chutes!

In early October, the skies above the U.S. Army's Yuma Proving Grounds in Arizona were filled with parachutes. Testing was conducted on the parachute systems for both the Orion crew exploration vehicle and the Ares I rocket, so teams from both Johnson Space Center and Marshall Space Flight Center were present.

The Ares I test was the first in a series of three designed to place 100 percent of the flight dynamic pressure on the parachute canopy. The Ares I recovery system uses parachutes similar in design to the shuttle's solid rocket booster chutes. Redesigned to accommodate the requirements for the Ares I first stage, the main chute measures 150 feet in diameter and weighs a ton, literally. It is the largest rocket parachute ever produced and is the main element of the Ares I's deceleration and recovery system. Overall, this test series was the ninth test of the Ares I parachute recovery system. Alliant Techsystems is the prime contractor for the first stage booster and United Space Alliance is responsible for the design, development and preliminary testing of the parachutes at the company's facilities at Kennedy Space Center.

The October test of the Orion parachute recovery system dropped a 20,700 pound weight tub from a C-130 to simulate the dynamic environment the actual test vehicle will experience when it is extracted from an aircraft at an altitude of 20,500 feet. A second test took place in December and another is scheduled for this year. These tests focus on better understanding the wake effects of the programmer parachute.

Testing on the Orion pilots, drogues and main parachutes is scheduled to begin in late 2010 and continue through 2014. Johnson Space Center leads the design of the crew exploration vehicle recovery system, and the Houston division of Jacobs Technology, in conjunction with Airborne Systems of Santa Ana, Calif., is designing, developing and testing the chutes at the Yuma Proving Grounds in Arizona.

A-3 Test Stand Tank Installations Move Forward

With the mid-fall delivery and installation of 14 water, isopropyl alcohol and liquid oxygen tanks, the A-3 Test Stand at NASA's Stennis Space Center passed another milestone. After the installation of all 14 tanks, the focus then turned to the delivery and installation of the test cell diffuser, which also began late 2009 and is scheduled to be complete by spring 2011.

The A-3 Test Stand at Stennis is a major project for NASA. The purpose of the A-3 stand is to provide high-altitude testing on the J-2X engine, which is currently in development.

The completion of the stand will bring a unique capability to Stennis. The installation of the tanks will support the chemical steam generators on the test stand. The steam produced by the generators is used to reduce pressure inside the test cell diffuser, allowing engineers to simulate altitudes up to 100,000 feet. That will ensure that the J-2X engine will start in space, which is crucial for the Constellation Program and NASA's plans to venture beyond low Earth orbit.

A 35,000-gallon liquid oxygen tank is installed near the A-3 Test Stand under construction at Stennis Space Center.

Construction is underway at Michoud Assembly Facility where Broadmoor is building the production facility for Ares I Upper Stage final assembly operations.

A New High Bay Rising at Michoud

Construction has begun on the structure that will serve as the production facility for Ares I upper stage final assembly operations at Michoud Assembly Facility. This new vertical assembly and weld high bay facility will stand 160-feet tall when it is completed in October.

Broadmoor of Metairie, La., was awarded the $22 million contract, which is the first major construction subcontract effort under the new manufacturing support and facility operations contract, under which Jacobs Technology officially took operational control of Michoud in July. Broadmoor will also make $4.3 million worth of modifications that support upper stage manufacturing robotic weld tools, as well as the facility's machining center. The construction for these modifications is scheduled to be complete in May.

Creating Fuels of the Future

Engineers at NASA's Johnson Space Center and White Sands Test Facility have collaborated with Dallas-based Armadillo Aerospace to design and test a rocket engine that runs on liquid oxygen and liquid methane for use on the moon or other extraterrestrial surfaces. Armadillo Aerospace built the engine, Johnson designed the nozzle and provided oversight on the project, while White Sands provided the testing facilities.

The countless hours of hard work resulted in an engine that runs on propellants that are cheaper and safer on Earth, but also have the potential of being manufactured on the moon and even Mars. Since the Apollo program, NASA has used hypergolic propellants, which ignite when mixed together and are both convenient and dependable. However, hypergolic propellants are heavy, expensive and toxic. So NASA has been actively searching for other options for more than a decade. One of those options is a combination of liquid methane and liquid oxygen.

The liquid oxygen/liquid methane engine, developed by Armadillo Aerospace with help from NASA through an Innovative Partnership Program agreement, was tested in the vacuum chamber at NASA's White Sands Test Facility.

Cryogenic liquid methane and liquid oxygen have many advantages: They are 10- to 20-times less expensive than hypergolic propellants. They also weigh less, which is important because every pound of weight carried into space requires 15 pounds of fuel to send it there. And the best news for the astronauts is that the new fuels are nontoxic, so they won't have to worry about it contaminating their spacesuits while performing spacewalks.

A team at NASA is already hard at work developing reactors that have the ability to convert moon dust into oxygen and create methane from the Martian atmosphere. These methods show great potential in further reducing the amount of propellants that are carried into space.

Ares I-X arrived at Launch Pad 39B on October 23, 2009—the first time since the Apollo Program that a vehicle other than the space shuttle has occupied a launch pad at NASA's Kennedy Space Center.

Kudos

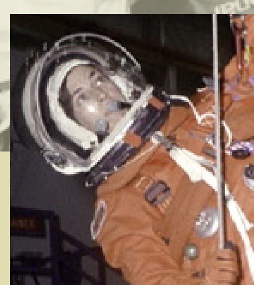
In November, Time magazine named the Ares I rocket the Best Invention of 2009, joining YouTube (2006) and the iPhone (2007) among the ranks of inventions honored. The magazine called the rocket a "worthy descendent" of past vehicles and described the Ares I-X test flight as "dazzl[ing] even the skeptics."

Other specific elements of the Constellation architecture were also honored elsewhere. In Popular Science's Best of What's New awards issue, the Orion Launch Abort System won in the aviation and space category. The magazine also recognized NASA's revolutionary planet-hunting Kepler space telescope, as well as the Lunar Reconnaissance Orbiter moon-mapping mission. The Kepler took home the Grand Award. The Kepler telescope also won Popular Mechanics magazine's 2009 Breakthrough Award.

Space Generations

Emerging Leadership

As the shuttle retires, the next generation is stepping forward to take the reins of the future.



Lifting 4.4 million pounds of metal and fuel off the ground is no small task. And doing it several times a year over the course of nearly three decades is even tougher. Accomplishing this phenomenal task, along with the countless other achievements of the Space Shuttle Program, takes the collaborative effort of a highly skilled workforce. With this group in mind, *Rendezvous* is taking a look at the men and women who have worked together over the last 30 years to make the program such a tremendous success.

In our last issue, we looked at the seasoned veterans of the Space Shuttle Program and how transition is affecting them. Now we turn our focus to the generation of workers who find themselves in the middle. With about half of their careers ahead of them, the program's mid-career workers have had the benefit of working under our seasoned veterans through the majority of a highly successful program. Now they find themselves approaching the second half of their careers, where they'll transition not only out of the shuttle program, but also into the role of veteran as we build the new program.

NASA: The Next Generation

Never before has the NASA workforce had such broad generational diversity in its ranks. The workforce is comprised of four different generations – in many of today's industries it is not uncommon to find Veterans (or the Silent Generation), Baby Boomers, Generation Xers and Generation Yers all working together. The space shuttle workforce is no exception.

For the mid-career workforce, situated between the workforce veterans and the Gen Yers, transition is a double-edged sword. While it's tough to watch a program you've invested so much of your career in come to a close, it is also a time of excitement and rich potential. As the agency stands on the edge of this large-scale transformation that will affect the future of human spaceflight, the mid-level workforce finds itself next in line for the leadership role.

With changes on the horizon, each generation represented within the shuttle program has its concerns. The middle generation, comprised of both Baby Boomers and Gen Xers, has years of service already under their belts. But it's not just a matter of a job for them – many also have to consider mortgages, their family's needs and other factors.

"This group, more than any other, has a variety of impacts," said Sue Leibert, transition lead for Space Shuttle Program human capital. "Those in this middle generation have a variety of concerns, from retirement and kids in college to transitioning into new jobs and new careers."

Of the many points of impact, they all seem to stem from one concern right now.

"The biggest concern is that while we know we'll have a human spaceflight program, we just don't know what it is," Leibert said.

Having that one piece of the puzzle settled should allow all the others to fall into place. From there, plans and budgets can be made, and the future can be mapped out a little more clearly. Whatever the plan happens to be, though, many are still confident that there will be more opportunities to come.

"I've been here long enough to know that there is always going to be more exciting work to do," said Stephanie Stilson, NASA flow director for Discovery and member of the middle generation. "You can pretty much create your own opportunities out here. From the folks I have contact with, you see that. Everyone has a pretty positive attitude."

Kris Hoffman, a lead engineer for high pressure turbopumps on the space shuttle main engines at Pratt & Whitney Rocketdyne and another representative of the middle generation of the human spaceflight workforce, has that same confidence in future options after the shuttle retires.

"My plan was to keep working the program and just stay on as long as I can," Hoffman said. "And that really hasn't changed. My plan is still pretty much the same. I'm just keeping my eyes and ears open for future opportunities."

So far, so good

Even with their "variety of impacts," the mid-career generation is taking transition in stride. They continue to show dedication and focus to the program in its final year. As one of the primary goals of transition was to retain the critical skills needed to fly out shuttle, those managing transition couldn't be more pleased.

"This generation, like both of the others, seems to be handling transition really well," Leibert commented. "Considering the uncertainty, the dedication and focus is amazing. With this middle generation, there was a lot of concern that they were going to bail, but we have seen the opposite really. It really has been fantastic."

After all, this generation considers the space shuttle theirs. They weren't really around for Apollo and all of those historic firsts, but they rolled out the shuttle and plan to stay on through its final mission.

"My career plan has always been to stay with Discovery," Stilson said. "Hearing about the shuttle retirement didn't really change that at all. I want to be here through her last flight, and I want to be a part of the team that gets all of the orbiters to their final destination."

The needs of the workforce must also be addressed to help this generation get from the last mission to the next program, project or job.

However, a successful transition will not just be defined by the safe flyout of the shuttle manifest. The needs of the workforce must also be addressed to help this generation get from the last mission to the next program, project or job. For Leibert and those working the human capital element of transition, considering multiple points of view while addressing those needs has been a critical piece in making this transition a success.

"When you have 10, 11, 12 thousand people working shuttle and they all have 10, 11, 12 thousand different needs and motivations, you can't have a one-size-fits-all approach," Leibert noted. "All of our different approaches are tailored to where people are and what they need."

From the different NASA centers to their supporting contractors, everyone is doing what they can to prepare their workforce for the transition. An integral part of this is providing them with the tools and options they need based on where they are in their career life cycle.

"A lot of the retention plans centered around this generation to not only keep them flying the shuttle through wheels stop, but also to help them bridge to the next job or through a break in service," Leibert said. "These plans provide that safety net."

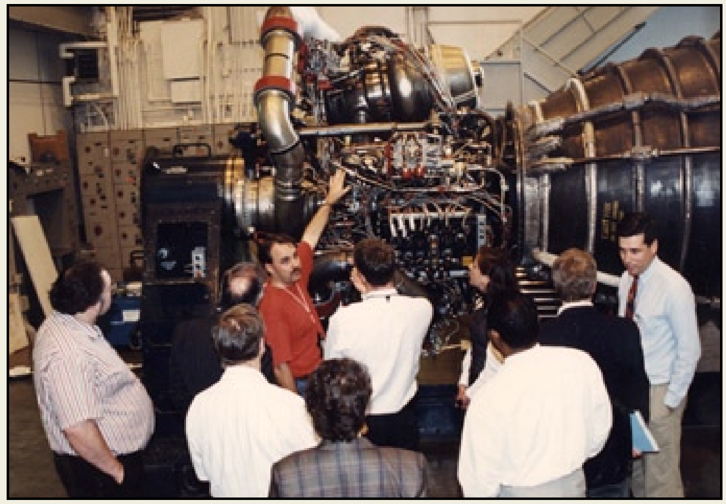
It seems to be working for most. Whether it is retention plans or other incentives, the program has been able to maintain the skills needed to successfully and safely fly the shuttle.

"I don't have anything to compare it to, but I'd grade transition pretty highly so far," Hoffman said. "Then again, the hard part is still to come."

To help prepare for what's to come, Hoffman has participated in motivational trips. These are opportunities for employees to head out to see a test firing or a launch and actually get to witness, first hand, their work in action. They're designed to give employees some encouragement as they face the hard part Hoffman mentioned.

Of course, much of what makes facing the future difficult at this point are the unknowns. With the Review of the U. S. Human Space Flight Plans Committee's report under consideration by the administration, waiting is proving to be one of the hardest parts. Program leaders hope that providing incentives and encouragement until plans are solidified will help in the meantime.

"From a 'what we can control' point-of-view, I think we're doing well," Leibert said. "The piece we can't control is the vision for the future. It's coming, so that will be a big help, but it's beyond our control right now. So we're focusing on the things we can control."



A Stennis Space Center engineer gives area VIPs a tour of the facility where space shuttle main engines are processed.

Communications

Another part of maintaining this critical portion of the workforce has been a dedication to timely, honest communication. Leibert and others handling the human side of transition understand that with so much at stake, members of the middle generations are looking for any information that's available. Even in the midst of some unknowns, open communication is a top priority.

"Recognize that we don't have the answers, but it won't be long until we do," Leibert said.

Leibert also urges … anyone concerned about transition to seek out information from management and to take advantage of all of the tools provided across the centers and contractors.

Leibert also urges not only this group, but anyone concerned about transition to seek out information from management and to take advantage of all of the tools provided across the centers and contractors.

"Talk to your supervisor," Leibert advised. "They'll tell you what they know when they know it."

That's advice Stilson has taken to heart.

"My director, Rita Willcoxon, sat down with each of her folks for a career face-to-face," Stilson said. "She walked me through what she thought

KSC will look like in the years to come and asked where I thought I best fit and where I'd like to end up."

Hoffman also takes advantage of the opportunities to speak with his management and prepare for transition. Twice a year, he takes part in Employee Engagement Dialogues, which offer an opportunity for employees to think about what they would like to be doing in the future and where they want to be after shuttle.

For the times between those conversations with supervisors, Leibert also pointed out that there are a number of other sources of information available.

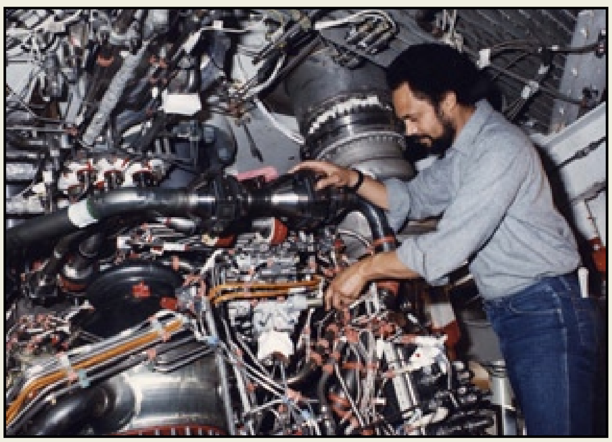
"Check out what's out there on the shuttle transition Web site, the Rendezvous Web site," she said. "And each center has transition Web sites now – at JSC we have the workforce transition site. There are a lot of tools out there to keep you informed and help you make decisions as we get closer to retirement."

The hope is that, one way or another, all the available information will be on hand when employees need it.

"What I've noticed with this transition is the effort to get everyone the information they need," Stilson noted. "I think management has done the best they can to convey the information they have to help us feel more confident."

Taking the reigns

The middle generation's contribution won't end with the shuttle program. With years of experience under their belt and years of work ahead of them, they'll have a vital role to play in the future of human spaceflight.



A technician performs maintenance on a space shuttle main engine to prepare it for testing.

"Every generation brings something important to the table," Leibert said. "The older generation brings all of that experience and dedication. The younger generation brings energy, enthusiasm and new ways of doing business. This middle generation brings that bridging function between why we did the things we did in the past, along with the knowledge of how to improve things in the future and the ability to teach those future generations."

Each member of this middle generation will bring aspirations and hopes for the future. For Hoffman, that vision is focused on exploration.

"I'd like to see us go back to the moon and Mars, and I'd like to be working on the engine for the launch vehicle that'll takes us there," Hoffman said.

That hunger and desire to explore more and to head back to the moon and beyond was ingrained in this generation by the one that preceded it. Coming of age in the midst of the space race and having the workforce veterans as their inspiration, this generation knows that the direction taken from here will be what inspires the next generation.

"We have all looked up to those folks and now we are becoming that older generation. I'm hoping we have that same effect on the younger generation," Stilson said.

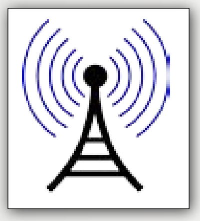
Maintaining this kind of leadership and passion has been one of the primary focuses of the transition effort. Not only are they critical to flying out the shuttle safely, but this middle generation will serve as the foundation that future human spaceflight endeavors will be built upon. Their experience, expertise and leadership are invaluable in the decades to come.

"These are the folks that are the building blocks," Leibert recognized. "They are the ones that have the critical skills and years of experience and will be around to teach the next generation. They are your transition."

Catherine Coleman, a member of the 1992 class of astronaut candidates at Johnson Space Center, gathers up a parachute.

Generation Timeline: The 1990's

As *Rendezvous* takes a look at the generations that comprise the shuttle workforce over a series of issues, we'll also look back at some of the events, shuttle-related and otherwise, that marked the path to where we are today.



1990 – The cellular communications industry introduced 2nd Generation, or 2G, digital technology, the predecessor to today's 3G technology.

April 24, 1990 – Hubble Space Telescope is launched during the STS-31 mission.

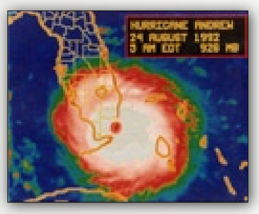
August 20, 1990 – President George H.W. Bush signs National Security Directive 45, triggering the start of Operation Desert Storm.

October 1990 – Microsoft Office for Windows 1.0 is released as a bundle of three applications — Microsoft Word, Microsoft Excel and Microsoft Powerpoint — forever changing the way the world does business.

August 6, 1991 – Tim Berners-Lee posted a brief description of the World Wide Web on the alt.hypertext newsgroup, thus making the Web available for public use.

December 21, 1991 – The signing of the Alma Ata Protocol officially dissolves the Soviet Union.

April 30, 1992 – The Cosby Show airs its final episode, sending the Huxtable family into syndication for the ages.



August 24, 1992 – Hurricane Andrew makes landfall in Florida and is the third most powerful hurricane of the 20th Century.

September 12, 1992 – Aboard STS-47, Dr. Mae C. Jemison becomes the first black woman astronaut.

February 28, 1993 – A seige begins at the Branch Davidian ranch outside of Waco, Texas. It will last 51 days.

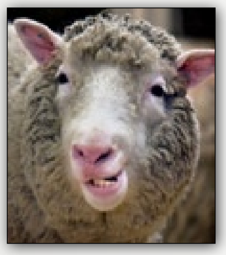
December 2, 1993 – STS-61 is launched to complete repairs on the Hubble Space Telescope.

October 4, 1995 – O.J. Simpson is found not guilty of the murder of Nicole Brown Simpson and Ronald Goldman.

EMERGING LEADERSHIP TIMELINE

January 1996 – Google is invented as a research project by Larry Page and Sergey Brin, Ph.D. candidates at Stanford University in California.

April 3, 1996 – Theodore John Kaczynski, better known as the Unabomber, is arrested by FBI agents at his small wilderness cabin near Lincoln, Montana..

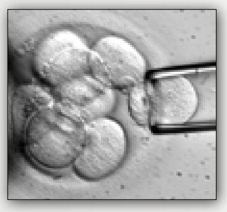


July 5, 1996 – Dolly the sheep is cloned from an adult somatic cell, using a nuclear transfer process.

July 4, 1997 – Mars Pathfinder successfully lands on the Martian surface.

August 31, 1997 – Princess Diana and her companion, Dodi Al-Fayed, die in an automobile accident in Paris.

October 1997 – The Toyota Prius, the first mainstream hybrid technology automobile, is unveiled to the international press.

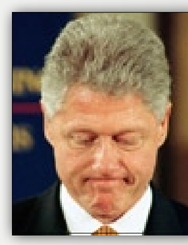


1998 – Stem cells derived from human embryos are isolated, creating opportunities for research into many hitherto incurable diseases, and presenting the moral dilemma of using human embryos for medical research.

October 29, 1998 – John Glenn becomes the oldest person to travel in space during STS-95.

November 20, 1998 – The first component of the International Space Station, Zarya, is launched into orbit. It is followed two weeks later by the Unity node, delivered aboard STS-88.

December 19, 1998 – President William Jefferson Clinton is impeached by the U.S. House of Representatives on charges of perjury, obstruction of justice and malfeasance in office, based on the Monica Lewinsky scandal and the Paula Jones lawsuit. The President was acquitted by the U.S. Senate on February 12, 1999.



April 20, 1999 – Two student gunmen open fire at Columbine High School in Denver, Colo. Twelve students and one teacher are fatally wounded before the gunmen take their own lives.

July 16, 1999 – John F. Kennedy Jr. perishes with his wife and sister-in-law when his plane crashes into the Atlantic Ocean enroute to Martha's Vineyard.

December 1999 – Concerns reach fever pitch as the world prepares for the impact of Y2K glitch and the Millennium Bug on the world's computer networks.

Transition websites:

- JSC Transition: http://transition.jsc.nasa.gov/
- JSC Workforce Transition: http://ma.jsc.nasa.gov/sites/workforce/pages/default.aspx
- KSC Transition: http://ksctransition.ksc.nasa.gov/index.asp
- Marshall Transition: https://shuttleportal.msfc.nasa.gov/msfctr/default.aspx
- Stennis Transition: http://sscintranet.ssc.nasa.gov/transition/
- Agency Transition: http://www.nasa.gov/transition
- Space Shuttle Transition: https://sspweb.jsc.nasa.gov/tmo/
- SSP Transition: https://sspweb.jsc.nasa.gov/
- Constellation: https://ice2.exploration.nasa.gov/ice/site/nasa/cx/

Moving Forward

Orion Rising

Constellation's design for the future is fast becoming reality

Pictured above: The Orion crew module destined for use in the Orion Launch System Pad Abort-1 test is loaded onto a Mississippi Air National Guard C-17 at Dryden Flight Research Center on Aug. 18 for its trip to White Sands Missile Range in New Mexico.

The last time Orion was featured in *Rendezvous'* Moving Forward section, the talk was all of the decisions to be made and tradeoffs to be reconciled. The work was primarily being done on paper, and a preliminary design was still taking shape.

Now, more than a year and a half later, important decisions have been made, the preliminary design review has been held and Orion is moving off of paper and into reality.

It's really exciting to be building Orion now," Mark Geyer, Orion project manager, said. "You can get your hands on the hardware and watch it take shape, see smoke and fire tests all over the place, get the team energized. There's a time when you need to go do these trades, and there's a time when you say, 'We need to just go build it – let's go.'"

Like the rest of the Constellation Program – and the rest of the agency – the Orion project is waiting to hear what decision will result from the Review of U.S. Human Space Flight Plans led by Norm Augustine. But unlike the other elements, the Orion project has the advantage of knowing that just about any scenario will need a capsule to get astronauts into space, and Orion can be that capsule.

"A lot of our design applies regardless," Geyer said. "All the options from the Augustine committee include Orion. Everything I hear says they want Orion for either the moon or certainly deep space. And there are very similar requirements regardless, so none of our work is wasted."

Add to that the fact that Constellation's marching orders are to proceed with the current plan until a final decision is made, and Orion hasn't wasted any time waiting around.

"It's very reasonable that we may end up staying with the current plan," Geyer said. "So we're still full steam ahead on the current architecture."

Lockhead Martin is building an Orion crew module Ground Test Article at the Michoud Assembly Facility in New Orleans.

The preliminary design review, held in August, helped cement the path forward. The preliminary design review is one of a series of checkpoints in the design life cycle of a complex engineering project before hardware manufacturing can begin. As the review process progresses, details of the vehicle's design are assessed to ensure the overall system is safe and reliable for flight and meets all NASA mission requirements. By the end, the basis for proceeding to the critical design phase is established.

Before Orion reached that milestone, the program had already been through more than 300 technical reviews, 100 peer reviews and 18 subsystem design reviews, all of which led up to the preliminary design review board.

"It's a difficult process," Geyer said. "And it should be. Because it really says that the design is sound, and it's time to go cut more metal and get into our big tests. And if the design is not sound, you're going to waste a lot of money. Now we can move forward building hardware, proceed to the big tests and prepare for the the critical design review."

Rescue divers secure the floatation ring around a mockup of NASA's new Orion spacecraft during water splashdown tests in Florida.

Maturing the technology, refining the decisions

All of the big decisions have now been made. For instance, Orion selected the Avcoat ablator system for thermal protection, the same heat shield used for the Apollo capsules and on parts of the shuttle in its earlier flights. The alternative was Phenolic Impregnated Carbon Ablator, or PICA, which was used on the Stardust mission.

One of the main differences between the two is that PICA is manufactured in blocks, while Avcoat is applied directly to the heat shield substructure and attached to the capsule as one unit. After three years of study and tests, the team of engineers working on the project determined that not only did the Avcoat's single-unit construction mean there would be no gaps in its protection, but the material was also the lighter choice and had fewer technical issues.

The choice of landing sites was also decided primarily by simplicity and weight – although getting the crew out of the capsule following a water landing might seem more complicated, the landing system that would support a land-based return is actually less reliable and a great deal heavier, making water landings the obvious choice. That decision then led to a reusability trade study last year that determined that even with water landings planned, much of the more expensive hardware inside the Orion capsule – for example, the fundamental avionics hardware – will be salvageable. And though the actual capsule structure will not be, it's not a big cost driver.

"So we'll go ahead and build the crew module's primary structure new every time," Geyer said.

Other decisions, such as the use of phased array antennas for the communications architecture and the choice of a 120-volt power system over a 28-volt system, were made with an eye to the future. Neither makes a major difference to the Orion project, but the 120-volt power system, for example, will save a lot of weight for the overall lunar architecture and a lot of future headaches if the lunar systems are consistent throughout the various elements.

A single architecture

The one decision left open after the preliminary design review was which parachute system to use in landing. Before the review, Orion chose a system with fewer components, and therefore, the project thought, increased reliability and safety. But as work continued, it became evident that the system was actually less reliable because of its complexity. So an integrated design assessment team was formed to look into alternatives or possible changes to the existing system.

The team's eventual recommendation, which was accepted in November, was to go with a parachute system similar to the one used by Apollo. It keeps the original parachute design, but uses a single attachment point for the drogue and main parachutes and a mortar deployment for the pilot chutes. The shape of the forward bay, where the parachutes are packaged, was changed slightly to increase the volume, enabling the packing density of the parachutes to decrease and alleviate some risk in the previous design.

With all of these major decisions made, the Orion team is now able to focus all of its efforts on a single architecture.

"Before it was parallel development, so we had to do double the work, in essence," Geyer said. "Now you get more and more detailed on the ones you picked, making sure you have all the details on that particular design. So we are seeing the Orion design mature very quickly now."

And gathering those details leads to actually building the systems designed by the team. The program is now buying pumps and fans for the environmental control and life support system; and the Operations and Checkout Facility in Florida – the factory where Orion elements will be built – was opened up last year. Tooling is showing up there, and the timetable for building the facility's first element has been moved up by six months. Meanwhile, at the Michoud Assembly Facility, the first flight-like ground test article is already well into fabrication, and structural testing will take place later this year.

The Orion flight test crew module is shown with its adapter cone, that attaches the abort system's rocket motor to the module.

A full-scale test firing of Orion's jettison motor at the Aerojet facility in Sacramento, Calif.

Putting Orion and its systems to the test(s)

Then there are the tests – and they are taking place all over the country. Vibration testing on a ground test article of the crew module built at Michoud Assembly Facility in New Orleans will be taking place in an acoustics chamber in Denver. A crane and pool are being built at NASA's Langley Research Center in Virginia to test how Orion will hit the water at different wave heights and wind speeds. At the Alliant Techsystems plant in California, Orion's round solar arrays will be deployed for the first time. And on STS-134, space shuttle Endeavour will compare the performance of Orion's rendezvous and docking system to that of its own as it closes in on the International Space Station for the second to last visit of the shuttle program.

"We'll do a lot of modeling on the ground, but what we've found is, there are some things you cannot reproduce on Earth," Geyer said. "For instance, you don't really understand the lighting that you're going to see in space until you get there."

Of course, the main event for Orion this year will be the Pad Abort-I flight test – the first in a series of launch abort system tests – this spring at the U.S. Army's White Sands Missile Range. A crew module the actual size, shape and weight of an Orion capsule will be propelled away from the launch pad by a six-second firing of its launch abort system abort motor, reaching an altitude of about 1 mile before the crew module is reoriented, the abort system is jettisoned and the parachutes deployed. In all, the entire flight will take about 90 seconds before touchdown.

Having recently seen just how awe-inspiring a flight test can be at the Ares I-X launch, Geyer said he can't wait to see Orion in action. It won't be quite the same experience – it won't be as large or visible for as long – but he still expects it to be a crowd pleaser.

"I think people will be excited by how fast it is and how dramatic that first abort motor is," Geyer said. "It goes from zero to 600 in 2.5 seconds – it will be impressive. And all the advanced maneuvering that the vehicle will do – I think it will get a lot of people's attention. It really is a very complex operation with a lot of moving parts and a lot of extremely detailed timing operations."

Proving an unflown critical system

That's not to say, however, that the test is just a fancy pyrotechnics show. The launch abort system is a crucial element in improving crew safety, and making it work correctly isn't easy. If it isn't done correctly, it can tear the vehicle apart. The system has to get the module to the correct height, fly it through a very rigid flight path and then deploy 12 parachutes, and unlike the Ares I-X with its shuttle-heritage solid rocket booster segments, this system has never been flown before.

"This is definitely, I think, the most complex phase of anything we will ever fly," Geyer said. "The nominal is much easier to coordinate. We're really testing out in a no-kidding flight test the most extreme environment we're going to see. And we're doing it before critical design review. That takes quite a bit of effort. It will be very exciting."

The ramp up of all of that activity should provide a nice counterpoint to the bittersweet wrap up of the shuttle program that will be going on at the same time, Geyer said.

"I've seen a lot of shuttle launches, and they're really exciting with the crew and their important missions," he said. "But then to see something different and have it fly … It's very emotional. It's very cool."

The Orion crew module that will be used for the Orion Launch Abort System Pad Abort-1 flight test is loaded onto a Mississippi Air National Guard C-17 at NASA's Dryden Flight Research Center Aug. 18 for airlift to the White Sands Missile Range in New Mexico

Above: Doremus (far right) is seated at the MMACS console with fellow team member Kevin McCluney during STS-30.
Below: Doremus in 1985.

Protecting a Culture of Safety

Bob Doremus and his Safety and Mission Assurance team make sure each remaining shuttle launch, mission and landing is as safe as humanly possible.

Bob Doremus, manager of the Space Shuttle Program's Safety and Mission Assurance office, knows a thing or two about the shuttle and its systems.

There are 51 mission pins on the wall in his office at Johnson Space Center — wall art that moved with him from his work as a flight controller in Mission Operations in the Systems Division, to a brief stint on the Orbital Space Plane project, to the Space Shuttle Program's Safety and Mission Assurance Office. And what he's learned over the years manning the Maintenance, Mechanical, Arm and Crew Systems, or MMACS, console in the pressure cooker known as mission control, not to mention the other stops along his career path, could fill a book.

In fact, NASA's Tacit Knowledge Capture Project has already tapped into Doremus' memory of his many years behind the console, troubleshooting mechanical system glitches with his team, watching each mission unfold across the screens in front of him. The MMACS console has responsibility for all the structural and mechanical systems on the orbiter — including such important items as doors, antennas, landing gear, and steering systems. And the people who man it are authorities on each one.

"Expert level knowledge is the minimum expectation," Doremus said. "And you're expected to have the communication skills needed to be able to pass that expertise on to the rest of the team in mission control."

Doremus' cumulative experience spanning those 51 missions served as prologue to the work he's doing now in Safety and Mission Assurance, or S&MA. There he learned that thorough preparation and confident leadership were two of the most important qualities a flight controller could possess.

"You had to know when mechanical systems were important and when they weren't," he explained. "How to know when it was absolutely necessary to speak up and say, 'Wait a minute,' and when to listen to what others had to say."

In other words, he had to know how to assess risks on the fly, which is very much what his S&MA office is responsible for now.

Balancing safety versus schedule

Every day in the life of the shuttle program, safety issues butt up against the pressures of maintaining launch schedules – with the final deadline looming, it can be tempting to march blindly toward it. But with the future of all NASA programs, not just that of the shuttle, depending on the success of the final flights, now's no time to cut corners on safety.

"We need to complete the remaining flights in the limited time that we have, and that's what we're attempting to do," Doremus explained. "But when we encounter a safety issue, we're going to take the time we need to resolve it before we fly."

" ... when we encounter a safety issue, we're going to take the time we need to resolve it before we fly."

Obviously, that presents a challenge considering the schedule necessary to support the manifest. Doremus cited several examples from the past year.

Following the STS-126 mission in 2008, some damage was found on one of Endeavour's three flow control valves, which channel gaseous hydrogen from the shuttle's main engines, through the propulsion system and back to the external fuel tank. Clearing valves for use by Discovery for the STS-119 mission required a program-wide engineering effort that delayed launch for several weeks. Once they understood the issue in context, it turned out to be an acceptable risk, but it required a lot of engineering attention to get to that point.

Another one that caused a delay prior to STS-127 was a hydrogen leak caused by a misalignment of the ground umbilical carrier plate on Endeavour's external fuel tank. The engineering teams at Marshall Space Flight Center and Michoud Assembly Facility needed time to fully understand the issue and find a technical fix before the mission was good to go. But after detecting the leak during launch attempts on June 13 and 17, the team had the problem solved and the shuttle ready to launch by July.

Following STS-127, unexpected foam loss noted during that mission brought the whole shuttle team together to determine whether similar foam loss was likely to happen again during STS-128. Tests and analyses were performed, presentations made and lengthy discussions held. But once everything was reviewed and everyone agreed that the risk was acceptable, STS-128 launched without a hitch.

"Our mission is to fly safely, not stay on the ground safely," Doremus explained. "And that means doing what we have to do to figure out if we're

"Our mission is to fly safely, not stay on the ground safely."

in an acceptable position to fly — and finish these remaining missions."

And that's the challenge. Not just for the S&MA team, but for everyone in a program with 129 missions under its belt. It's safety first, schedule second.

Battling complacency

In addition to the safety versus schedule challenge, Doremus said that the most insidious threat to the success of the remaining missions is complacency.

"The absolute wrong attitude for us to have is that it's okay to let some things go because we've got only a couple of flights left," Doremus emphasized. "These missions are not easy, and they're not simple. They've required a surge of effort. We have to 'stay hungry,' as Bill Gerstenmaier said, and keep in mind just how hard it is to fly these flights."

That means preserving the processes that have seen the shuttle through this far and keeping records up to date, even when we're mere months away from not needing them anymore. It would be easy to let things slip, but Doremus believes that the shuttle's strong safety culture will ensure that doesn't happen.

"It makes my job easy," he said. "The safety culture that was established here in the S&MA office by the previous managers and in the S&MA organizations at each of the centers is robust and vital. And program management really gets it when it comes to safety."

That doesn't mean that Doremus or other program leaders take it for granted; while it's important to keep up discipline and maintain rigor, Doremus said that taking care of the people responsible for the work also has to be a top priority. He uses his S&MA office — a group of managers responsible for safety, quality, risk, reliability, process and configuration — as an example.

From left to right: Safety panel chairman Roy Glanville, deputy manager Don Beckmeyer, systems safety manager Sally Davis, process manager Brad Miller, reliability manager Hung X. Nguyen, SSP chief safety officer M. Scott Johnson, risk manager Mike Canga, quality manager Sam Daugherty, program support assistant Beverly Braddy, manager Bob Doremus and secretary Tristyn Meza-Goble.

"We're working with them on training and development to make sure they have what they need for life after shuttle," he explained. "To be honest though, there's a strong desire to finish out shuttle and see this thing through, get to the end and have that 'Hey, we did it!' feeling. I see that motivating a lot of people."

There has always been a concern that allowing people to do what they need to prepare for the future might create its own safety problem – that too many critical skills would find it necessary to leave before the program was finished flying. But Doremus said that wasn't proving to be as big of a problem as feared.

He compared the journey to white water rafting.

"Everyone has to pull together and do their part, because there are hazards and obstacles along the way," he said. "There are times of extreme excitement, when we're going through a particularly difficult or tricky section of the river. There are also times of relative calm when we still have to pull together to make it through. But at the end, we'll look back and say 'Wow! What a great ride! We did it. We really accomplished something.'"

That's what motivates him. That, and the thrill of problem solving, the excitement of working missions and the experience of seeing a childhood dream come true — playing a part in the nation's space program.

R-E-S-P-E-C-T: A key to effective leadership

Between Mission Operations and S&MA, Doremus learned a lot about working with and, eventually, leading engineering teams. He said the key is to trust not just your own team, but also to trust the teams responsible for other systems, such as electronics, robotics or propulsion. And a big part of that is respect.

"Conveying respect to one another, avoiding the jealousies over who owns what, that's when it clicks," he advised. "The leader sets the tone, and if he or she is listening to people and respecting their ability, then teamwork flows."

Having observed some 30 different flight directors operate, Doremus took mental notes and developed a working definition of what makes a good leader.

"A good leader needs to be decisive," he said. "A good leader is respectful of the people on his team and treats them with respect. And a good leader communicates confidently with his team. He has to be able to say, 'We're going to make it through this, even though it's difficult.' A good leader is a calming or steadying influence that motivates the team to achieve the mission."

He also believes that good leaders are always good teachers. Respect for the job they are asked to complete, particularly when it comes to the routine stuff, is an important lesson that is the responsibility of a leader to instill in his team.

"With every job comes the potential for heartache," he said. "In the shuttle program, great risk goes along with great reward. It's hard to describe sometimes, but paying attention to every detail is a real part of your job. Your actions can have ultimate consequences."

This is true for almost every shuttle program team and discipline. It's ingrained in program leadership, mission control, ground processing, flight operations, everywhere — and especially in Safety and Mission Assurance.

Hooked by Apollo 11

Doremus was born in Missouri, but was less than a year old when his family moved to Texas, and he's been there ever since. As a little kid, he had a big picture of the moon on the wall of his room. He remembers being in Surfside, Texas, at a family beach outing on the Sunday of the Apollo 11 moon landing. He was in third grade.

"We took a break from being out in the water and listened to the landing on the radio in our car," he recalled. "And then that night we watched them walk on the moon on TV. It was amazing."

The moon landing determined the direction of his life, just as it did for so many shuttle program veterans.

After earning his engineering degree at Texas A&M University in 1982 and working a brief stint at Bechtel on the South Texas Nuclear Project, he landed at Ford Aerospace in 1984, training to be a flight controller in what eventually became the MMACS group in Mission Operations. But it wasn't long before his job transitioned to the Space Transportation System Operations contract with Rockwell. Five years later he found himself in Mission Operations on the civil service side, still serving as a flight controller in mechanical systems, and that's where he stayed for a total of 18 years. It's where he learned how to solve problems and quickly assess an issue's threat to safe flight in real time.

Real-time education

"You learn in simulations how to solve problems, how you fit in with everything else that's going on," he said.

It's rigorous training for the real thing. Manning a console in a back room at mission control, he developed that sense of profound accountability shared by almost everyone who works missions.

"You end up feeling responsible for everything," he said. "Because as a flight controller you get really zealous about guarding the crew's safety and the safety of the vehicle."

By 1988, Doremus was ready to move to the front room at mission control. As it happened, his first mission was the Return to Flight mission after the two-plus year stand-down following the Challenger accident. Due to some attrition in the group, he had just three months to prepare and remembers feeling "green as all get out." But he was ready.

"Gene Kranz would sit in the viewing area right behind our console during ascent and, of course, we really looked up to him," Doremus recalled. "He would be back there listening to the voice loops. It was an extra incentive to do your job well because you wanted him to think you were worthy of the front room."

Another thing he remembered was that he was sitting at 1960-era consoles in the mid-'80s.

"I'd be thinking, 'Hey, this stuff is kind of old,'" he remembered. "Then I'd think, 'This is where they sat when they landed on the moon,' and, 'Wow, what am I doing sitting here?' And then I'd think, 'By the way, there's a spaceflight going on,' and I'd snap to."

Doremus at the Ascent/Entry/Orbit 1 MMACS console during STS-37.