National Aeronautics and Space Administration




# ESD

## EXPLORATION SYSTEMS DEVELOPMENT

*special issue*

APRIL - MAY 2014






**COMBINED MONTHLY HIGHLIGHTS REPORT**
*Recent progress and accomplishments from the programs*

**EXPLORATION SYSTEMS DEVELOPMENT 'THEN & NOW'**
*A look back at the last three years of progress and development in ESD*

**A LETTER FROM DAN DUMBACHER**
*A retirement farewell from ESD's Deputy Associate Administrator*

National Aeronautics and Space Administration

Dear ESD Team,

This month's Exploration Systems Development *Combined Monthly Highlights Report* again shows the fantastic progress that the nationwide team is making. Just three short years into the endeavor, it is truly amazing to see how much has been achieved.

Since we received approval to proceed in 2011, Orion, the Space Launch System, and the Ground Systems have gone from concept and formulation into implementation and execution. Now we are building hardware across the entire system. The swift and efficient progress into hardware is undeniably impressive. All those at the NASA Centers,in industry, our international partners and those giving academic support are to be congratulated.

This team is on a mission! The respective program updates show: the Orion Exploration Flight Test-1 article integration at NASA's Kennedy Space Center, Space Launch System hardware manufacturing, and Pad 39B / Vertical Assembly Building/ Crawler/ Mobile Launch Platform modifications at Kennedy Space Center. Take a quick look at the "Before and After" pictures in this edition, and see the progress made since 2011.

Now the time has come to turn my place on this team over to another – a "player to be named later," if you will. ☺ As I depart, Bill Hill will continue as the Acting leader of Exploration Systems Development. The team is in tremendous hands. In large part, much of what has been accomplished to date has been due to Bill's quiet, dedicated and thoughtful leadership. He personifies NASA, and it has been both a pleasure, and an honor, to work with him.

As for me, I am heading off on a new journey – one that will prepare the next generation of explorers. I will be helping Purdue University develop curious and capable engineering leaders to take us to Mars and beyond! This unique opportunity to help shape the future was one that I could not pass up — time waits for no man.

Everyone on the Exploration team is to be commended. I would like to especially thank: Paul McConnaughey, Marshall Smith, Cris Guidi, Tom Rathjen, Mark Geyer, Todd May, Mike Bolger, Garry Lyles, Julie Kramer-White, Phil Webber and Pepper Phillips for their exemplary work in getting the team this far, this fast.

Thanks must also go to those who taught me so much over the years, and helped me along the way, including: Otto Goetz, Joe Lombardo, Wayne Littles, Bob Ryan, Jim Odom, John Thomas, Bob Sieck, Carolyn Griner, and many, many others. Thank you for giving me the chance to work on the NASA team, allowing me to try, fail, learn, and succeed.

As I head off to Purdue's "black and gold," please know that I will always bleed NASA blue!

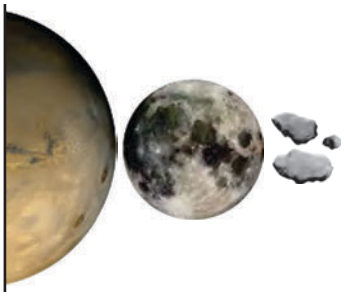
To all: Godspeed, Ad Astra, Carpe Diem, and most of all, **ON2MARS!!**

Dan

Dan Dumbacher
Deputy Associate Administrator
Exploration Systems Development Division
Human Exploration and Operations Mission Directorate
NASA Headquarters

**MONTHLY ACCOMPLISHMENTS**
May 2014

# orion



# Houston: We are Go for Exploration!

**KSC, JSC launch and mission control centers simulate Orion's first flight operations**

In just a matter of months, NASA will send its new human-rated spacecraft into space for the first time. And back here on the ground, the Mission Control Center in Houston will be at the helm under the command of Mike Sarafin, lead flight director for Exploration Flight Test-1 (EFT-1), (above left).

It's a milestone for which Sarafin's flight control team of about two dozen people has been preparing for two years, and in May they participated in their first joint integrated simulation, along with the Mission Management Team, the Test and Launch Control Center and the Engineering Support Team, all located at NASA's Kennedy Space Center in Florida. Covering the pre-launch and in-orbit phases of Orion's mission, the teams had to deal with the kinds of problems that could require real-time decisions before and during the actual mission.

With no crew aboard Orion for the first two missions, flight controllers will serve as the eyes and ears monitoring the health and status of the spacecraft. If something goes wrong, it will be up to them to fix it. That's not exactly a new concept for the team members, all of whom have experience at space shuttle flight control consoles under their belt. Skills such as understanding a failure, its impact and its workaround are talents that are bred into flight controllers at NASA's Johnson Space Center in Houston.

But this won't be quite like any mission they've flown before.

EFT-1 is the first flight event that will use the new mission control equipment and flight software platform. A lot of the training with the flight control team has helped wring out the system. The testing has revealed flight software problems the team was able to work through and repair with plenty of time to spare. They have done simulations, tested out new tools and communication loops in the redesigned control room, and verified that Orion-formatted data could successfully be transmitted to mission controllers. The preparations are not complete, but the team will be ready when it's time to launch.

**Continued on page 2**

**Continued from page 1**

As NASA's prime contractor for the Orion Program, Lockheed-Martin is responsible for conducting EFT-1 and its mission manager, Bryan Austin, is directing the test. The primary control area will be Hanger AE on the Cape Canaveral Air Force Station, Florida, which is used to support NASA evolvable expendable launch vehicle missions.

Lockheed-Martin personnel in both Houston and Denver participated in the two-day simulation, as did personnel from the Orion Program, Ground Systems Development and Operations Program, and United Launch Alliance. The simulation exercised the NASA Mission Management Team and Engineering Support Team decision-making systems and personnel.

**See related video below:**
Public Affairs Officer Dan Huot interviews Flight Director Mike Sarafin about EFT-1:
**bit.ly/TnEx5e**

# Heat Shield? Check!

On May 30, the world's largest heat shield, measuring 16.5 feet in diameter, was successfully attached to the Orion spacecraft at the Operations & Checkout building at Kennedy Space Center in Florida. The heat shield installation marks one of the final steps in the spacecraft's assembly leading up to its first test flight this fall, Exploration Flight Test-1 (EFT-1).

The heat shield is one of the top mission critical elements that will be tested during Orion's first space flight as it protects the spacecraft from the extreme temperatures of reentry that can reach up to 4,000 degrees Fahrenheit. Comprehensive data from the test flight will influence design decisions most critical to crew safety to lower risks and safely carry humans on future missions to deep space.

The heat shield began its journey in January 2012 in Colorado, at Orion prime contractor Lockheed Martin's Waterton Facility near Denver. That was the manufacturing site for a titanium skeleton and carbon fiber skin that give the heat shield its shape and provide structural support during landing. The structures were shipped in March to Textron Defense Systems near Boston, where they were used in construction of the heat shield itself.

Textron installed a fiberglass-phenolic honeycomb structure on the skin, filled each of the honeycomb's 320,000 cells with the ablative material Avcoat, then X-rayed and sanded each cell to match Orion's design specifications.

The Avcoat-treated shell will shield Orion from the extreme heat it will experience as it returns to Earth at 20,000 mph. The ablative material will wear away as it heats up during

Orion's reentry into the atmosphere, preventing heat from being transferred to the rest of the crew module.

**See related stories:**
Orion in Final Assembly at Kennedy Space Center
**lmt.co/TnGCxW**

Heat Shield for NASA's Orion Spacecraft Arrives at KSC
**1.usa.gov/TnGKxq**

# Airbus/ESA complete first critical review of NASA's Exploration Mission spacecraft

The European Space Agency (ESA) is a step closer to building their contribution to the future of human spaceflight and exploration by completing the preliminary design review of the European Service Module for NASA's Orion spacecraft that will send astronauts beyond low Earth orbit to explore our solar system.

The European team is contributing the service module and expertise to the Orion multipurpose crew vehicle with flight-proven technology used on ESA's series of Automated Transfer Vehicle supply spacecraft.

The European service module will provide power, thermal control, consumables and propulsion to the vehicle, including the crew module.

The cooperation highlights the major involvement of ESA, NASA and European industry on this important project, based on a long-standing partnership of the agencies across many areas of human and robotic spaceflight.

A Preliminary Design Review is one of a series of checkpoints in complex engineering projects. Having passed this review, the next step is to start the detailed design and procure the subsystems.

As the review process continues, the spacecraft design will be assessed again to ensure the safety and reliability of the overall system and its compliance with Orion requirements.

The teams developing the service module reviewed the documentation in April and May before meeting for a week in Bremen, Germany. Reviewers from ESA, NASA and the US prime contractor Lockheed Martin evaluated documents delivered by Airbus Defence & Space and European contractors.

The Preliminary Design Review concluded with a formal board on May 15 that provided the go-ahead for the next phase. The next major review milestone is the Critical Design Review scheduled for the end of 2015, aiming for Orion's first fully integrated flight test with the European Service Module and Space Launch System in 2017.

**See related stories:**
Airbus Defence and Space's system design of European service module for US MPCV spacecraft Orion approved by ESA
**bit.ly/1lbVae7**

The German Space Agency Is a Vital NASA Partner
**1.usa.gov/1lbUC80**

## NASA Astronauts must first splash down to take off to an asteroid

NASA is planning to send astronauts to an asteroid in the early 2020s, and preparations are already underway in the world's largest swimming pool - the Neutral Buoyancy Lab at Johnson Space Center in Houston.

Wearing modified versions of the orange space shuttle launch and entry suits, NASA astronauts Stan Love and Steve Bowen went underwater on May 9 to work through mission operations for NASA's Asteroid Retrievel Mission (ARM). Find out how the astronauts learned to tackle this mission and what they might be wearing at: **1.usa.gov/1hlVRSW**

# Future of exploration showcased at 30th Space Symposium event


The prime contractors for NASA's Orion and Space Launch System (SLS) program came together to tell NASA's deep space story at the 30th Space Symposium conference held May 19-22 in Colorado Springs, Colo. The team showcased the new systems that will take humans farther into space than ever before, during events throughout the three-day conference.

A panel discussion about the inspiration and future of spaceflight took place with former astronauts Kent Rominger from ATK, John Grunsfeld from NASA, and Lockheed Martin's Mike Hawes and Boeing's John Shannon.

Four young engineers representing SLS and Orion participated in the Space Symposium New Generation activities geared at young professionals 35 and under. The panel highlighted a new generation of professionals that are working to help take the next steps for deep space exploration.

The SLS and Orion deep space industry team hosted the first inaugural SpaceSLAM! networking event that invited young professionals to pitch original STEM ideas in an entertaining format.

For more information about Space Symposium, go to:
**bit.ly/1mZ5m8f**

# Deep space exploration discussed at Houston forum

Orion & SLS team members had the opportunity to talk about deep space exploration with Congressman Randy Weber at a Houston Business Forum breakfast on May 13. Pictured from left to right are Lockheed Martin's Eric Perry & Linda Singleton, Weber, Lockheed Martin's Stephanie Hicks and ATK's Brian Duffy.


Lockheed Martin engineer Vanessa Aponte served on a STEM Panel for EICnetwork.tv on May 21. The webcast was sponsored in part by Lockheed Martin and can be viewed for play back online at: **bit.ly/1oAPlGF**

Lockheed Martin Orion Spacecraft CPE Henry Martinez, won the Dr. George Herzl award for "best paper" for his paper called "Testing Orion's Fairing Separation System", at the 42nd Aerospace Mechanisms Symposium held May 14-16 in downtown Baltimore.

Lockheed Martin participated in the Family Day held at Kennedy Space Center on Saturday, May 10. The exhibit, which highlighted the Orion Program, was visited by hundreds of employees who brought family and friends to the event. Captain Orion, Lockheed Martin Test Engineer Herb Yamada, gave three kid-friendly, Science, Technology, Engineering and Math- (or STEM) themed presentations to large crowds of excited kids.

# Space enthusiasts get onboard Orion at Comicpalooza. No joke!


More than 30,000 comic book fans turned out for Comicpalooza, held May 23-25 in Houston. NASA and Lockheed Martin volunteers staffed the exhibit area, which took over three floors of the massive George R. Brown Convention Center, making this event the largest comic convention in Texas.

Orion team staffers recruited cosplay characters and comic collectors to join the #ImOnBoard campaign by signing the banner and posting their "selfies" at the event.

In addition, NASA's Exploration Systems outreach leads Ashley Edwards, Barbara Zelon and David Hitt provided a panel discussion entitled "Top Secret: Mars Exploration Plan!"

Convention attendees were thrilled to learn about the upcoming flight test later this year and that Orion would one day transport humans to explore Mars. Some of the more interesting comments captured during the event:

"Wow! This is Science Non-Fiction at a Science Fiction Event!"

"No, Orion's propulsion system does not contain Dylithium Crystals."

Elmo was tickled to sign the #ImOnBoard banner for Orion's first mission. Hear what he thinks about flying into space on Orion in this interview with Space.com's Tariq Malik just before the launch of STS-135: **bit.ly/SBKOt6**

Learn more about Comicpalooza at **http://www.comicpalooza.com/**

The Orion Service Module Static Test teams at Michoud Assembly Facility in New Orleans, (upper left), Kennedy Space Center in Florida, (upper right), Glenn Research Center in Cleveland, Ohio, (lower left), and Lockheed Martin's Waterton Facility near Denver, (lower right), received Orion Program Manager Commendations for their outstanding efforts in the successful completion of the Orion Service Module Static Testing in support of Exploration Flight Test-1.


A is not just for Apples anymore. The 26 week spelldown to launch is now underway. Follow it on Facebook at: **on.fb.me/1no0Jq4**

## Coming up in June:

- EFT-1 Crew Module / Service Module mating, KSC
- Parachute Test Vehicle (PTV-8) drop test, Yuma, Ariz.
- Exploration Day on the Hill, Wash. DC


Read more about Kevin Pfitzinger at: **on.fb.me/1kEynJe**

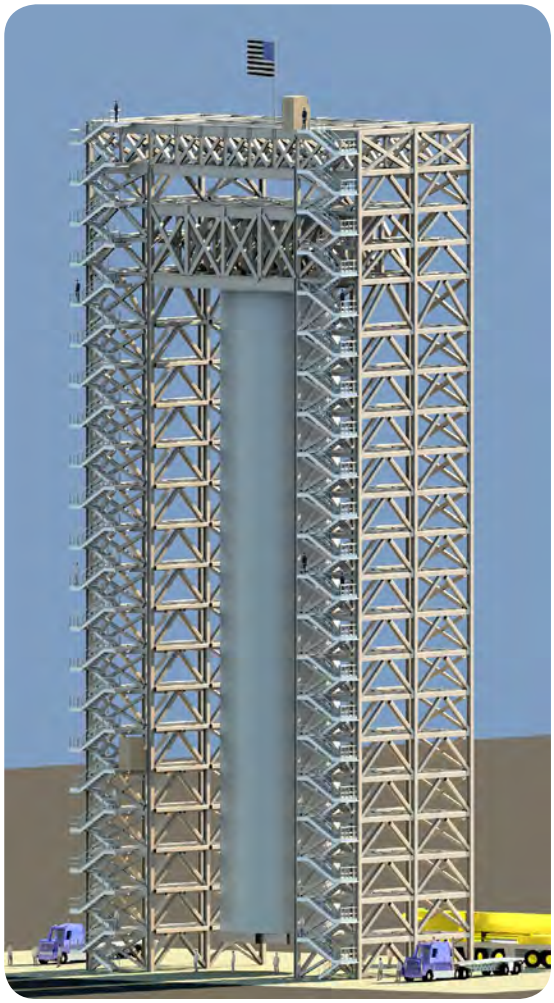
National Aeronautics and Space Administration

# Space Launch System
Highlights

May 2014

## Breaking Ground: Making History

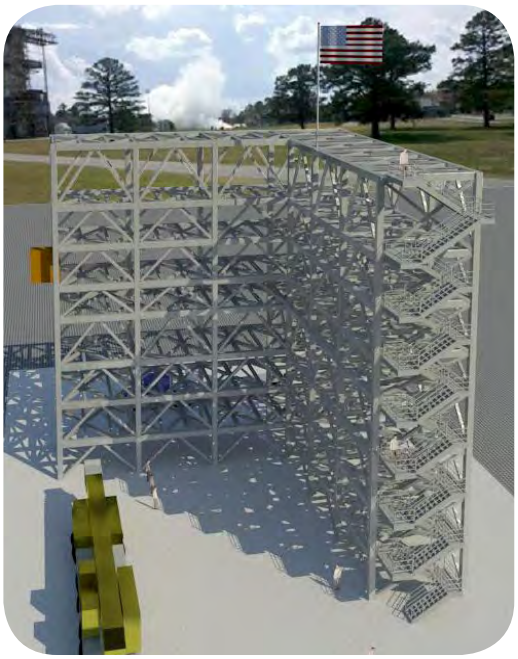
### SLS Structural Test Stands to be Built at Marshall Space Flight Center



SLS will have the largest cryogenic fuel tanks ever used on a rocket. Stands to test the tanks and other hardware to ensure that these huge structures can withstand the incredible stresses of launch will be built at NASA's Marshall Space Flight Center.

NASA is contracting for the construction of the test stands through the U.S. Army Corps of Engineers, which has awarded a $45.3 million contract to Brasfield & Gorrie of Birmingham, Alabama. For the full story, click **here**.

◄ Artist concept of Test Stand 4693 to be constructed at the Marshall Center. The 215-foot stand will be used for structural loads testing on the liquid hydrogen tank for the SLS core stage. *(NASA/MSFC)*



Artist concept of Test Stand 4697 at the Marshall Center. The 692-ton steel structure, about nine stories high, or 85 feet, will be used for structural loads testing on the SLS core stage liquid oxygen tank and forward skirt. *(NASA/MSFC)* ►

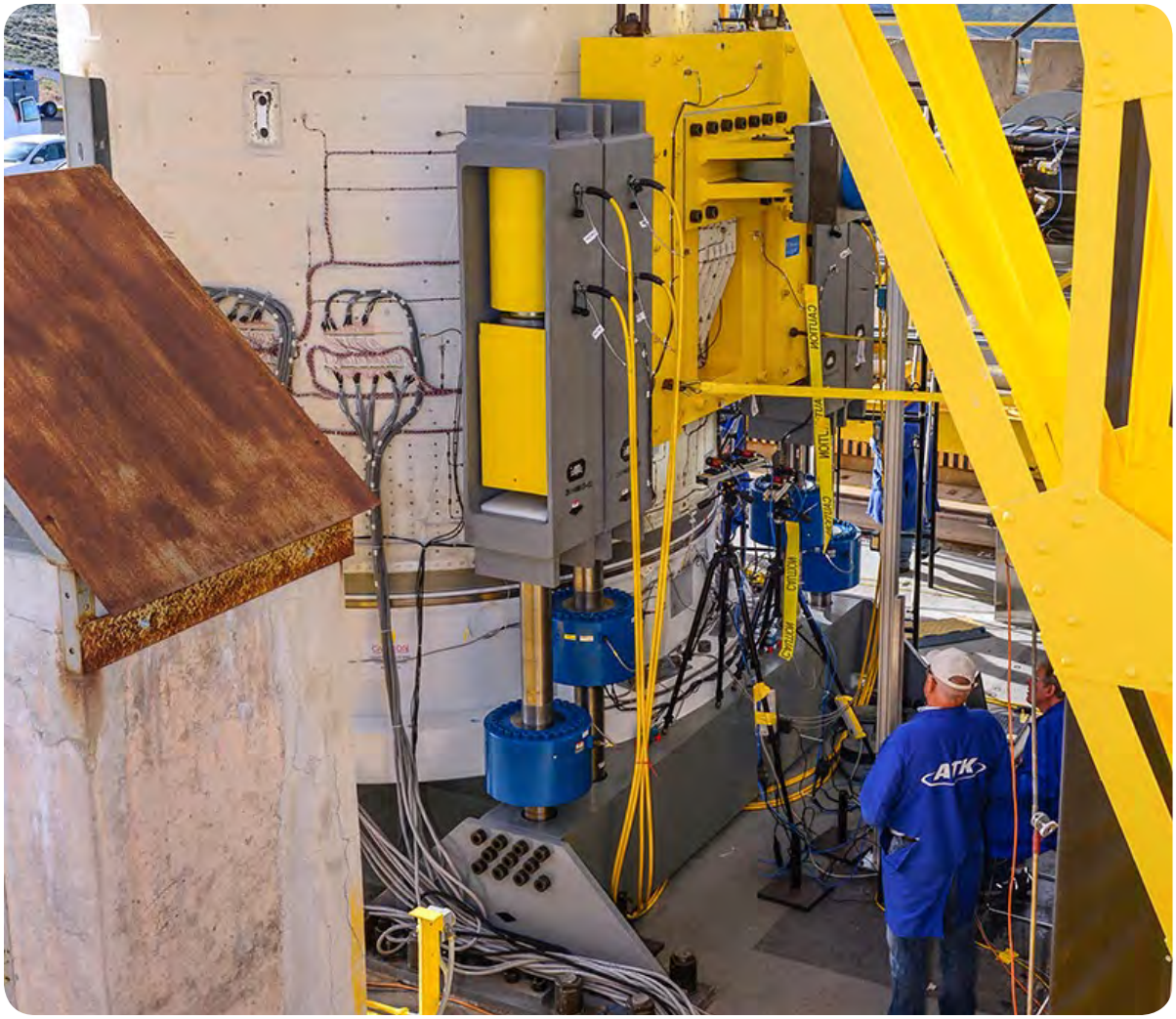
# Hardware Arrives at Cape Ahead of Orion's First Flight Test

The port booster, stage adapter and the second stage of the Delta IV rocket—which will take NASA's Orion spacecraft to space for its first flight test—recently arrived by barge in Cape Canaveral, Florida, from United Launch Alliance in Decatur, Alabama. The adapter, designed and built at NASA's Marshall Space Flight Center, will connect Orion to the Delta IV rocket. United Launch Alliance is constructing the Delta IV for that maiden flight. The hardware is now housed at the Horizontal Integration Facility at Space Launch Complex 37 on Cape Canaveral Air Force Station. The pieces are being processed and checked out prior to being moved to the nearby launch pad. *(NASA/KSC)*


# NASA Achieves Key Milestone Leading to RS-25 Engine Testing

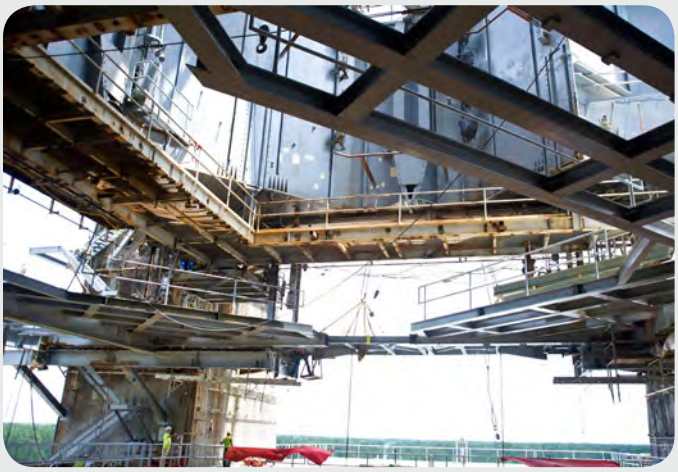
A member of the A-1 Test Stand operations team examines the progress of a cold-shock test on the new A-1 structural piping system May 1. The test marked a milestone in preparing the stand to test the RS-25 rocket engines that will power the core stage of the SLS. Delivery and installation of the first RS-25 engine is planned for early summer. For the full story, click **here**. *(NASA/Stennis)*

# Engineers Test NASA's SLS Booster Forward Skirt to the Limits




At left, NASA and ATK engineers complete structural loads testing on the SLS booster forward skirt at ATK's facility in Promontory, Utah. Structural loads tests are performed to ensure each piece of hardware can endure loads without any adverse effects to the vehicle, or most importantly, to the crew. For the forward skirt test, engineers used increments of force—about 200,000 pounds per minute—to prove the design capabilities meet the strength requirements, with sufficient margin. The structure was also subjected to a combination of axial and lateral loads, which are critical at liftoff. For the full story, and video, click **here**. *(ATK)*

## NASA Moving Forward on Test Stand Upgrades for SLS Core Stage Testing



"Before-and-after" photos show the progress of renovation work on the B-2 Test Stand at Stennis Space Center as NASA prepares for testing the SLS core stage in 2016. For the full story, click **here**. *(NASA/Stennis)*

# Spaceflight Partners: PEM Technologies

*EDITOR'S NOTE: Every month, SLS Highlights turns the spotlight on one of the industry partners helping to create the largest rocket ever built for human space exploration. In this issue, we profile PEM Technologies, LLC of Natrona Heights, Pennsylvania.*


From left, PEM employees Tom Sherer, Tom Ravotti and Don Risko set up to machine an Aerojet Rocketdyne spherical ball valve sealing surface. *(PEM)*

PEM Technologies, LLC has been working with Aerojet Rocketdyne since 2012 to develop a final machining and finishing process for ball valve components of the main fuel flow control for the J-2X engine.

Formed in 2010 to provide advanced electrochemical machining technology with facilities in Natrona Heights, Pennsylvania, PEM Technologies, LLC is co-located with JV Manufacturing where together the companies develop, demonstrate, manufacture and support PEM machining of high accuracy, fine surface finish components.

PEM, which stands for Precision Electrolytic Machining, is a process of full-form machining of metal components by dislodging surface atoms with a preformed metal electrode that never touches the workpiece. A solution of deionized water and salt provide a conductive path between the electrode and workpiece while a precise DC voltage pulse causes a current that result in precise metal removal without any degradation to the surface.

"The most interesting and challenging aspect about working with this technology is finding, developing and implementing new applications for the PEM process, such as components for artificial heart valves, fuel cells, diesel engine fuel systems and jet engines," said Don Risko, Vice President of PEM Technologies. "The opportunity to support America's space program by developing a cost effective, faster manufacturing solution that reduces a 19-step process to a one-step PEM process, is an exciting experience for PEM Technology."

# SLS On the Road…

An inflatable SLS stands tall May 7 at the Capitol in Baton Rouge for NASA Louisiana Aerospace Day 2014. *(NASA/MSFC)*

Comic fans of all ages visit the SLS and Orion spacecraft booth at Comicpalooza, held May 23-26 in Houston. *(NASA/Orion)*


Keith Hefner, SLS program associate manager, speaks to attendees May 7 at the SpaceOps 2014 conference in Pasadena, California. *(NASA/MSFC)*

Spectators at NASA's Student Launch challenge sign the "I'm On Board with SLS and Orion" poster May 17 at the Bonneville Salt Flats in Tooele County, Utah. *(NASA/MSFC)*

For more SLS news, updates and resources, visit www.nasa.gov/sls

Follow SLS on:

### SLS on Deck:

- Exploration Systems Development (ESD) Update Day
- NASA Day on the Square
- RS-25 Installation at Stennis Test Stand

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GSDO GROUND SYSTEMS DEVELOPMENT & OPERATIONS

EXPLORATION BEGINS HERE

PROGRAM HIGHLIGHTS • MAY 2014

*At NASA's Kennedy Space Center in Florida, the Ground Systems Development and Operations (GSDO) Program Office is leading the center's transformation from a historically government-only launch complex to a spaceport bustling with activity involving government and commercial vehicles alike. GSDO is tasked with developing and using the complex equipment required to safely handle a variety of rockets and spacecraft during assembly, transport and launch. For more information about GSDO accomplishments happening around the center, visit http://go.nasa.gov/groundsystems.*

# Orion Test Vehicle Undergoes EFT-1 Pre-transportation Simulation

NASA's Ground Systems Development and Operations (GSDO) Program spent five days preparing and evaluating the hardware and rehearsing the processes for readying the Orion crew module for overland transportation from Naval Base San Diego in California to Kennedy Space Center in Florida.

After the spacecraft's first trip into space on Exploration Flight Test-1 (EFT-1) later this year, Orion will be recovered by a U.S. Navy ship after splashdown in the Pacific Ocean and brought to the naval base to be prepared for transportation back to Kennedy.

*Workers simulated moving the Orion boilerplate test vehicle in place for lifting into the crew module transportation fixture May 14, 2014, at the Mole Pier at Naval Base San Diego in California.*

*Workers prepared for a simulated fit check of the hatch cover on the Orion boilerplate test vehicle May 13, 2014, inside a protective structure at the Mole Pier at the Naval Base San Diego in California.*

A team of about 20 technicians and engineers from Kennedy, Lockheed Martin, the U.S. Navy and the U.S. Air Force practiced pre-transportation operations and fit-check testing of support equipment with the Orion boilerplate test vehicle May 12-16 at the Mole Pier and a storage facility at the naval base.

In a storage facility at the naval base, the Orion test vehicle was lifted by crane and placed in the crew

***To SIMULATION, Page 2***

*From SIMULATION, page 1*

module recovery cradle, built by Lockheed Martin. Workers then secured Orion to the cradle, which in turn was secured to a pair of container load trailers. Wheels on either side of the trailer allow it to move easily forward and backward. Orion was transported from the storage facility about a mile to the Mole Pier.

Workers built up a protective structure at the pier for Orion. The test vehicle was moved inside to simulate removal and installation of the hatch cover. The test was performed to ensure that the designated support equipment and associated procedures were effective in removing and installing the hatch cover.

For the complete story, visit http://go.nasa.gov/1h41XqI.

For more information about Orion, visit http://www.nasa.gov/orion.


*RIGHT: The Orion boilerplate test vehicle was on display at Petco Park in San Diego, California, on May 10, 2014, before the San Diego Padres' baseball game.*

*Modifications continued May 28, 2014, on the Mobile Launcher, or ML, at the Mobile Launcher Park Site at Kennedy Space Center. A construction worker trims a section of a steel wall. The ML is being modified and strengthened to accommodate the weight, size and thrust at launch of NASA's Space Launch System and Orion spacecraft.*


*Inside the Vehicle Assembly Building at Kennedy Space Center, engineers and technicians performed a GIZMO demonstration test May 1 on the ground test article Launch Abort System, ogive panel and an Orion crew module simulator to confirm that the GIZMO can meet the reach and handling requirements for the task.*

# Employee Spotlight --- Connie Lehan

Connie Lehan is the cross-program schedule lead in the Ground Systems Development and Operations (GSDO) Program at Kennedy Space Center. Her primarily responsibility is to represent GSDO in cross-program (Exploration Systems Directorate, GSDO, Space Launch System and Orion) integration, developing products and analysis.

Lehan has worked at Kennedy for 24 years. She came to the center in 1990 and worked for Lockheed Martin. She wrote simulation programs to support launch team training. She transitioned to NASA space shuttle operations in 2000, and then to GSDO in 2007.

"GSDO is a team of very smart and talented people, and I enjoy working and learning from them," Lehan said.

She is a second-generation employee of NASA's space program. Her father worked in the Mercury, Gemini and Space Shuttle Programs.

"His stories inspired me to want to work for the space program," Lehan said. "Now I'm excited to have the opportunity to be involved in the beginning of a new program and to be a part of history."

When not at work, Lehan's hobbies include reading, gardening, going to the beach and spending time with her three sons: Jesse, 17, Joby, 16, and Josey, 14.

Her first car was a 1980 green Datsun 210. She has two golden retrievers, Roxy and Hurley.

Other family members also are working in space-related areas. Her brother Louie works for NASA at Kennedy in Ground Processing, and her other brother, Diego, works for Lockheed Martin in Colorado. Her parents, Jose and Connie, live in Titusville, Florida.


*A mining competition participant talks with a representative at the Ground Systems Development and Operations booth May 22, during NASA's 2014 Robotic Mining Competition at the Kennedy Space Center Visitor Complex in Florida.*

*Team members check their robot before the start of a mining session May 22 in the mining arena during NASA's 2014 Robotic Mining Competition. More than 35 teams from colleges and universities around the U.S. designed and built remote-controlled robots for the mining competition.*

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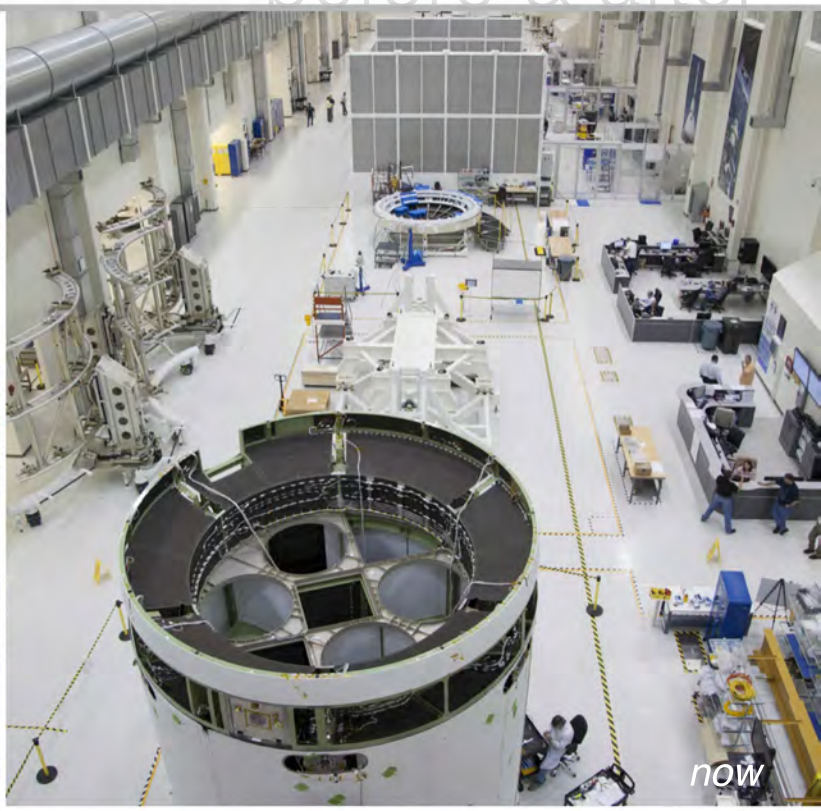
# ORION before & after


## Operations & Checkout Facility

## Crew Module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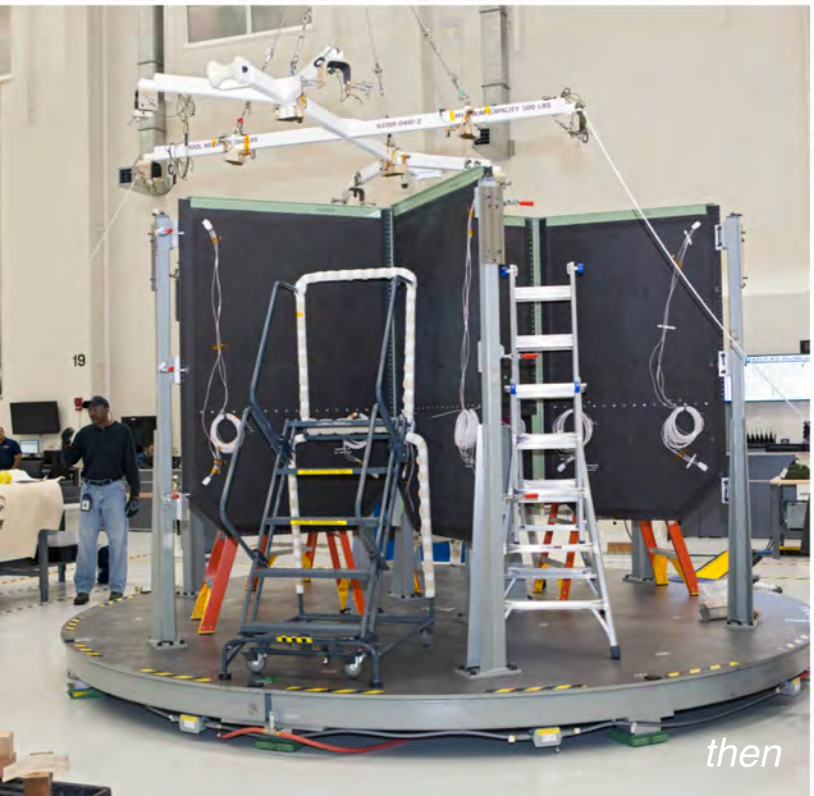
# ORION before & after



## Heat Shield

## Service Module

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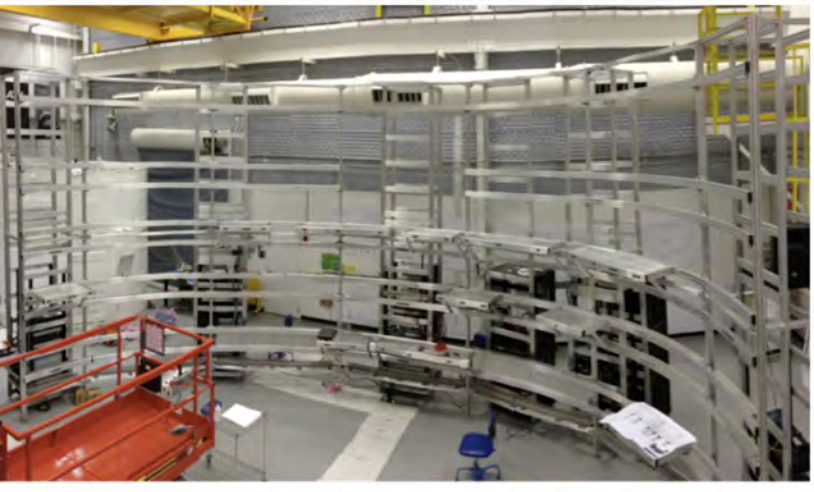
# SPACE LAUNCH SYSTEM before & after


## Vertical Assembly Center (VAC) Progress at MAF

## Stages and Avionic Progress

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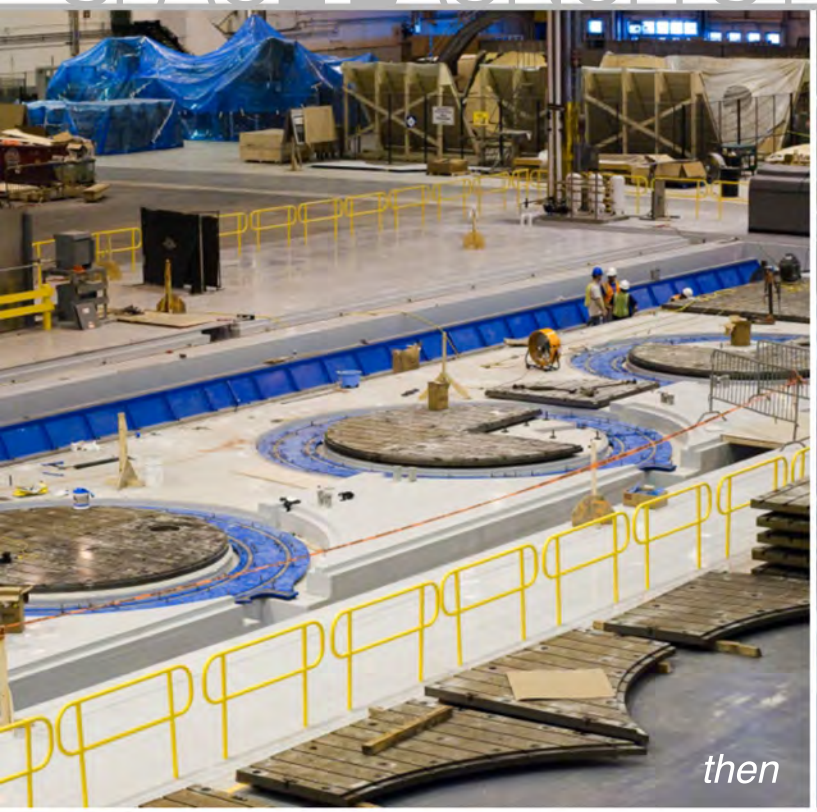
# SPACE LAUNCH SYSTEM before & after





## Core Stage Welding Tools at MAF

## Rocket Testing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# GROUND SYSTEMS before & after



## Launch Pad 39-B

## Firing Room 1


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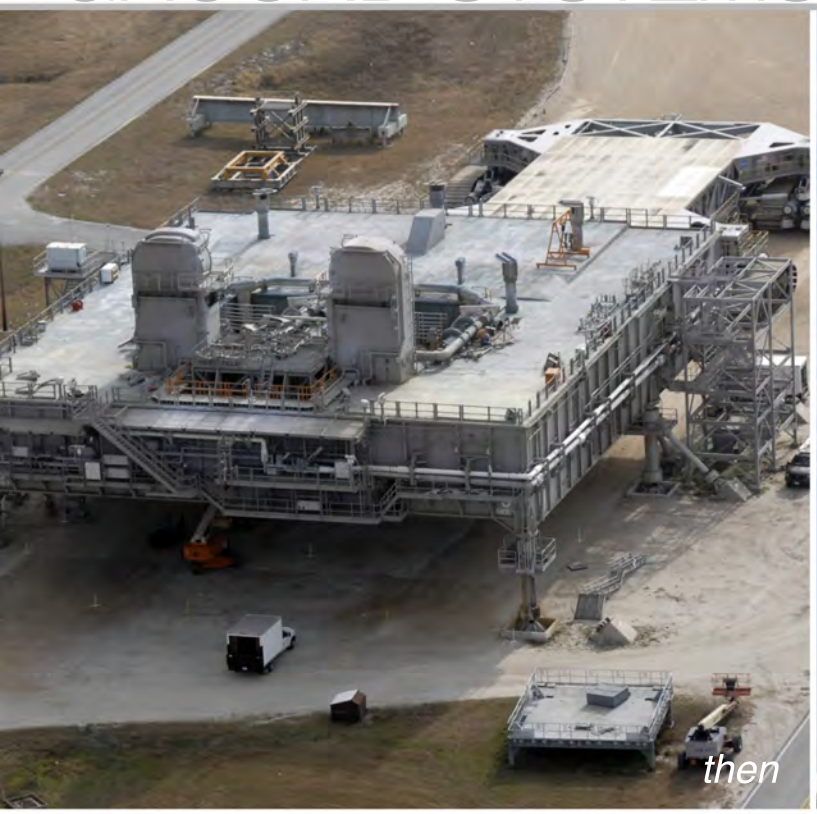
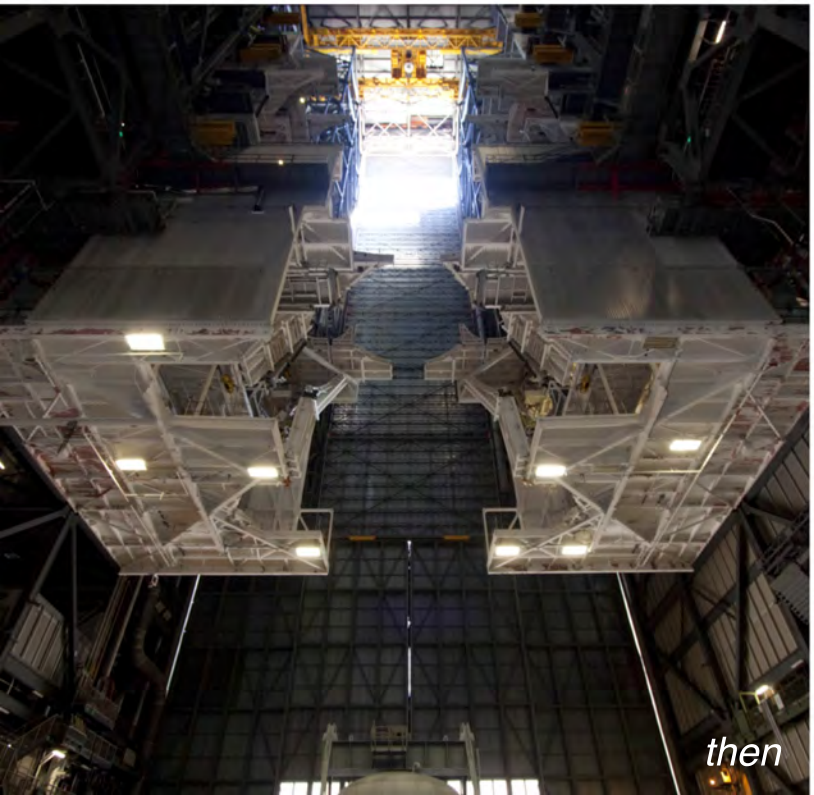
# GROUND SYSTEMS before & after

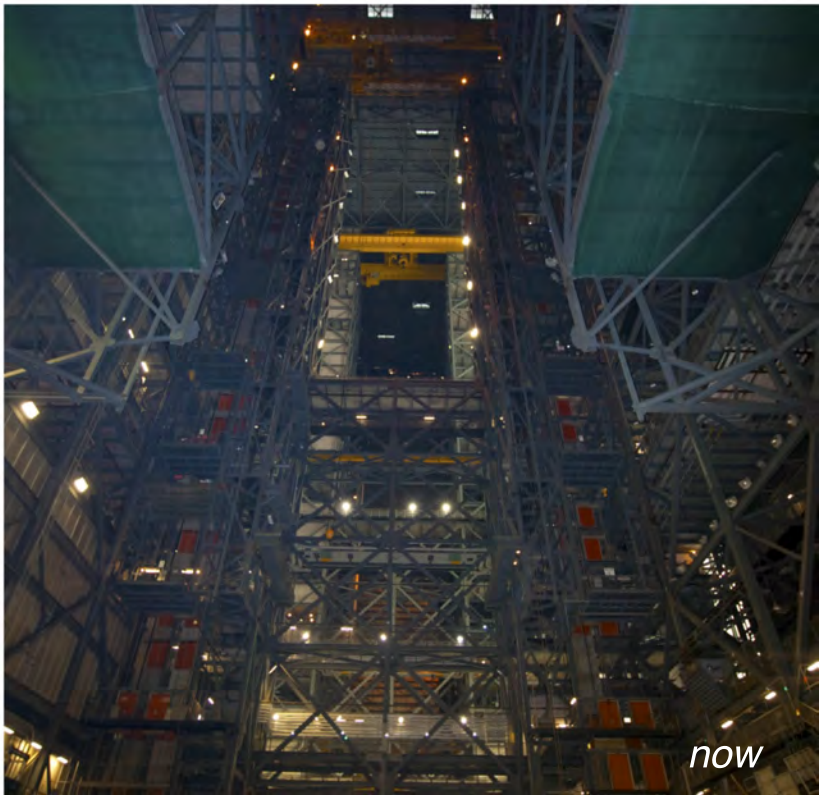




## Mobile Launch Platform

## Vehicle Assembly Building





# EXPLORATION SYSTEMS DEVELOPMENT