National Aeronautics and Space Administration

Roundup

LYNDON B. JOHNSON SPACE CENTER

Winter | 2014

JSC 2.0.13: A LOOK BACK

JSC Director

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NASA/PHOTO

I'D LIKE TO START OFF 2014 by relating a couple of JSC 2.0 stories. The first one involves the External Relations Office taking a fresh look at how they communicate about the International Space Station on NASA TV. They determined they could more effectively and efficiently communicate by morphing the daily one-hour show called "Space Station Live" into a daily half-hour show, primarily aimed at media representatives who follow NASA closely and are interested in details, plus a weekly two-minute video called "Space to Ground" designed for the general public. The snappy "Space to Ground" has the advantage that it can be easily used in a variety of venues, including the NASA home page, outreach events, airport kiosks, museums/science centers, traveling exhibits and various social media. The changes allow us to reach more people, produce products better suited to two different audiences and overall make better use of our resources. We're getting good feedback on the changes, but one of the first responses came in an email from a woman who said her 79-year-old mother, who is a big NASA fan and avid watcher of NASA TV, was very disappointed that her 60-minute show had been cut in half! While I don't like disappointing anyone (and I've sent a signed photo to the mom in a gesture of goodwill), it's actually a nice reminder that there are people everywhere who are inspired by what we do and really want to hear all about it.

The second story comes from the Chief Financial Office/LA, which held a JSC 2.0-themed holiday door-decorating contest. One of the doors featured elves representing each team member—each one of them standing on their "letter to Santa." The letters were actually brief descriptions of an innovation that the team member had personally done. I really appreciated that this group understands that for JSC 2.0 to be successful, every person needs to take action. It was powerful to see a collection of actions, illustrating that there are many different ways to contribute—and that one idea can be a catalyst for others.

I'm passionate about JSC 2.0 because I'm passionate about its purpose: **to advance human spaceflight by being lean, agile, responsive and adaptive to change.** Only by doing that will we be able to make future exploration missions, leading to a mission to Mars, possible—and possible not just because we solve the many exciting technical and operational challenges, but because we've figured out how to do it in a way that fits a budget that both the administration and Congress are willing to provide, makes the best use of every person we have, leads to smart decisions about roles for commercial and international partners and engages the public.

Ellen Ochoa

On the cover:

In this edition of *Roundup*, we look back at the major milestones involving human spaceflight and Johnson Space Center in 2013.

NASA/MICHAEL STUDINGER

Photo of the quarter:

This image of the Transantarctic Mountains was taken from the NASA P-3 airborne laboratory on Nov. 27, 2013, near the end of the 2013 IceBridge Antarctic campaign. NASA's Operation IceBridge images Earth's polar ice in unprecedented detail to better understand processes that connect the polar regions with the global climate system.

The top 10 International Space Station research results

IF THE INTERNATIONAL SPACE STATION was a guest on the "Late Show with David Letterman," it might provide a countdown of its top 10 research discoveries to celebrate its 15 years in orbit this past November. Luckily, International Space Station Chief Scientist Julie Robinson, Ph.D., recently created this top 10 research results list for the space station research blog, "A Lab Aloft." This list highlights significant outcomes from the various science disciplines studied in orbit that have benefitted people all over the world and contributed to the existing body of scientific knowledge.

Number 10 on the list is the prevention of the loss of bone mass in space through diet and exercise. In the early days of the space station, astronauts were losing about 1.5 percent of their total bone mass density per month. Researchers discovered that high-intensity resistive exercise, dietary supplementation for vitamin D and specific caloric intake can remedy this problem. This research is important for continuous astronaut and cosmonaut residency aboard the space station and for deep-space exploration in the future.

NASA/PHOTO

European Space Agency astronaut Luca Parmitano and NASA astronaut Chris Cassidy enjoy fresh fruit during Expedition 36. Fruit is part of a healthy diet, which helps astronauts maintain healthy bone mass during long-duration spaceflight.

Number nine is the study of mice in orbit to help understand mechanisms of osteoporosis. This research led to availability of a pharmaceutical on Earth called Prolia to treat people with osteoporosis, a direct benefit of pharmaceutical companies using the spaceflight environment to improve health on Earth.

Number eight is the use of hyperspectral imaging for water quality in coastal bays with the Hyperspectral Imager for Coastal Ocean (HICO) aboard station. The U.S. Environmental Protection Agency used HICO to develop a proof of concept to help monitor and protect water supplies, and plans to develop an app that anyone can use to obtain real-time water quality information.

Number seven on the top 10 list is colloid self-assembly using magnetic fields for development of nanomaterials. Colloids are tiny particles suspended in a solution, which are critical in products such as lotions, medications and detergents, as well as in industrial processes. Microgravity study aboard the space station slows movement of these colloidal mixtures, helping researchers understand how they interact. This may one day lead to better control of mixtures on the ground and development of new nanomaterials for use on Earth.

Number six is the development of a new process of cool flame combustion. The Flame Extinguishing Experiment investigations revealed "cool flames" that burned at a relatively low temperature (around 1,112 degrees Fahrenheit) for at least a minute after being extinguished. Observations of the temperature and shape of flames from burning gases in microgravity may help improve fuel efficiency and reduce pollutant emissions in practical combustion on Earth.

Number five is the pathway for bacterial pathogens to become virulent. Researchers identified the genetic pathway activating in Salmonella bacteria, allowing an increased likelihood to spread in microgravity. This led to new studies of microbial vaccine development on the space station.

Number four is the reach of space station educational activities to inspire more than 43 million students across the globe. The many inquiry-based projects allow students to be involved in human space exploration, with the goal of stimulating their studies of science, technology, engineering and mathematics.

Number three acknowledges that dark matter is still out in space, and station is looking for it. The Alpha Magnetic Spectrometer-02 (AMS-02) aboard the space station measures galactic cosmic rays using the most cutting-edge technology in existence. The data collected by AMS-02 helps scientists understand the nature of dark matter and dark energy, both of which are ongoing mysteries of the universe.

Number two is the robotic assist for brain surgery. The development and use of robotic arms for missions on the space shuttle and space station has led to the development of neuroArm, the world's first robot capable of performing surgery inside MRI machines. NeuroArm enhances the senses of vision, touch and hearing for surgeons, and has been used to successfully treat dozens of patients.

Finally, number one on Robinson's top 10 space station research results list is the new targeted method of chemotherapy drug delivery with breast cancer trials now in development. A process investigated aboard the space station, known as microencapsulation, allows for the formation of tiny, liquid-filled, biodegradable microballoons that contain various pharmaceuticals. The microballoons can streamline anti-tumor drug delivery right to the tumor site. This space station discovery has important lifesaving potential.

With continued operations until at least 2020 and likely beyond, there are many more benefits to look forward to from space station research.

Read more about the top 10 results: http://go.usa.gov/ZYXw

Orion sets the stage in 2013 for Exploration Flight Test-1

THE BEST MAY BE YET TO COME, but there's no denying that 2013 was a standout year for the Orion Program.

NASA's newest spacecraft rang 2013 with an appearance in the presidential inaugural parade, and closed out the year with the delivery of the world's largest heat shield to Kennedy Space Center (KSC). Add in a series of successful development tests, steady progress on the spacecraft and the first power on of the crew module, and you've got 12 jam-packed months.

NASA PHOTO

NASA astronauts Cady Coleman and Ricky Arnold step into the Orion crew module hatch during a series of spacesuit check tests conducted on June 13 in the Space Vehicle Mockup Facility at Johnson Space Center.

Next year's first mission, Exploration Flight Test-1, or EFT-1, will top it all off. During that flight, an uncrewed Orion will launch from KSC for a four-hour, two-orbit trip 3,600 miles above the Earth—higher than any spacecraft built for humans has traveled in more than 40 years.

"We're so close now, and the team continues to demonstrate exceptional performance in keeping us on track." said Orion Program Manager Mark Geyer. "We're close enough to feel it now, and the team is looking forward to testing what they've built."

NASA and the European Space Agency (ESA) announced in January that the two agencies had signed an agreement for ESA to design and provide the service module for Orion's second mission, Exploration Mission-1, in 2017. Orion's service module fuels and propels the vehicle in space and houses propulsion, thermal and power systems, including the solar arrays. The new design gave Orion a new look as well, updating the two formerly round solar arrays to four rectangular panels similar to ESA's Automated Transfer Vehicle.

Simultaneous with the design work toward Exploration Mission-1, the EFT-1 spacecraft moved steadily toward completion. More than 66,000 parts have arrived at KSC so far, including, in December, the spacecraft's heat shield. The heat shield will protect the crew module from temperatures of almost 4,000 degrees Fahrenheit as it returns to the Earth.

Heat shield development started in January 2012 at Orion prime contractor Lockheed Martin's Waterton facility near Denver. The heat shield titanium skeleton and carbon fiber skin, which give the heat shield its shape and provide structural support during landing, were manufactured there, then shipped to Textron Defense Systems near Boston in March of 2013. There a fiberglass-phenolic honeycomb structure was installed on the skin, and each of the honeycomb's 320,000 cells were filled with Avcoat™, an ablative material that burns away rather than transfer heat to the capsule.

Each of the cells were X-rayed and sanded to ensure the final product matched Orion's exact design specifications. That work wrapped up in the first week of December, and NASA's Super Guppy delivered it to KSC, where it will be installed on the vehicle in 2014, just before the crew and service modules are mated.

At KSC, the crew module, service module and launch abort system are all nearing completion and have spent the past year undergoing tests to ensure they'll be ready for launch next year.

In April, the crew module was secured in a massive 20-foot-tall test fixture inside the Operations and Checkout Facility for static loads testing. Hydraulic cylinders were used to slowly apply pressure to various areas of the spacecraft, simulating the loads it will have to operate under during launch, reentry and landing.

Orion came to life for the first time in November as its avionics systems were powered up for a series of systems tests. The data gathered proved that Orion's vehicle management computer and its innovative power and data distribution system would perform as expected.

NASA PHOTO

Textron technicians apply the Avcoat™ material by "gunning" the material into each of the 330,000 individual cells of the honeycomb structure.

NASA PHOTO

With the well deck drained, the Orion capsule is recovered aboard the USS Arlington, and the stationary recovery test is complete.

In addition to tests on the vehicle itself, numerous tests of specific systems and procedures took place throughout the year. The parachute team successfully conducted three Parachute Compartment Drop Test Vehicle airdrop tests at U.S. Army's Yuma Proving Ground in Arizona. In July, the Orion mock-up dropped from its highest altitude at 35,000 feet. One of the tests was designed so that one of three massive parachutes cut away early on purpose, leaving the spacecraft to land with only two. Despite this scenario, the spacecraft still demonstrated a successful landing. In 2014, they'll also test the jettison of the forward bay cover as part of the tests, which must be safely removed to allow the parachutes to deploy.

The NASA/U.S. Navy team that will recover Orion after its splashdown in the Pacific Ocean advanced from the swimming pool to the sea over the course of 2013. Work began early in the year to select hardware and develop procedures here in Houston at the Neutral Buoyancy Laboratory. Then, in August, Orion and Navy teams performed a successful recovery test at Naval Station Norfolk in Virginia in August, when Orion was tethered and pulled into the well deck of the USS Arlington. The next test in February 2014 will take them to the open sea for an underway recovery test off the coast of San Diego.

And at the Mission Control Center (MCC) in Houston, flight controllers are getting ready for their part in EFT-1 by conducting simulations and tests of their own. In September, Johnson Space Center's MCC connected with the Lockheed Martin Exploration Development Lab to execute an Orion software integration test, sending many nominal and contingency commands across the connection to assist with the verification of flight software loads in mission control and exercise flight control teams.

Then, in October, recorded Orion telemetry was successfully transmitted from the MCC in Houston to the White Sands Test Facility in New Mexico, which serves as the communication hub between the MCC and Tracking and Data Relay Satellite System (TDRSS). That was the first time Orion-formatted data was sent across that link and paves the way for future tests of the command flow between the vehicle at KSC, White Sands Test Facility, TDRSS and the MCC in Houston.

NASA PHOTO\ BILL INGALLS

The Orion space capsule, along with NASA astronauts Lee Morin, Alvin Drew, Kjell Lindgren, Serena Aunon, Kate Rubins and Mike Massimino, pass the presidential viewing stand and President Barack Obama during the inaugural parade on Jan. 21, 2013, in Washington, D.C.

Milestones

JANUARY:
Completed the Critical Design Review for the Exploration Flight Test-1 (EFT-1) Radiation Environment Monitor. The EFT-1 Auxiliary Payloads manager signed a statement of acceptance for the Battery-operated Independent Radiation Detector that will measure the radiation environment inside the Orion capsule during its first flight in 2014.

FEB. 12-14:
The 2013 Human Research Program Annual Investigators Workshop, "ISS: Finite Duration, Infinite Possibilities," takes place. The workshop achieves a significantly high level of interest and participation from the research community with over 600 attendees. Attendees included 265 researchers from industry, government and academia; 150 civil servants; 150 NASA contractors; and 64 students, post docs and NASA interns.


NASA/PHOTO

MARCH 11:
Students participate in NASA's Exploration Design Challenge. The challenge gives students from kindergarten through 12th grade the opportunity to play a unique role in the future of human spaceflight (and Orion's first unmanned launch) by thinking and acting like scientists and engineers to overcome one of the major hurdles for deep space—protecting astronauts and hardware from the dangers of space radiation.

MAY 9:
Sierra Nevada Corporation Space Systems announces the completion of its first major, comprehensive safety review of its Dream Chaser spacecraft. Dream Chaser and the United Launch Alliance Atlas V rocket combination are under development with NASA's Commercial Crew Program.

JAN 2013 | FEB 2013 | MAR 2013 | APR 2013 | MAY 2013 | JUNE 2013

JANUARY:
NASA announces an agreement with the Orion Program's first international partner, mapping out a plan for the European Space Agency to provide a service module for EFT-1 in 2017.


NASA/PHOTO

MARCH 14:
Chris Hadfield becomes the first Canadian commander of the International Space Station (ISS) in a change-of-command ceremony.


NASA/PHOTO

MARCH 26:
Space X's Dragon is detached from the station and deorbited, splashing down in the Pacific Ocean with valuable scientific cargo.


NASA/PHOTO

APRIL:
NASA's ISS Program reviewed the docking system spacecraft could use for future missions to station, including the companies working with the agency's Commercial Crew Program. Plans call for the NASA Docking System design to be made available to all U.S.-based crew-carrying spacecraft docking with the space station in the future.

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NASA/PHOTO

2013 Crews


NASA/PHOTO ISS034-S-002

EXPEDITION 34


NASA/PHOTO ISS035-S-002

EXPEDITION 35


NASA/PHOTO ISS036-S-002

EXPEDITION 36


NASA/PHOTO ISS037-S-002

EXPEDITION 37

JULY 16:
U.S. spacewalk is terminated early at the one hour, 32-minute mark after Parmitano's Extravehicular Mobility Unit (EMU) helmet begins to fill up with water. The event prompts a mishap investigation and the grounding of U.S. spacewalks for the year while an extensive investigation puts EMU 3011 back in circulation for contingency use pending the board's findings.

NASA/PHOTO

MAY 28/29:
Soyuz TMA-09M is launched from Baikonur with the Expedition 36/37 crew (Fyodor Yurchikhin, Luca Parmitano and Karen Nyberg); arrives at station six hours later.

JULY 19:
Students simulate NASA's Neutral Buoyancy Laboratory training during a summer camp at the Durango Discovery Museum in Durango, Colo. Science museums across the nation participated in JSC's Spaceflight Explorers, a project that provides science, technology, engineering and math activities to increase student awareness and interest in NASA's human spaceflight missions.

SEPT. 18:
Antares launches from Wallops with the Cygnus spacecraft on a demonstration mission to the space station. After a navigation glitch delays the final phase of its rendezvous, Cygnus makes its maiden arrival at the station on Sept. 29.

AUG. 16:
Cosmonauts Yurchikhin and Alexander Misurkin conduct a seven hour, 29-minute spacewalk—the longest in Russian spacewalk history—to route power and Ethernet cables for the future arrival of the Russian Multipurpose Laboratory Module, as well as to collect experiment packages.

NASA/PHOTO

DEC. 4:
Orion's heat shield is ready to turn up the heat as it arrives at Kennedy Space Center via the Super Guppy aircraft.

JULY 2013 | **AUG 2013** | **SEPT 2013** | **OCT 2013** | **NOV 2013** | **DEC 2013**

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JUNE 15:
The "Albert Einstein" ATV-4 resupply ship arrives at the station with more than 7 tons of supplies (launched from French Guiana on June 5).

NASA/PHOTO

JULY 22:
Two NASA astronauts conduct flight suit evaluations inside a fully outfitted test version of The Boeing Company's CST-100 spacecraft—the first time the world got a glimpse of the crew capsule's interior.

OCT. 28:
Orion comes to life when its avionics system is powered on for the first time after being installed inside the crew module. A series of tests show that Orion's vehicle management computer and innovative power and data distribution system all perform as expected.

NASA/PHOTO

NOV. 7:
The last test of Morpheus at Johnson Space Center, the Ground Takeoff and Landing test, is successfully flown.

NASA/PHOTO

NOV. 9:
The Olympic torch destined for the XXII Olympic Winter Games in Sochi is displayed during a Russian spacewalk by cosmonauts Oleg Kotov and Sergey Ryazanskiy.

DEC. 2:
NASA enhances its daily NASA TV "Space Station Live" program with a new 30-minute format. Later, on Dec. 6, a new weekly Web series called "Space to Ground" debuts, showcasing a short wrap-up of weekly station activities.

NASA/PHOTO ISS038-S-002

EXPEDITION 38

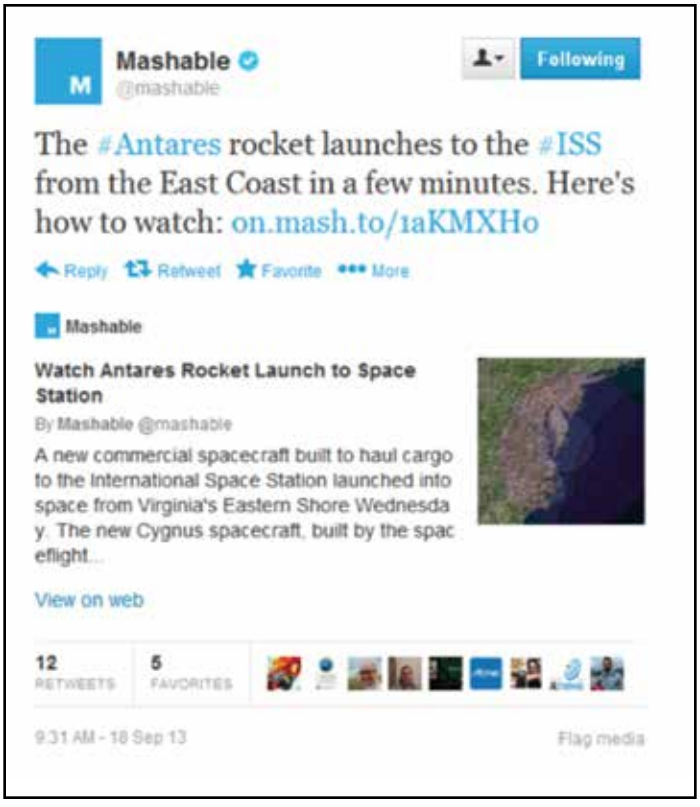
2013 **Social Media** Spotlight

THE WIDESPREAD USE OF SOCIAL MEDIA is making it easier to share NASA's messages around the world, and 2013 was no exception. Tweets, videos and posts, gaining followers, getting retweets and connecting with millions of people through the use social media brought NASA into households and digital devices like never before. *Entrepreneur* said of NASA's social media effort, "When you think of NASA, you probably think of spaceships, telescopes and lunar expeditions. What you might not know is that the organization is also a powerhouse when it comes to social-media marketing—an achievement they've reached without the benefit of a social-media budget."

Earth observation photos posted by astronauts living on the International Space Station have grabbed the attention of many social media users, as well as traditional media news stories. This photo posted by Astronaut Karen Nyberg (@AstroKarenN) of Typhoon Haiyan on Nov. 9, 2013, was retweeted more than 6,000 times. Compare that to popular tweets by the @NASA flagship account, including a tweet about the Voyager spacecraft reaching interstellar space that was retweeted over 5,000 times, and it shows how inspiring our combined efforts are to a public hungry for the mystery and drama our universe organically provides. Nyberg has also posted to Pinterest throughout her entire mission. Astronaut Mike Hopkins, who is living on the station until March 2014, is also posting Earth photos and mission updates to his Twitter account, @AstroIllini.

Mission events popular in the traditional news have also proven to be huge topics of conversation on social media. For instance, when Orbital Science's Cygnus vehicle launched for the first time to the station on Sept. 18, 2013, 9,170 tweets were posted on the subject, giving 157 million people around the world the opportunity to see those posts. *Mashable* tweeted about the launch twice to their nearly 3.5 million followers.

Social media has also provided an additional capability to easily share NASA's missions and messages with the public. This photo of South Africa (on the opposite page) taken from the station was posted in honor of Nelson Mandela on the day of his passing and received more than 10,000 retweets, giving more than 60 million people the opportunity to view the photo.



Out-of-this-world photos come to Instagram

NASA kicked off their account on another popular social media site in 2013: Instagram. Not too far behind, Johnson Space Center also began their presence on the photo-centric site. Gaining 350,000 followers in less than three months, NASA's Instagram account has allowed a new audience the opportunity to view photos from space.

"350,000 followers agree: no one does selfies quite like NASA.

It's the year of the 'selfie,' and the year that social media-transmitted self-portraits were taken to new heights with the arrival of U.S. space agency NASA on Instagram.

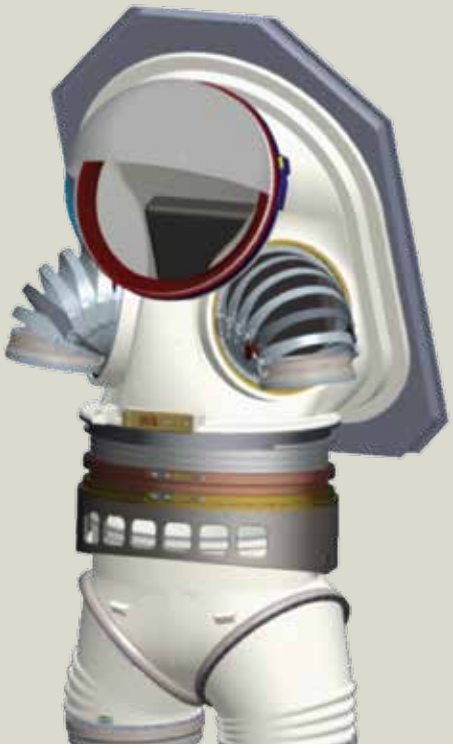
In less than three months, the space agency has accumulated over 350,000 followers and given them an incredible insight into the day-to-day lives of astronauts and NASA's work unraveling the mysteries of the universe."-- CNN

Visit www.nasa.gov/connect to check out all NASA's social media sites if you haven't already. It's time to connect, share and be inspired by your space program!

Spacesuits transform for ambitious missions

In 2013, the Advanced Exploration Systems Advanced Extravehicular Activity (EVA) Development project awarded the contract for design and manufacturing of the first human-rated, exploration-class prototype EVA spacesuit for human-vacuum testing in more than three decades. This suit, dubbed the Z-2, builds on the knowledge gained from all previous EVA flight and prototype suits and includes a broad range of new capabilities and enhancements that will support spacewalks in a variety of potential future destinations. The Z-2 design review was successfully completed in preparation for manufacturing of the suit in 2014.

The group also completed assembly of the Portable Life Support System (PLSS) 2.0, the first new design of a PLSS in more than 30 years. Designed for deep space, this new PLSS is much more robust and flexible and also allows for microgravity and surface spacewalks at multiple destinations.



NASA's 'what's next' team

THEY ARE NASA'S "WHAT'S NEXT" TEAM.

Small but agile, the Concept Analysis Team, or CAT, as this handful of multi-disciplined professionals is formally known, has a far-reaching charter.

They reach out from their organizational roots within Johnson Space Center's Engineering Directorate to experts across NASA to establish capabilities that will enable the nation's next steps in human exploration.

NASA PHOTO

The Concept Analysis Team at JSC plots future spaceflight goals.

Much of CAT's attention has been focused on NASA's asteroid redirect mission (ARM) and two cornerstone exploration capabilities, the Orion Multi-Purpose Crew Vehicle (MPCV) and Space Launch System (SLS).

"The way I talk about this with my kids is that it is our 'what's next' team," said CAT lead Mark McDonald. "CAT's purpose is to figure out what's next."

Stepping into the assignment in 2010, McDonald inherited a guiding strategy for CAT activities referred to as "capability-driven framework."

"That's NASA's policy for exploration, in that we are going to develop capabilities to enable future exploration missions and identify which are the right capabilities we need next," McDonald said. "The first run of that justified the Orion Multi-Purpose Crew Vehicle and Space Launch System programs. They are fundamental capabilities necessary to move forward with exploration."

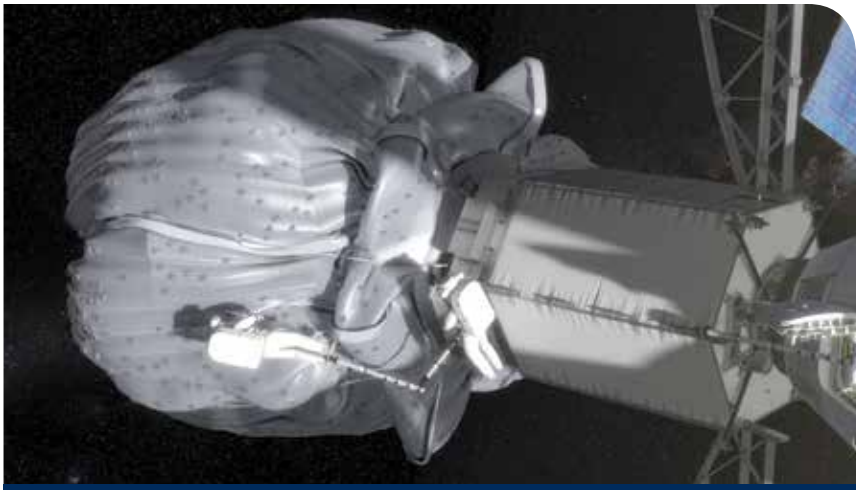
A joint human and robotic demonstration, ARM will capture and maneuver a small asteroid into a stable orbit around the moon with an uncrewed spacecraft.

ARM's robotic first chapter will push into deep space for the asteroid capture. Once in lunar orbit, an asteroid up to 10 meters in length will be available to NASA and the agency's partners for decades. That should be long enough to carry out missions of human exploration and scientific investigation while also developing future capabilities for human deep space missions and, potentially, planetary defense.

The first encounter between NASA astronauts and the asteroid may come as soon as Exploration Mission 2, the inaugural piloted test flight of Orion and the SLS rocket that is targeted for 2021.

CAT emerged as part of the Engineering Directorate's Systems Architecture and Integration Office, which was established in 2008 to assess advanced systems and concepts for robotic and human missions. The team works closely with NASA's Human Spaceflight Architecture Team, or HAT, a senior multi-disciplinary cross-agency team responsible for carrying out regular strategic assessments, explained Joe Caram, who oversees CAT's activities as Engineering's deputy manager for Technical Integration Office.

"HAT does the up and out architectural trades, or the broader scope of these missions," McDonald said. "When they specify a mission, our team goes down into the great depths of analysis to say it looks good or it won't work. It's the interplay between the two teams that creates healthy answers."



NASA PHOTO

In this conceptual image, the two-person crew uses a translation boom to travel from the Orion spacecraft to a captured asteroid during a spacewalk.

NASA PHOTO

This conceptual image shows NASA's Orion spacecraft approaching the robotic asteroid capture vehicle. The trip from Earth to the captured asteroid will take Orion and its two-person crew an estimated nine days.

Orion and SLS figure prominently the exploration framework.

"They are fundamental capabilities necessary to move forward with exploration," McDonald said. "The question is: With an MPCV and SLS, what next?"

The options are broad, ranging from the human asteroid exploration goals outlined by President Obama and some from the commercial sector to the lunar missions favored by some in Congress and NASA's international partners. Mars, the president's choice, looms as the ultimate commonly favored destination for human explorers.

ARM's robotic and human phases are structured on a flexible path to achieve any of those objectives.

Advances in solar electric propulsion, an in-space propulsion technology already used aboard NASA's Dawn main belt asteroid mission and some Earth-orbiting communications satellites, is an example.

Selected to power the robotic phase of the ARM mission, solar electric propulsion might propel a future lunar tug rising from Earth orbit. When coupled with the life support, spacecraft docking and extravehicular activity (EVA) mobility requirements for the human phase of ARM, solar electric propulsion, along with traditional chemical propulsion operated in a hybrid mode, promises to greatly reduce the travel times to Mars.

As CAT systems and integration leads, Pedro Lopez and Heather Hinkel found themselves tasked with matching ARM requirements to Orion and SLS capabilities. They succeeded with teamwork and the expertise found across JSC and NASA's other centers in avionics, EVA, environments, human factors, life support, power, structures and thermal.

Orion is baselined for a crew of four and missions of up to 21 days, but without the docking or spacewalk capabilities for a human asteroid encounter.

Mass constraints are a constant challenge in mission planning, as well as spacecraft development. Design changes are costly, noted Lopez and Hinkel.

They found solutions in "mission kits" that could be added to the ARM mission to meet the requirements for guidance and docking, spacewalks and communications. The mission crew was reduced to two astronauts to offset the mass of mission-specific additions.

"We studied the logistics, the maximum mission duration," Lopez said. "We looked at what factors we needed and how we could add them without impacting the Orion and SLS design."

Hinkel, working with colleagues at the Jet Propulsion Laboratory, led efforts to pre-stage EVA tools for the astronauts on the robotic components of the ARM mission to offset mass. Past experience with the Sensor Test for Orion Relative Navigation Risk Mitigation development test objective flown on STS-134 helped her integrate guidance components into the international docking system hardware on the robotic spacecraft for use by the Orion crew.

Power from the solar electric power system solar arrays on the robotic spacecraft will furnish electricity to the astronauts through the docking interface.

"The interplay between the robotics and human mission elements to make everything work has been very impressive," Hinkel said.

The core team approach allows CAT members to call upon the expertise of their NASA colleagues without pulling those specialists away from their day-to-day responsibilities.

"It is very much a broad team," McDonald said. "It's a bunch of A-team players. When you hand someone the all-star players at every position, you get a fantastic team. That's what gives CAT so much energy—you have the best of the best across the disciplines."

NASA PHOTO

This concept image shows an astronaut retrieving a sample from the captured asteroid.

Roundup

The Roundup is an official publication of the National Aeronautics and Space Administration, Johnson Space Center, Houston, Texas, and is published by the External Relations Office for all Space Center employees. The Roundup office is located at the Johnson Space Center, Building 2. The mail code is AD94. Visit our website at: http://www.jsc.nasa.gov/roundup/online/ For distribution questions or to suggest a story idea, send an email to jsc-roundup@mail.nasa.gov.

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NASA hails success of commercial space program, plans readied for astronauts

A LITTLE OVER TWO YEARS after the Space Shuttle Program ended, the United States has two space transportation systems—SpaceX's Falcon rocket and Dragon spacecraft and Orbital's Antares rocket and Cygnus spacecraft—capable of delivering science experiments and supplies to the International Space Station.

NASA Administrator Charles Bolden hailed the success of the agency's public-private partnership with American companies to resupply the space station and announced the next phase with U.S. companies to transport astronauts is set to begin late November 2013.

Orbital's Antares rocket, with the Cygnus cargo spacecraft aboard, is seen as it launches from Pad-0A of the Mid-Atlantic Regional Spaceport, NASA Wallops Flight Facility, Va., on Sept. 18, 2013.

The rockets and spacecraft developed by NASA's partners Space Exploration Technologies Corp. (SpaceX) and Orbital Sciences Corp. under Commercial Orbital Transportation Services (COTS) have significantly increased NASA's ability to conduct new scientific investigations aboard the orbiting laboratory. All current and planned U.S. experiments aboard the station will be facilitated in some way by a SpaceX or Orbital Sciences resupply mission.

"America's best days in space exploration are ahead of us thanks to the grit and determination of those in government, and the private sector, who dare to dream big dreams and have the skills to turn them into reality," Bolden said. "We've ended the outsourcing of space station resupply work and brought those jobs back home to America. The commercial space industry will be an engine of 21st century American economic growth and will help us carry out even more ambitious deep space exploration missions."

SpaceX was selected as a NASA partner in 2006 to develop its Dragon spacecraft and Falcon 9 rocket. SpaceX completed its COTS development with a demonstration mission to the space station in 2012, restoring an American capability to deliver and return cargo for the first time since the retirement of the space shuttle in 2011.

SpaceX has since flown the first two of 12 contracted cargo resupply flights to the space station through a $1.6 billion Commercial Resupply Services (CRS) contract with NASA.

Orbital Sciences was selected as a NASA partner in 2008 and completed development of its Cygnus spacecraft and Antares rocket in October 2013 with a successful demonstration mission to the space station. The final review of the mission by NASA marked the beginning of closeout activities for the COTS program. Orbital Sciences is poised to launch the first of its eight cargo resupply missions to the space station in December 2013 through its $1.9 billion CRS contract with NASA.

Orbital Sciences and SpaceX offer some similar capabilities to resupply cargo, ensuring NASA can maintain continuity in delivering critical supplies for space station crews. Each company also offers unique capabilities of importance to NASA. Orbital Sciences' Cygnus spacecraft can carry a large pressurized volume of cargo. Cygnus burns up in Earth's atmosphere on reentry, which allows astronauts to discard items no longer needed aboard the station by loading them inside the spacecraft before its departure. SpaceX's Dragon is the only spacecraft in the world capable of returning large amounts of cargo from space, which includes science experiments conducted aboard the station that can be delivered to researchers on Earth. Dragon also can carry unpressurized cargo, destined for the exterior of the space station, underneath the spacecraft.

Johnson Space Center managed NASA's COTS program, which led to two brand-new commercial providers building new rockets, new spacecraft and starting regular cargo flights to the space station. The partners also achieved a number of firsts for the U.S. commercial space industry. This included the first commercial spacecraft to orbit and return to Earth, achieved by SpaceX. The company also was the first commercial provider to resupply the space station. Orbital Sciences was the first company to launch to the space station from Virginia, beginning its mission from the new Mid-Atlantic Regional Spaceport Pad-0A at NASA's Wallops Flight Facility in Wallops Island, Va.

NASA and its Commercial Crew Program partners also are working to develop the next generation of U.S. spacecraft and rockets capable of transporting humans to and from low-Earth orbit from American soil. NASA intends to use new commercial capabilities to fly U.S. astronauts to and from the International Space Station within the next four years. On Nov. 19, the agency issued a final Request for Proposals for the new Commercial Crew Transportation Capability contract, designed to ensure commercial companies meet NASA's safety requirements for transporting NASA crews to the space station. This procurement phase is expected to include crewed demonstration missions to the space station before 2017.