In December 2014, NASA will launch Orion, the most advanced spacecraft ever built, 3,600 miles into space—the farthest a spacecraft designed to carry humans has traveled in 40 years. This will be Orion’s first test flight, and no crew will be aboard. However, a successful second test flight set for 2017 may open the door for Orion’s first astronauts to spend four days in lunar orbit in 2021.

Not since the Apollo missions ended in 1972 have American astronauts traveled beyond low Earth orbit. By heading for the Moon, Orion will begin where those missions left off before embarking on more ambitious journeys to asteroids, the Martian moons—and eventually the red planet itself.

Because Orion will travel farther than any crewed spacecraft ever has, it requires the most advanced technology and materials ever used. Designing, building, and testing Orion has involved hundreds of scientists at NASA, the European Space Agency, and Lockheed Martin. Here, three NASA scientists explain their contributions to the spacecraft that is ushering in an exciting new era of space exploration.
Two Modules, Two Missions

Lara Kearney
Deputy Manager, Crew and Service Module Development

Before working on Orion, Lara Kearney specialized in making the spacesuits astronauts wear for extravehicular activities (EVA), or space walks. In that role, she oversaw the creation of the complex computer systems and materials that keep astronauts safe and dextrous while performing tasks in space that would be difficult even within Earth's gravity and with bare hands.

This experience will be useful for future Orion missions when astronauts will conduct EVAs, whether on the Moon or Mars. But for now, Kearney is focused on Orion's crew module, where the four-person crew will reside, and the service module, which serves a range of functions, from providing in-space propulsion to generating and storing power while in orbit to providing water, oxygen, and nitrogen for the crew module. “We’re in a very interesting time in development,” Kearney says, “because we’re working on two vehicles at the same time.”

Not only must Kearney shift her focus between these two modules with very different functions, but she and her team must simultaneously prepare these modules for upcoming test missions. The first, Exploration Flight Test-1 (EFT-1), will be an unmanned flight test of the launch abort system, crew module, service module, and the spacecraft adaptor, which connects Orion to the launch rocket. That flight will take place in December 2014.

“The last few months have been about putting the final touches on the hardware,” Kearney says. “We’re bringing the whole vehicle together and making sure it’s ready to fly.” For example, Kearney’s team is ensuring that the heat shield will protect the spacecraft during reentry to Earth’s atmosphere, when it will endure temperatures up to 4000°F.

The other mission she’s overseeing is Exploration Mission-1 (EM-1), a second unmanned flight test scheduled for 2017. “That’s where we’re bringing on the crew systems,” she says. Specifically, she will be looking at how the crew’s water and oxygen supplies will factor into the launch. At every step, one of Kearney’s top goals is to find every way possible to minimize weight and materials. “We’re looking for regenerable technologies,” she says, “which save mass and cost.” For example, the current method of removing carbon dioxide and keeping the air oxygen-rich for the crew requires disposable cans. Kearney’s team is exploring devices that will make breathable air without drawing from disposable containers—which, after use, are deadweight on a mission where every centimeter of space and gram of mass count.

One of the biggest challenges Kearney’s team faces is that the process of testing their designs takes considerable time. For both EFT-1 and EM-1, Kearney and her team must accommodate for technology—especially in electronics and avionics—advancing so quickly that last month’s designs can already be out of date. The solution is to build in a way that anticipates advances and allows them to be integrated in an ever-evolving design. “You try to build your systems to be flexible, with open architecture,” Kearney says.

Much work lies ahead, but recent progress on Orion has been inspiring for Kearney. “I live in Houston, surrounded by managers and engineers, and we see most things on paper,” she says. When she went to Florida and saw the early incarnation of the EFT-1 vehicle, it was a thrill. “Seeing the hardware come together and performing how people designed it,” she says, “that’s the best part of the job.”

Ensuring Safe Landings

Jose Ortiz, Ph.D.
Lead Systems Engineer, Launch Abort Systems

Dr. Jose Ortiz focuses on an essential component of Orion that he hopes will never be used. The Launch Abort System (LAS) is designed, as Ortiz says, to “rescue the crew from harm’s way” should anything malfunction. The safety system reaction time is measured in milliseconds.

No matter how precise the planning, there is always a chance for disaster when sending a crew through space at hundreds of miles per hour, attached to rockets drawing from reservoirs of volatile chemicals. “The crew is always taking a risk,” Ortiz says.
While Orion will be sending astronauts farther into space than humans have ever gone before, the most high-risk time frame is before the craft even leaves the atmosphere. According to Ortiz, the ascent phase of the mission—when Orion is on the launchpad, the rockets ignite, and the vessel leaves Earth’s surface—is the most dangerous. His team’s goal is to minimize the risk to the crew during those critical minutes when the craft is speeding upward to break Earth’s gravitational pull.

Ortiz and his team designed the secondary rockets that, should the main rockets fail during takeoff, propel the crew module away from the launch rocket’s dangerous combustion. He is also responsible for the parachutes that would deploy following a failed launch and allow the crew module to descend safely to the ground. After a successful launch, these parachutes would need to survive the entirety of the Orion mission so that, upon reentry, the module would slow gradually from 20,000 miles per hour to 20 miles per hour for a safe landing.

As in all NASA development, the grunt work for Ortiz and his team lies in the copious research and practice needed to account for all possible scenarios. “It’s all tested and tested and tested to make sure it’s going to work,” Ortiz says. So when a model is built and works as planned, it’s cause for celebration, as happened in 2010 at the White Sands Missile Range test site in New Mexico. His team tested the “pad abort flight test at rest,” which confirmed the function of the motor responsible for jettisoning the crew should something malfunction while Orion is on the launch pad. “It was just perfect,” he says. “It followed the simulation exactly.” Another successful test took place this past June, when a test module was dropped from 35,000 feet from a C-17 airplane to a successful landing on the U.S. Army’s Yuma Proving Ground in Arizona.

Right now, Ortiz is focused on prepping the LAS for EFT-1. “The test isn’t for emergency procedure,” Ortiz says, but “will test the parachute and crew module reentry.” He and the rest of the Launch Abort System crew will be ready to take those lessons to the next stage, when, as soon as 2021, astronauts’ lives will depend on their work.
Seamless Integration

Kathy Schubert
Manager, Service Module

Kathy Schubert is charged with making sure all the delicate, sophisticated, and very expensive components in the Orion craft work together reliably. If that isn’t daunting enough, some of these components—specifically the crew module’s power and propulsion elements—are being built by the European Space Agency (ESA). For Schubert, that means calculating and accounting for different units of measurement when imprecise figures can mean a fatal error.

“We started working with ESA three years ago to define the hardware they’ll contribute,” Schubert says, “and we’ve matured their design to the same level as our vehicles for EM-1.” Since these components are being built across the Atlantic on different machinery, Schubert and her team are tasked with designing special adapters that make sure the U.S.-made designs can physically accommodate the European components.

Like many of her Orion colleagues, Schubert focuses on keeping mass to a minimum. She and her team constantly trade documents and evaluate each other’s work to make sure not only that the final craft works seamlessly when assembled, but that the final design does not weigh even a fraction of an ounce more than necessary. “On the Orion side, we have well-established processes to work with Lockheed Martin,” she says, referring to the manufacturer charged with building the ship and its components. “At every discipline level, within the structural engineering teams at both Lockheed and the ESA, we participate in their reviews,” she says.

One solution that helps to ensure the mechanics will work together, and keep the overall cost down, is to outfit Orion with “heritage hardware,” such as an engine from the Space Shuttle, that has been used on previous missions. “Part of our agreement with the ESA is to provide [such an] engine,” Schubert says, “We have offered that to them for the European service module.”

For Schubert, all the hours spent trading information and verifying compatibility of various components pay off when the actual hardware works as planned. “We are getting so close to our EFT-1 mission,” she says. “It’s always exciting to see hardware work successfully, so the parachute drop test, that is one of those defining moments.” With the 2017 EM-1 launch getting closer every day, it is encouraging to see that all the hard work ends with a tangible demonstration of engineering. “Your reward is seeing that hardware,” she says, “and knowing that the rigor and discipline that has gone into making it on time has paid off.”

Launching a Student Experiment

In March 2013, NASA, Lockheed Martin, and the National Institute for Aerospace announced the year-long Exploration Design challenge, for which high school students created designs for a shield to protect astronauts and equipment as Orion flies through the Van Allen Belt, a field of intense radiation that surrounds the Earth.

Researchers at the three sponsoring organizations assessed students’ designs in an online simulation of radiation exposure. The design by Team ARES—a shield that incorporated layers of tantalum, tin, zirconium, aluminum, and polyethylene—showed the greatest radiation protection in that simulation.

Lockheed Martin provided funds to build a prototype of Team ARES’s concept to install in Orion’s crew module. Team ARES will see their experiment take flight in December when they travel to Kennedy Space Center in Florida for Orion’s EFT-1 launch.

—MELISSA HARTMAN

The Orion spacecraft includes the launch abort system (LAS), crew module, and service module. Learn more about the spacecraft and its mission at www.nasa.gov/exploration/systems/mpcv.

www.cty.jhu.edu/imagine