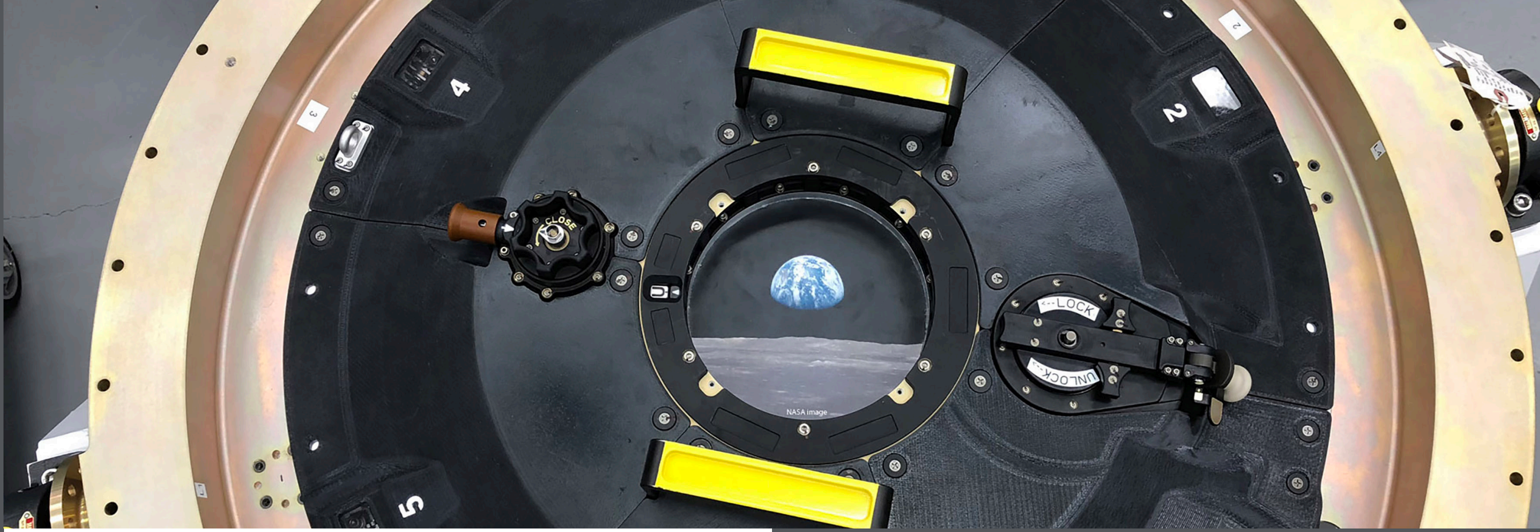

Deep Space with Humans on Board

Humans On Mars

If space is the final frontier, then human travel in to deep space, beyond the Moon, is the ultimate frontier. NASA's Orion program intends to do just that – travel with humans on board back to the Moon and out into deep space, and one day soon, Mars.

But before human travel, NASA is launching a series of test missions to target risk reduction, efficiencies identification, and industry partnerships enhancement. A successful Exploration Flight Test-1 is already behind them and NASA is poised to launch the next un-crewed phase of its mission, Exploration Mission-1 (EM-1), in late 2019. And then, EM-2 will follow in 2023, but with one major addition; this spacecraft will be crewed.

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>
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> Lockheed Martin Space

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The conditions of deep space require a multi-mission approach with rigorous parts testing and the construction of a new spacecraft for each mission. This ensures both the integrity of the parts but also poses a challenge for Lockheed Martin, prime contractor for the Orion vehicle: repeatability.

“The goal of the Exploration Missions and the spacecrafts themselves are that you’ll start to limit the design changes and the design updates as you go from one mission to the next,” said Brian Kaplun, manager, additive manufacturing at Lockheed Martin Space. The idea is that a part would be thoroughly tested before going forward “because these capsules become copies of one another, so that each one is an enhancement but the baseline remains static.”

Material Makes the Part

In its quest to position the nation and U.S. companies as world leaders, NASA is using advanced manufacturing techniques, such as 3D printing on board both the rocket and spacecraft. In fact, EM-1 has more than 100-3D printed parts on board. “What’s become apparent recently is the maturity of the 3D printing systems,” said Kaplun. “The actual machines doing the printing are more reliable and when you install a new piece of equipment and you print a part on two separate machines with the type of quality controls we have in place, you will get a part that will perform very similarly.”

Lockheed Martin Space has seven 3D printers in its Additive Manufacturing Lab, the latest of which is the Stratasys Fortus 900mc™, with its higher thermal capability and ability to print larger parts. With each capsule newly constructed for that flight, the importance of repeatability takes on a new significance. “It becomes a lot more attractive to be able to utilize additive manufacturing on EM-1 and have that high degree of confidence for the same part on EM-2, 3 and beyond,” said Kaplun. “It’s a really attractive time to be able to break in with additive parts.”

In addition to the manufacturing process, the materials used have a rigorous needs assessment attached to them. “The granddaddy of flight components has been the ULTEM™ 9085 resin material,” said Kaplun. “It’s well-understood, has excellent strength properties, excellent thermal properties, excellent out-gassing; it really is ideal for utilization in space environments.” But one property has been missing in this material for use in deep space: electro-static dissipative (ESD) capabilities.

“There’s always been the attraction of having an ESD-compliant polymer,” said Kaplun. “There were ESD compliant polymers available but they were ABS, and ABS is not something we would be able to fly on a spacecraft,” due to mechanical, functional and dimensional stability issues.

“So when Stratasys allowed us access to be a Beta customer for this new material, Antero™ (ESD), we got a material that’s strong and capable of being used as a structural polymer that has those ESD qualities that we were looking for,” said Kaplun. Antero (ESD) is a Stratasys PEKK-based high-performance polymer with low-outgassing properties and ESD capability. “We’ve been able to see orders of magnitude savings both in cost and schedule on all of these parts because the part builds are very consistent, the material properties are well understood, and the build parameters are becoming better understood. Also, the properties of the ESD PEKK eliminate a large amount of the post processing that we would otherwise have had to do. So that also nets a tremendous amount of time savings.”

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ESD PEKK "has enabled us to achieve very consistent builds that move beyond the realm of prototyping and into production in a manner that is consistent," said Kaplun. "It yields repeatable results, and we can now, with a high degree of confidence, know that we're not just making a single part but a family of parts."

The Stratasys Antero (ESD) part on Orion is the outside of the docking hatch and measures one meter in diameter. "The hatch covering is made entirely of ESD PEKK," said Kaplun. ULTEM™ 9085 resin covers would still have needed some sort of coating or nickel plating to deflect the static charge, making ESD PEKK very attractive to Lockheed. The six-piece part joins together to form a ring on the outside of the docking hatch, "much like a pizza in six slices with a hole in the middle, or a donut," said Kaplun.

Lockheed Martin expects more ESD PEKK parts will follow on Orion. "We're excited to use this as a proof of concept because there are similar systems on the other hatches and elsewhere on the vehicle," said Kaplun. ESD PEKK is also biocompatible, or suitable for human contact, and there are other large-scale parts such as oxygen ducting and large sections of the tubing and mapping brackets on the spacecraft that may also be Antero (ESD)-suitable. "Due to the large size and complexity of these parts they are very attractive for polymer manufacturing and 3D printing because they can be done all in one piece," said Kaplun.

Kaplun sees something very special about a space mission that's going to have people on board. "There's that intimate connection when you can associate yourself with the astronauts going on the mission, and it's nice to be able to tie-in technological advancement [like 3D printing] to these missions."

The electro static dissipati ve qualities of Antero™ (ESD) PEKK material make this part flight-worthy.

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