

GUEST EDITORIAL Cady Coleman with Susan Alzner of shift7

WILL NASA'S NEXT GENERATION SPACESUIT FIT YOU?

Artemis: Twin sister of Apollo. Goddess of the Moon. Guardian and supporter of girls and young women. As NASA's Artemis lunar exploration program prepares to "land the First Woman and Next Man on the Moon, using innovative technologies," there is an opportunity to change the course of history—by innovating spacesuit design to be as suitable for the range of women's bodies as they are for the range of men's.

Spacesuit fit can be a determining factor in the performance of mission critical activities, such as spacewalks. For Artemis astronauts, the stakes are high: spacewalking ability will likely determine which astronauts walk on the Moon.

NASA has announced that they are committed to providing spacesuits that fit all astronauts for future exploration missions. In October 2019, the agency presented a prototype of a new suit design for Extravehicular Activity (EVA): the Exploration Extravehicular Mobility Unit (xEMU):

The new lower torso includes advanced materials and joint bearings that allow bending and rotating at the hips, increased bending at the knees, and hiking-style boots with flexible soles. On the upper torso, in addition to the updated shoulder placement, other shoulder enhancements allow astronauts to move their arms more freely and easily lift objects over their heads or reach across their body in the pressurized suit.

—NASA, October 8, 2019¹



Photo Credit: Astronaut Paolo Nespoli— NASA

Cady and the ISS spacesuit in 2011

It is exciting that the new suit's improved range of movement will enable a wider range of astronauts to use it. The xEMU is not finalized; testing and iteration will continue as the Artemis program evolves.

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Each Spacesuit Is a Spacecraft— in the Shape of a Human

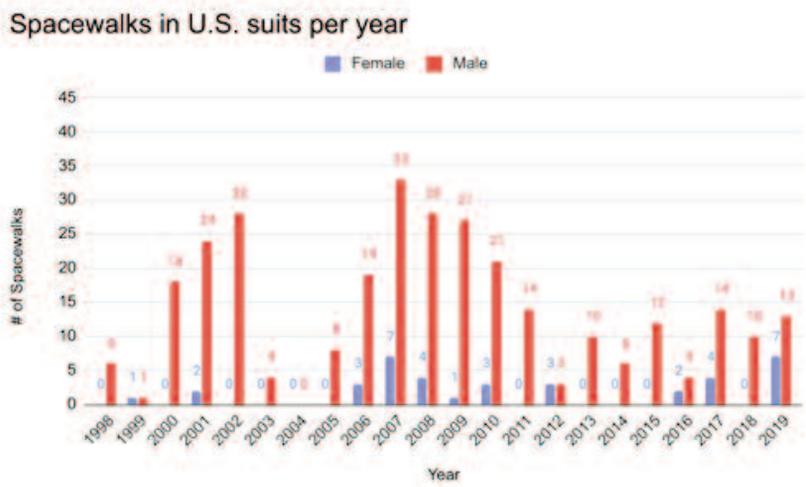
Spacesuits today are made mostly of modular components in sizes ranging from medium to extra-large. Spacesuit fit is critical as it affects an astronaut's ability to operate equipment effectively. If any part of a spacesuit is too big or too small, range of motion and control will be affected, making work in the suit harder. Seemingly small design details can have enormous impacts on an astronaut. Even simple tasks can become difficult or impossible, and injury can result, given that spacewalks and even practice runs are typically at least six hours long.

When I was selected as an astronaut in 1992, the decision had already been made to eliminate the small-sized spacesuit from the International Space Station (ISS) inventory in order to save money. The elimination of the small suit only affected women astronauts, who had been operating well in that size suit during the Space Shuttle era. As NPR reported in 2006, NASA found in a 2003 assessment that none of the male astronauts were limited by suit size, but eight out of twenty-five female astronauts found that the medium suits were too large for them and limited their performance.²

The main issue for a smaller astronaut wearing a medium suit is that the rigid torso is too wide. Imagine wearing a suit of armor, with the suit armpits intersecting at your biceps, and the "hip" area at your upper thigh. This creates ergonomic issues, including limiting range of motion, making it much harder for an astronaut to reach and operate spacesuit controls and tools.

Additionally, a suit that is too big has larger spaces filled with air. Astronauts train in the Neutral Buoyancy Lab (NBL), which is a pool containing a full-sized mock up of the ISS. In the pool, extra air inside the suit always stays oriented toward the surface, making it more challenging for a smaller astronaut to change her position.

Mary Robinette Kowal captured the consequences beautifully in her novel *The Calculating Stars* when the protagonist explained: "In truth, having an air bubble inside the suit wouldn't be a problem in space, but the NBL was where people decided if you



had what it took to do a spacewalk.”³

Many smaller astronauts failed to qualify in the EVA suits available for the space station. Astronauts like myself who did achieve ISS status had to break barriers, including by making modifications for suit fit, and pioneering new approaches for training and for tasks. With the help of Kathy Thornton, a veteran shuttle spacewalker who had worn a small suit, and other EVA team members, I found a way to attach padding to my hips in order to keep me more centered in the medium suit, which dramatically improved my performance in the NBL. Another adaptation I needed was for attaching my safety tether leash: the D Rings at my hips were hard for me to reach on the medium suit, so I added extension loops to them. Ultimately, many modifications we created together were adopted as new standards, helping to make improvements for all astronauts.

For some perspective, 104 astronauts have undertaken spacewalks in U.S. suits between 1998 and 2019. Only twelve of those were women. And of the 340 spacewalks in U.S. suits over this time period, only thirty-seven were by women—just 11 percent. The year 2020 is off to a strong start, with four spacewalks by women in the month of January alone. As the more recent astronaut classes are trending toward 50 percent women, NASA will need to ensure there are spacesuits that fit them all.

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Photo Credit: NASA

Spacesuit Engineer Kristine Davis demos the mobility of the xEMU

Participatory Design Matters

With NASA’s commitment to include at least one woman in humanity’s first steps back on the Moon, it will be important that the agency and its private sector partners proactively and continually involve a fully representative group of astronauts in the suit design process. The initial xEMU design is already a vast improvement on the current EMU. The way to ensure that *all* astronauts can successfully perform mission tasks in the spacesuit is to continue the design process with them through every step of development, focused on the performance of activities.

Decisions made today will affect generations of astronauts. Previous spacesuit designs have been used for decades because of the challenges involved in testing and verifying a new suit. Consider investments made in selecting and training astronauts and in the missions we undertake. The spacesuit should not be the limiting factor in our ability to perform critical functions. Some smaller women astronauts have been donning spacesuits that don't fit them for years. It's exciting that they may soon be able to focus less on suit issues and more on carrying out the exploration mission. It's vital that inclusion is a priority in suit design.

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Space as an Accelerator

Space exploration is so compelling that its practices and accomplishments can raise standards across society. When we really needed computers to be small for Apollo, we made it happen, and they are even smaller now for Artemis. Space exploration is a technology accelerator. It should also be a global equality accelerator. As the space program ensures inclusion, it will signal the importance of inclusion globally.

Flying in space safely is hard and requires incredible teamwork. This is a community of people who care deeply about the imperative of space exploration. As we prepare to venture further from Earth, now is the right time to ensure that current and next generations can know they will fit in the spacesuits of the team that represents humankind. Maybe even you!

Footnotes:

¹<https://www.nasa.gov/feature/a-next-generation-spacesuit-for-the-artemis-generation-of-astronauts>

²<https://www.npr.org/templates/story/story.php?storyId=6627320>

³<http://maryrobinettekowal.com/novel/the-calculating-stars/>

Dr. Cady Coleman served as a NASA astronaut from 1992–2016. She flew twice on the Space Shuttle Columbia (STS-73, STS-93) and lived on the International Space Station for six months during Expedition 26/27. She was selected as an EVA (Extra Vehicular Activity) crewmember for all three missions. She currently serves as Arizona State University Global Explorer.

Susan Alzner is cofounder of shift7 <https://shift7.com>, advancing tech forward, open, shareable practices to drive impact on systemic challenges.