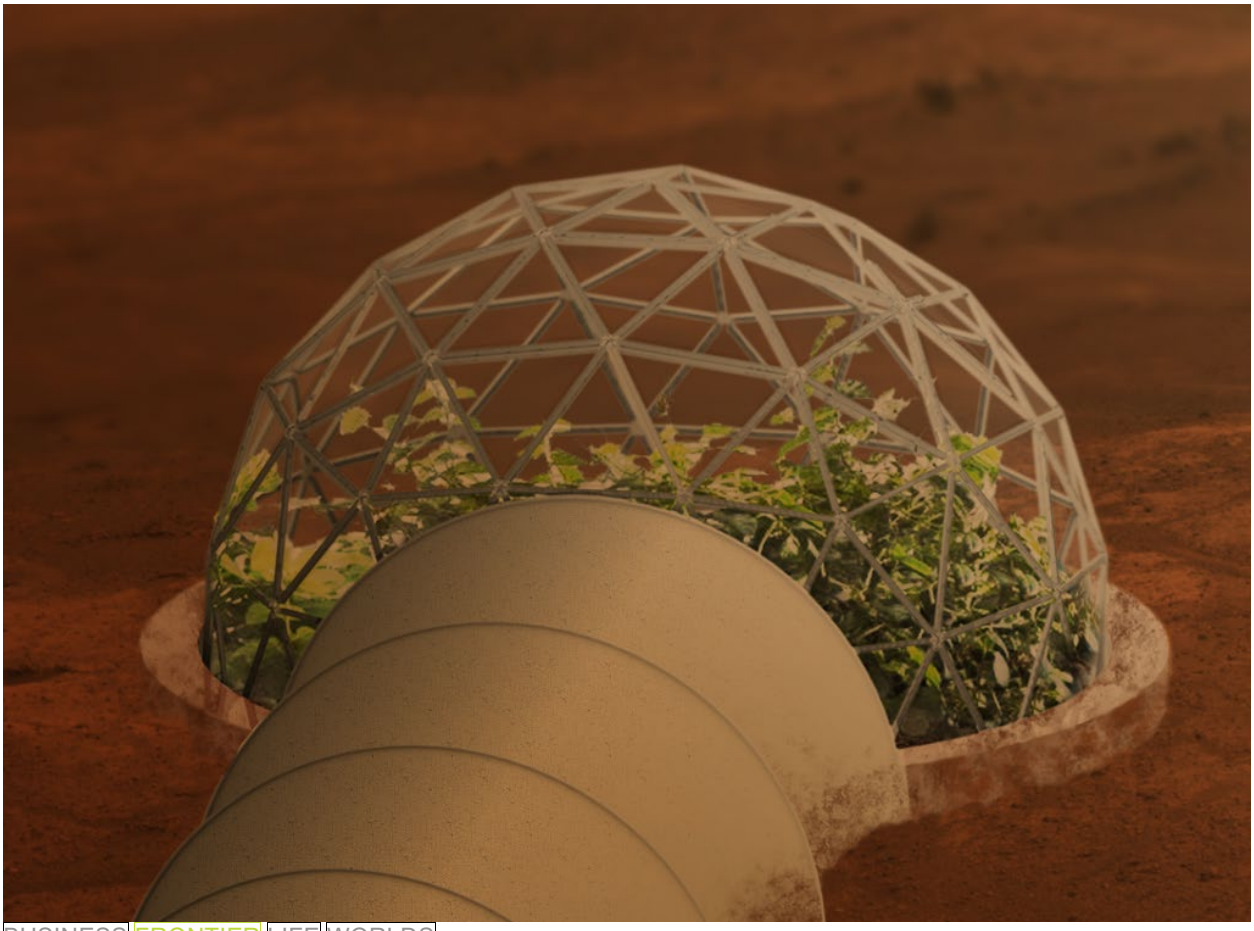
Filling Space DEMOCRATIZING ENGAGEMENT WITH SPACE



BUSINESS FRONTIER LIFE WORLDS

How do you engineer sustainable human habitation in space?

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To live off-planet, humanity will need to learn to use limited resources efficiently. The technologies we develop to support sustainable habitation are important off-planet. They may also help us live sustainably here on Earth. We spoke with Christine Escobar of Space Lab Technologies, a company in Colorado devoted to engineering sustainable human habitation in space. She shared details about some of Space Lab's current projects and the company's vision. She also spoke about her personal motivation for pursuing sustainable habitation solutions.

What is your µG-LilyPond system and what have you learned from its recent flight aboard Blue Origin's New Shepard?
µG-LilyPond is a thin film hydroponic growth chamber for use in microgravity. It will be able to grow small vegetables, like microgreens, as well as water lentils or duckweed. It's like a

miniature vertical farm that allows a very high yield in a small volume with relatively low energy cost. The µg-LilyPond growth chamber provides a controlled environment for floating aquatic plants with a stable water film for the plants to grow upon. It also has a special harvesting method, to separate the plants from the water when they are ready to be eaten.

The µG-LilyPond water delivery and biomass harvest technologies had been bench tested in Earth gravity but the only way to see if they really will work in microgravity is to send them into space, even if it's just for a few minutes. Through the recent suborbital flight, we were hoping to learn how the duckweed mechanically interacts with the water. Will it flow through the plumbing or get stuck? Will it stay on the surface of the water or will it become submerged? Duckweed fronds have special surface properties that should allow them to stay on the water surface even if there is no gravity to provide buoyancy.

We were thrilled to find on our first test flight that the duckweed plants appeared to travel effortlessly through the plumbing and to the growth beds! We also wanted to see whether we can deliver water (with duckweed) to a growing surface and keep it there. During a couple of minutes of reduced gravity, we were able to observe how surface geometry and material properties affect the stability of the water surface. The lessons learned on this short suborbital flight will allow us to improve the growth chamber design so that it has a higher chance of success during extended operations. We hope to eventually test the technology for much longer durations on the International Space Station.

How does the µG-LilyPond relate to Space Lab's other work in habitation and space systems?

Space Lab is a very small business located in Boulder, Colorado. I cofounded the company in 2016 with my husband, Adam Escobar, who is our CEO. We develop sustainable technology for human space exploration. This means that we provide the tools and resources for people to live and work in space productively and reliably. We also provide engineering support to government or private companies that share in that goal. This means we focus on life support, thermal control, environmental monitoring, crop production and other food systems, accommodations for crew health and comfort, telemetry and communications systems, data processing, power systems, and even science instrumentation. You could say that we think of ourselves as space habitat outfitters.

What sets us apart from other companies is that we envision a sustainable approach to space exploration. In fact, we believe that deep space exploration is a tremendous sustainability challenge because it is so expensive to launch anything into space and so hard to go back home if equipment breaks down. The more we explore, the more it pays to reuse, recycle, and regenerate consumable resources onboard the spacecraft, rather than carrying them all with you and then throwing away the waste. If we want to continue exploring farther into space for longer durations, habitation systems must be highly reliable, robust, and resource efficient. These are the cornerstones of our design philosophy at Space Lab. Our ultimate vision is to one day build a completely self-sufficient space habitat that is Earth independent. We truly believe that if we can achieve sustainable habitation in an uninhabitable environment, then we can achieve sustainable habitation here on spaceship Earth as well.

We've got a lot going on since we founded the company in 2016. We're developing an advanced oxygen flow meter for the next space suit, a novel non-toxic spacecraft radiator (called FRESR), a washing and sanitizing machine for microgravity (called ProWASH), and even a Martian greenhouse concept, called MarsOasis!

How did you become involved in the development of human spaceflight-related technologies?
Ever since I was little, I was drawn to the mystery of space, for the same reason that has driven all explorers throughout human history: insatiable curiosity and a thirst for knowledge. I was inspired in high school by a book about Biosphere II to pursue a career in the development of habitats and life support systems that would enable humans to live and work in outer space.

Biosphere II was a three-acre facility in Arizona, built to be an artificial, materially closed ecosystem. From 1991 to 1993, a crew of eight people lived within its sealed walls, showing that humans can artificially replicate the biomes of Earth on a small scale to support human life for long durations. With capabilities such as these, human beings would be able to explore farther beyond our planet, finding answers to critical questions about our universe. What's more, we would learn to make efficient use of our primary life support system on Earth, securing our species' survival. I began to envision a future in which our combined creativity, passion, and respect for the natural ecosystems on Earth will carry us forward – into space and into a future where we, as a species, no longer threaten our own viability.

This project sparked something deep in my imagination that never left me, but there was no university degree program that I could turn to for training in such a unique and multidisciplinary subject. So, I sought out an education in ecology, systems and information engineering, and aerospace engineering, providing a unique skillset for developing sustainable space life support technology. Over the years, I have held a variety of positions, gaining technical leadership and engineering management experience. While conducting PhD research at the University of Colorado at Boulder, in bioastronautics, my husband and I decided that we would have the biggest impact on the human spaceflight industry if we combined our science and engineering skills in our own company. Thus, Space Lab was born.