How to make the food and water Mars-bound astronauts will need for their mission

June 1 2020, by Matt Williams

The prototype space greenhouse developed by the TIME SCALE project, which recycles nutrients to grow food. Credit: Karoliussen/HORIZON

If we ever intend to send crewed missions to deep-space locations, then we need to come up with solutions for keeping the crews supplied. For astronauts aboard the International Space Station (ISS), who regularly receive resupply missions from Earth, this is not an issue. But for missions traveling to destinations like Mars and beyond, self-sufficiency is the name of the game.

This is the idea behind projects like BIOWYSE and TIME SCALE, which are being developed by the Centre for Interdisciplinary Research in Space (CIRiS) in Norway. These two systems are all about providing astronauts with a sustainable and renewable supply of drinking water and plant food. In so doing, they address two of the most important needs of humans performing long-duration missions that will take them far from home.

Even though the ISS can be resupplied in as little as six hours (the time between launch and the time a supply capsule will dock with the station), astronauts still rely on conservation measures while in orbit. In fact, roughly 80% of the water aboard the ISS comes from airborne water vapor generated by breathing and sweat, as well as recycled shower water and urine—all of which is treated with chemicals to make it safe for drinking.

Food is another matter. NASA estimates that every astronaut aboard the ISS will consume 0.83 kg (1.83 pounds lbs) of food per meal, which works out to about 2.5 kg (5.5 lbs) a day. About 0.12 kg (0.27 pounds) of every meal is just from the packaging material, which means a single astronaut will generate close to a pound of waste per day—and that's not even including the other kind of "waste" that comes from eating.

In short, the ISS relies on costly resupply missions to provide 20% of its water and all of its food. But if and when astronauts establish outposts on the moon and Mars, this may not be an option. While sending supplies to the moon can be done in three days, the need to do so regularly will make the cost of sending food and water prohibitive. Meanwhile, it takes eight months for spacecraft to reach Mars, which is totally impractical.

So it is little wonder that the proposed mission architectures for the moon and Mars include in-situ resource utilization (ISRU), in which astronauts will use local resources to be as self-sufficient as possible. Ice on the lunar and Martian surfaces, a prime example, will be harvested to provide drinking and irrigation water. But missions to deep-space locations will not have this option while they are in transit.

To provide a sustainable supply of water, Dr. Emmanouil Detsis and colleagues are developing the Biocontamination Integrated cOntrol of Wet Systems for Space Exploration (BIOWYSE). This project began as an investigation for ways to store freshwater for extended periods of time, monitor it in real-time for signs of contamination, decontaminate it with UV light (rather than chemicals), and dispense it as needed.

Artist’s impression of Biolab. a facility designed to support biological experiments on micro-organisms, small plants and small invertebrates. Credit: ESA – D. Ducros

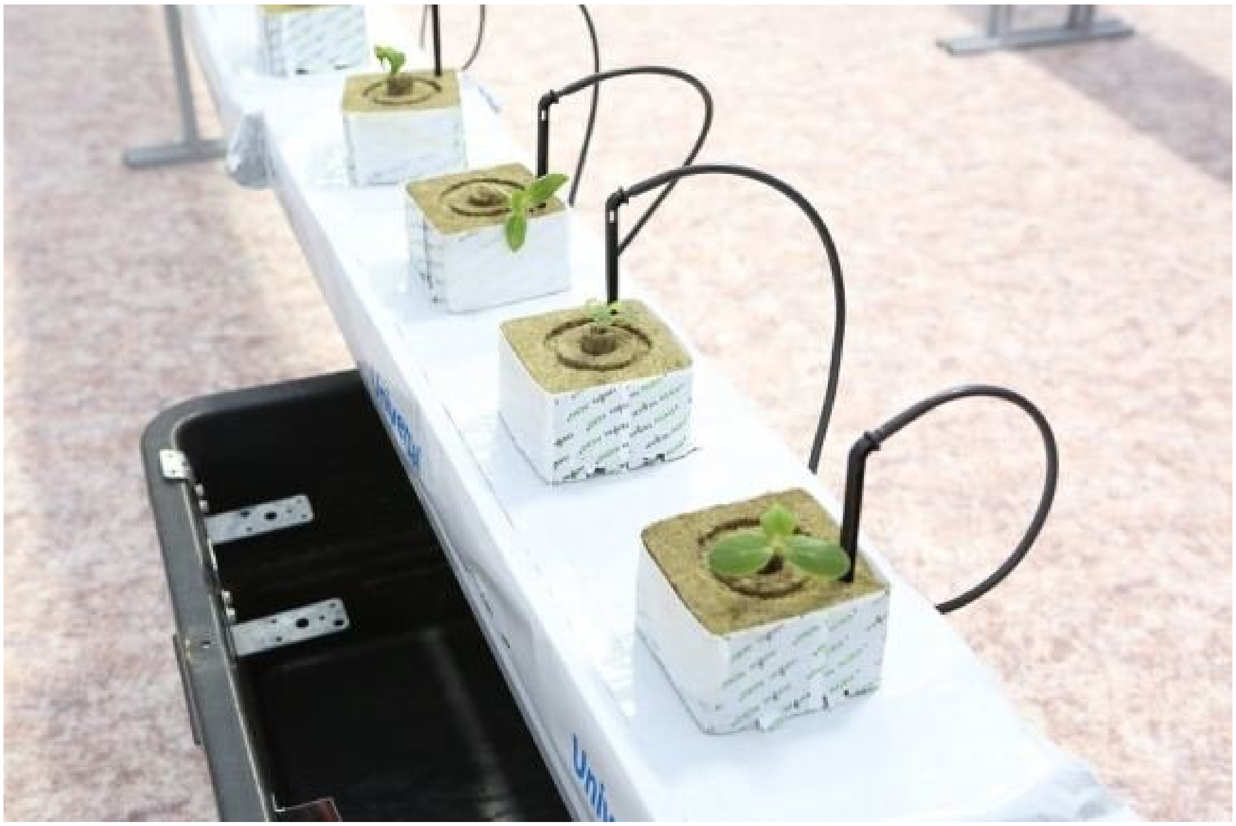
What resulted was an automated machine that could perform all of these tasks. As Dr. Detsis explained: "We wanted a system where you take it from A to Z, from storing the water to making it available for someone to drink. That means you store the water, you are able to monitor the biocontamination, you are able to disinfect if you have to, and finally you deliver to the cup for drinking… When someone wants to drink water you press the button. It's like a water cooler."

In addition to monitoring stored water, the BIOWYSE machine is also capable of analyzing wet surfaces inside a spacecraft for signs of contamination. This is important, due to humidity buildup in closed systems like spacecraft and space stations, which can cause water to accumulate in areas that are unclean. Once this water is reclaimed, it then becomes necessary to decontaminate all the water stored in the system.

"The system is designed with future habitats in mind," added Dr. Detsis. "So a space station around the moon, or a field laboratory on Mars in decades to come. These are places where the water may have been sitting there some time before the crew arrives."

The Technology and Innovation for Development of Modular Equipment in Scalable Advanced Life Support Systems for Space Exploration (TIME SCALE) project is designed to recycle water and nutrients for the sake of growing plants. This project is overseen by Dr. Ann-Iren Kittang Jost from the Centre for Interdisciplinary Research in Space (CIRiS) in Norway.

This system is not unlike the European Modular Cultivation System (EMCS) or the Biolab system, which were sent to the ISS in 2006 and 2018 (respectively) to conduct biological experiments in space. Drawing inspiration from these systems, Dr. Jost and her colleagues designed a "greenhouse in space" that could cultivate plants and monitor their health. As she put it: "We (need) state of the art technologies to cultivate food for future space exploration to the moon and Mars. We took (the ECMS) as a starting point to define concepts and technologies to learn more about cultivating crops and plants in microgravity."



Plants cultivated in the TPU autonomous greenhouse. Credit: TPU

Much like its predecessors, Biolab and the ECMS, the TIME SCALE prototype relies on a spinning centrifuge to simulate lunar and Martian gravity and measures the effect this has on plants' uptake of nutrients and water. This system could also be useful here on Earth, allowing greenhouses to reuse nutrients and water and more advanced sensor technology to monitor plant health and growth.

Technologies like these will be crucial when it comes time to establish a human presence on the moon, on Mars, and for the sake of deep-space missions. In the coming years, NASA plans to make the long-awaited return to the moon with Project Artemis, which will be the first step in the creation of what they envision as a program for "sustainable lunar exploration."

Much of that vision rests on the creation of an orbital habitat (the Lunar Gateway) as well as the infrastructure on the surface (the Artemis Base Camp) needed to support an enduring human presence. Similarly, when NASA begins making crewed missions to Mars, the mission architecture calls for an orbital habitat (the Mars Base Camp), likely followed by one on the surface.

In all cases, the outposts will need to be relatively self-sufficient since resupply missions won't be able to reach them in a matter of hours. Dr. Detsis explained, "It will not be like the ISS. You are not going to have a constant crew all the time. There will be a period where the laboratory might be empty, and will not have crew until the next shift arrives in three or four months (or longer). Water and other resources will be sitting there, and it may build up microorganisms."

Technologies that can ensure that drinking water is safe, clean, and in steady supply—and that plants can be grown in a sustainable way—will allow outposts and deep-space missions to achieve a level of self-sufficiency and be less reliant on Earth.

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