What to Pack for Mars

Citation: You can't take much into space. When a rocket is on the launchpad, 99.9 percent of the mass is the fuel and the vehicle itself. That leaves 0.1 percent for everything else the crew and all their supplies. When considering what to bring, how do we trade off between consumables (needed for survival), spare parts (for safety), and research equipment (which gives the mission value)?

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trolyzed to make oxygen, methane, and more hydrogen. The methane could be used as fuel, and the hydrogen could be reused to produce more oxygen.

Dining on a Mars voyage also poses some challenges. A 1000-day, five-person mission would require 8000 kg of food, of which about 15 percent would be packaging. NASA scientists are developing new techniques for preserving the food and reducing the packaging. Tests show that heating food to 120 °C for 2 to 3 minutes and then placing it under high pressure (about 600 megapascals) for another few minutes will kill any harmful microorganisms without damaging the food. Bombarding the food with microwaves for 5 to 10 minutes will also do the trick.

Either method would increase shelf life to five years. That may sound like overkill, but getting provisions to Mars for an extended stay might mean first sending supplies aboard an unmanned shuttle, with the crewed mission following two years later, says Michele Perchonok, manager of advanced food technology at NASA. She says the space agency will soon ask for approval from the U.S. Food and Drug Administration for its first Martian prepackaged food product: mashed potatoes.

Of course, you could just dehydrate everything and then reconstitute as needed. But Zubrin advises against it. To simulate life on Mars, he has spent weeks at a time living with a small crew of scientists and students on remote Devon Island in the Canadian Arctic and in the southern Utah desert. They eat only what a Mars-bound crew would likely take with them.

"Our first year in the Arctic, it was all crackers," Zubrin recalls. On later visits, they brought along a lightweight electric bread maker and began serving bread, pasta, and rice. The addition of a few simple cooked items, he says, was a huge boost to the crew's morale. The crew ate together and took turns preparing meals. "We'd have contests over who could cook the best meals with limited ingredients," Zubrin says.

Growing food on Mars would cut down on payload weight and give astronauts a chance to munch on fresh produce. Lettuce and tomatoes, for instance, could be grown hydroponically in a greenhouse. Soybeans, wheat, peanuts, and other dried beans could be used to make pasta, bread, and cereal. But cultivating a garden, grinding flour, and cooking from scratch would all divert efforts from life-sustaining chores like finding water and repairing equipment. Salad or survival: The choice is pretty clear.

SO, YES, MARS IS HARD. Wernher von Braun knew it, and yet the planet remained ever in his sights. In his novel, he included a 62-page scientific appendix dense with tables of rocketry data, landing maneuver calculations, and hand-drawn diagrams. Getting to Mars, to von Braun, was not some fantastic dream; it was a workable, solvable problem and an engineering challenge of the best kind, because it inspires us, builds us up, and unites us as a society. He saw his book not so much as a work of fiction but as a practical guide, a road map, a way forward.

"It is the vision of tomorrow which breeds the power of action," he wrote in the novel's preface. "Thousands of scientists and engineers are laboring constantly to perfect our knowledge of rocketry and rocket propulsion, and millions of dollars are spent yearly to advance such research. What the results will be is beyond the public ken, but they will surely exert a vital influence upon the future of the entire Earth and well beyond its present confines."

"When referring to technological advances," he added, "the word 'impossible' must be used, if at all, with utmost caution." ❑

[THE RIGHT STUFF]

WHAT TO PACK FOR MARS

A successful mission REQUIRES A WELL-PLANNED SUPPLY STRATEGY + + +

BY OLIVIER L. DE WECK

YOU CAN'T TAKE MUCH INTO SPACE. When a rocket is on the launchpad, 99.9 percent of the mass is the fuel and the vehicle itself. That leaves 0.1 percent for everything else—the crew and all their supplies. When considering what to bring, how do we trade off between consumables (needed for survival), spare parts (for safety), and research equipment (which gives the mission value)?

Starting in 2005, NASA asked my group at MIT to develop SpaceNet, software that helps mission planners evaluate these trade-offs. The program manages and models the complex supply chain of vehicles and supplies along with the processes and orbital dynamics required for manned missions, whether they're to Mars, the International Space Station (ISS), or a lunar outpost. We designed our software to model each step in a mission as well as a whole campaign of missions. SpaceNet allows planners to quantitatively compare different mission architectures to optimize the exploration capability and launch mass. We also want to make supply chains robust so that one failed or delayed mission doesn't ruin the whole plan.

In 2005, we tested our computer models by participating in the Haughton-Mars Project, in which a small group of researchers live in an Arctic base as if they were on Mars. The experience was enlightening. We found that of the operational inventory (that 0.1 percent of launch mass), two-thirds went to ground vehicles and fuel for powering the base. From this experience, we've calculated that each crew member added to a 600-day Mars mission would require sending 13 metric tons more cargo to the Martian surface.

But even if you deliver the right amount of supplies, it matters how they are organized. For example, there are between 15 000 and 20 000 objects on the ISS. If you take the total number of useful crew hours in a year and divide by the total operating budget, you find that the value of 1 hour of an astronaut's time on the ISS is US $186 000. So 5 minutes spent looking for one hard-to-find item wastes $15 000.

On a Mars mission, time will be even more valuable. Storage should be reconfigurable so that the most needed items are always accessible and everything else is out of the way. We're now working on an RFID system that tracks the location of each piece of inventory at all times. The ultimate goal is to create smart, self-aware environments that are both safe and effective for exploration far from Earth. We hope that better space logistics will give future astronauts more time to do valuable work.

—As told to Joshua J. Romero

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