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ABOVE Salt crystals grown in an experiment that took place aboard the International Space Station

NASA/JSC, VARDA SPACE INDUSTRIES/JOHN KRAUS X2

ANALYSIS

The next generation of drugs could be made in space

A California start-up recently recovered a batch of drugs manufactured by an automated satellite

On 21 February, a metre-wide (3ft) space capsule landed in the Utah desert after eight months in orbit. Its cargo: a batch of Ritonavir, an antiviral drug used in the treatment of HIV and COVID-19.

Carried out by Californian start-up Varda Space Industries, the mission was intended to demonstrate the potential for the automated manufacturing of pharmaceutical drugs in space, possibly paving the way for new and more efficient methods of developing medicines.

Varda's W-1 mission launched aboard a SpaceX Falcon 9 rocket in June 2023. The capsule being tested weighed around 90kg (almost 200lbs), even though it's theoretically capable of manufacturing nearly 100kg of products over several months spent in orbit. For this initial mission, however, just a small amount of Ritonavir was manufactured during a 27-hour test run.

In-flight analysis indicated that the manufacturing process ran as planned and although final results are not yet available, Varda is already busy preparing for a second mission that will carry its first commercial payload into space.

But why go to all of the trouble?

Over the past few decades, experiments aboard the International Space Station and other spacecraft have proved that it's possible to make small quantities of pharmaceutical drugs in space.

It turns out that microgravity conditions cause many of the processes used to build complex crystalline molecules – such as the proteins and antibodies used in many medicines to treat everything from cancer to heart disease – to behave differently from how they do on Earth.

For instance, the liquid solutions from which crystals form no longer separate according to density, plus solids don't naturally fall or rise within them. And the lack of gravity means any structures that grow don't warp out of shape and change their nature.

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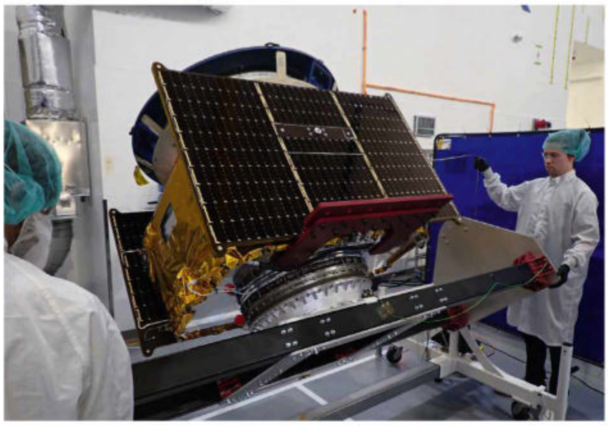
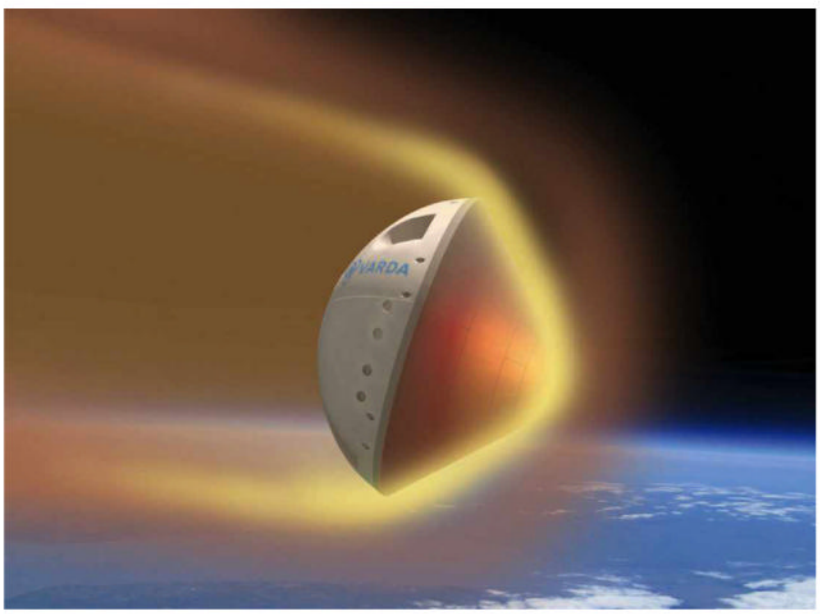
Earth-grown counterparts," says Prof Anne Wilson, a researcher based at Butler University in Indianapolis who conducted a series of experiments growing crystals in 2022.

"Our studies have shown that microgravity-grown crystals are more uniform, structurally improved and often larger," she says.



LEFT The main unit of the Varda W-1 mission under construction (the automated drug manufacturing capsule is upside-down at the top, between the solar panels)

BELOW An illustration of the Varda's W-1 mission during its re-entry into Earth's atmosphere



Pharmaceutical companies have already harnessed the lessons learned from space experiments to improve manufacturing processes on Earth. But space-grown crystals can also display unusual and useful properties, and could potentially be more effective than medicines made on Earth.

"Microgravity enhances crystallisation so that you get more perfect and similar crystals," says Dr Katie King, a microgravity researcher based at the UK space medicine firm BioOrbit.

"This technology can also be used to crystallise protein receptors from the body that medicines target. We can then better understand these in laboratories on Earth. The other application is to use the crystals themselves in medicines.

"Varda is attempting to use microgravity to find potential new and more effective forms of drugs. We at BioOrbit, in contrast, are working on turning existing drugs into something that patients can take at home."

When it comes to making materials in space for use on Earth, economics remains a big challenge. While reusable launch vehicles such as Falcon 9 lower the costs of reaching orbit significantly, Varda also plans to make its own spacecraft increasingly versatile and reusable, allowing refurbishment and turnaround for relaunches on shorter timescales.

The company's co-founder Delian Asparouhov says the initial run cost is around $12 million (£9.5m), but predicts that could rapidly be lowered to about $2m (£1.6m) million per mission. With plans for later generations of larger and more economical space labs already in the works, other players could soon start throwing their hats into the ring.

"There are huge benefits," says King. "The full extent has yet to be tapped into and there's a lot more to learn for drugs, medicine and life science in general. Varda's re-entry system is really the most pioneering part of what the company is doing because it opens the space for other companies to use microgravity in a variety of new applications."

by **GILES SPARROW**

Giles Sparrow is a science journalist who specialises in space and astronomy.