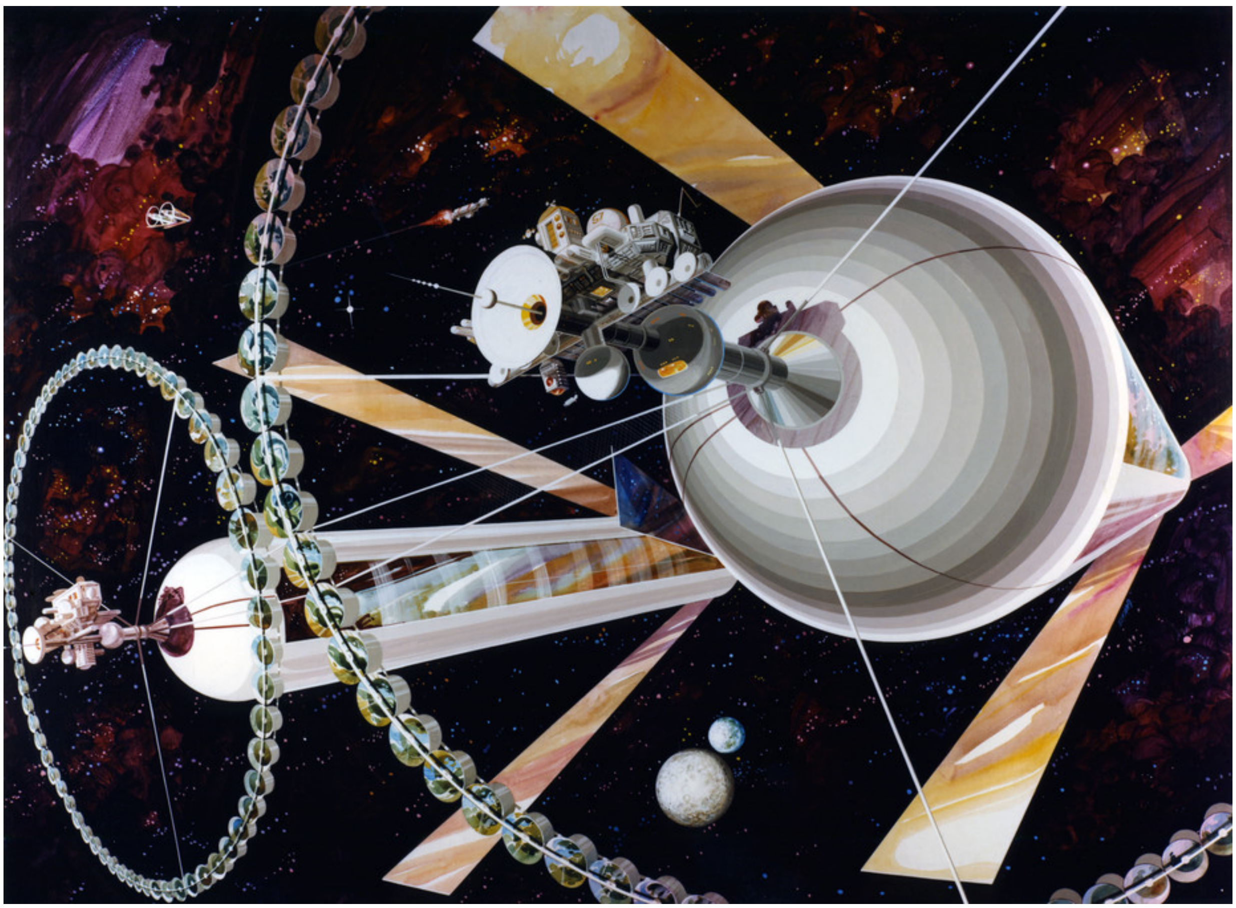
Factories in space: how extra-terrestrial industry could keep humans alive

August 19 2016, by Mike Cruise



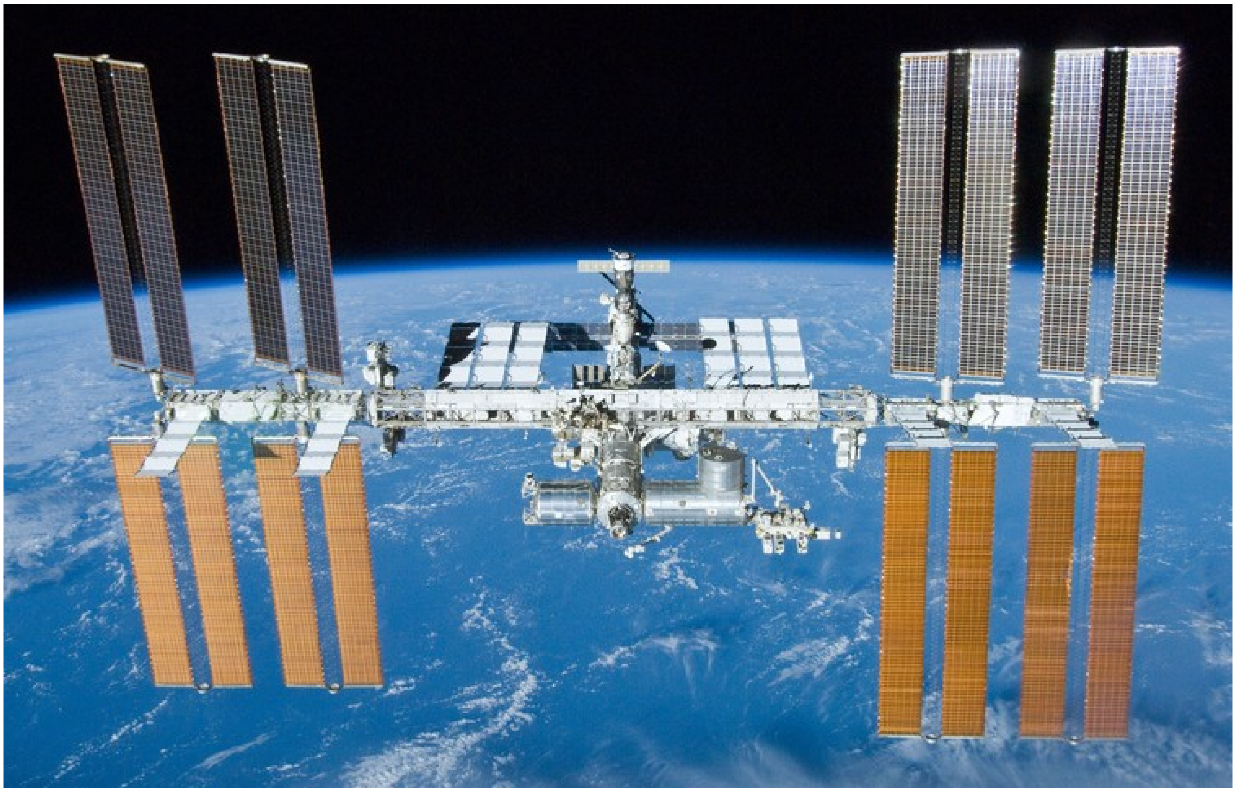
Artist's depiction of a pair of O'Neill cylinders. Credit: Rick Guidice NASA Ames Research Center

Science fiction truly turned into reality in October 1957 when Sputnik was launched – humankind's first step beyond the Earth. Since then, progress has been rapid. A significant number of men and women have now travelled to space to explore it and do research.

But while we tend to think of space as the playground of scientists, could it prove more useful in the future? Could we one day gain economic benefits through innovative industrial activity at factories in space, taking advantage of the minimal amount of gravity?

Governments funding very expensive space missions have long looked for ways to secure an economic return. In the late 1990s, NASA encouraged any industry that said it could make space pay to get involved. Under this financial incentive, many claims were made for the industrial promise of the microgravity environment experienced in orbit. The lack of gravity might allow the growth of protein crystals important in the fight against cancer, it was said. New materials might be manufactured in zero gravity to exhibit new and useful properties, it was thought. There were many other claims.

But the costs of launching materials and the necessary equipment, processing the ingredients and returning the end products to Earth gradually showed these ideas to be economically unsustainable. Access to space comes at prices per kilogram, currently approaching the cost of gold. In fact, it turns out that almost anything processed in space proves to be far too expensive to create a viable business back on Earth. But could this change?



International Space Station. Credit: NASA

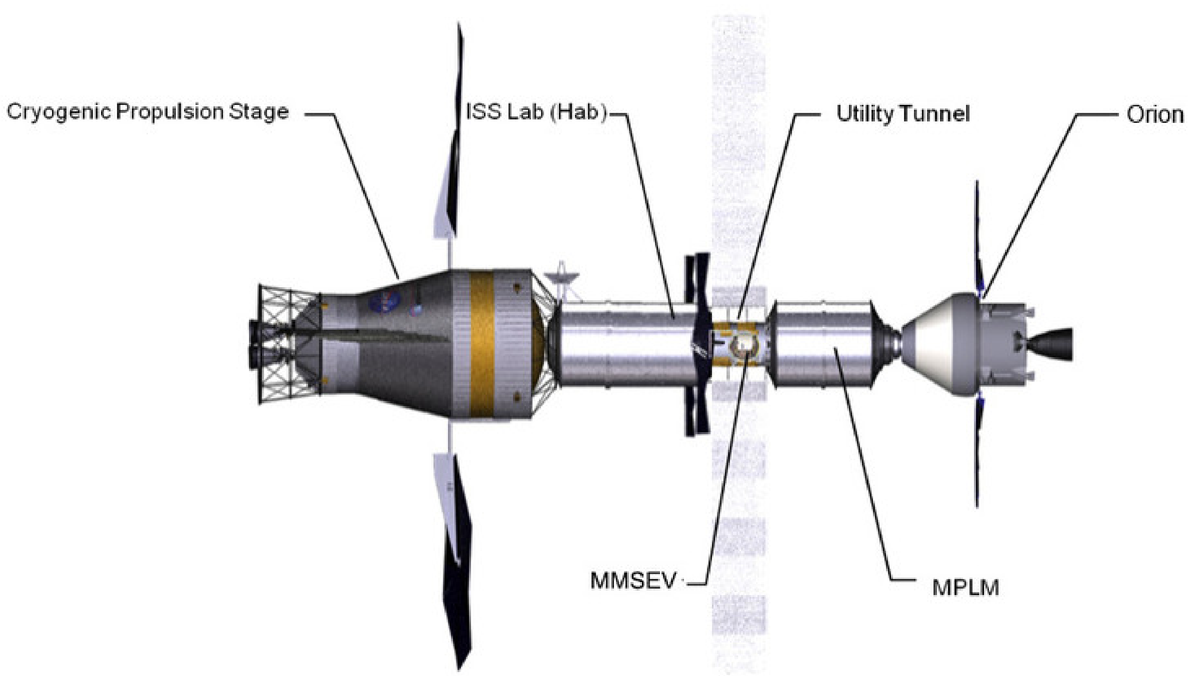
The near future

We already have opportunities for industrial participation in space on the International Space Station. It orbits the Earth 16 times a day with between six and nine astronauts on board. A wide range of experiments in the life and physical sciences are carried out each day on the ISS, making it a kind of flying, zero-gravity laboratory. Many of these experiments generate information of direct relevance to industry.

As one example, understanding how molten metals flow during the casting of complex shapes requires measurements of the properties of metals near their melting point. This is best done on samples floating in microgravity with no container contaminating the sample. The data obtained will improve the future economics and reliability of casting on Earth. The microgravity environment is an important tool in understanding physical and life processes here on Earth.

The European Space Agency (ESA) has recently polled industry, seeking new ideas for commercial involvement in the ISS. Most of the suggestions have centred on providing cheaper access to the ISS using simplified equipment, not new industrial processes. So industry has the chance to participate and test new ideas, but on the whole industry's involvement is in finding cheaper ways of getting to and from space – not doing business in microgravity.

The lifetime of the ISS is limited. ESA will make a decision in December this year whether to extend the operation, in conjunction with NASA, up to 2024. The ISS will almost certainly have to be deorbited and destroyed by 2030.



Concept for the design of the ISS-Derived Deep Space Habitat. Credit: NASA

The next step beyond the ISS is currently being discussed under the opaque title of the Deep Space Habitat – "DSH" in NASA-speak. This could be a temporary "colony", remote from the Earth and beyond the low-Earth orbit where the ISS floats. It would be built using hardware from the ISS and might manage to process materials from local moons or asteroids to keep it going, reducing the costs of resupply. Water and oxygen would initially be the targets, mostly because a human needs about 30kg a day of these to sustain life.

The far future

Future exploration missions might also benefit from processing materials on asteroids to generate rocket fuels for the return journey or for construction materials – but this is a step much more distant in time. Some of these proposals claim asteroid mining may have long-term economic benefits for everyone. These materials are present on many planetary surfaces but the current factories to process them would need huge transportation resources, more massive than the end products. Even so, missions now being studied may start to test these ideas on the Moon, or Mars' moon Phobos, within a decade or so.

We have yet to identify many materials that can only be created in a microgravity environment but have serious uses elsewhere. There certainly are possibilities. Creating a solid foam by introducing gases into a mixture of molten glass and molten metal and allowing the mixture to cool without gravity separating the components might create a structural material with the strength of steel and the corrosion resistance of glass. But a more likely product from factories in space would be the erection of large structural sections to build further factories and space stations.

Thinkers many decades ago imagined long-term "space colonies" travelling far from Earth. These would provide independence from an Earth in crisis and would need sustainable support systems. American physicist Gerard K. O'Neill proposed huge cylinders, kilometres long, and the attractive illustrations show fields and factories coexisting in this artificial world. Sputnik, the ISS and the future Deep Space Habitat are steps on the way to such colonies. Once established, we may may then need factories in space to keep us alive while we're so far way from the Earth.

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