A solution to space junk: Satellites made of mushrooms?

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Artist's impression of the orbital debris problem. Credit: UC3M

According to the latest numbers from the ESA's Space Debris Office (SDO), there are roughly 6,900 artificial satellites in orbit. The situation is going to become exponentially crowded in the coming years, thanks to the many telecommunications, internet, and small satellites that are expected to be launched. This creates all kinds of worries for collision

risks and space debris, not to mention environmental concerns.

For this reason, engineers, designers, and satellite manufacturers are looking for ways to redesign their satellites. Enter Max Justice, a cybersecurity expert, former Marine, and "Cyber Farmer" who spent many years working in the space industry. Currently, he is working towards a new type of satellite that is made out of mycelium fibers. This tough, heat-resistant, and environmentally friendly material could trigger a revolution in the booming satellite industry.

As it stands, one of the biggest concerns with satellites is the risk of collision they pose once they become defunct. Until such time that their orbit decays and they burn up in the atmosphere, satellites are likely to collide with each other and produce small pieces of space debris. To mitigate this, and prevent the exponential rise of debris in orbit (aka. Kessler Syndrome), satellite manufacturers are investigating ways to deorbit them quicker.

However, this overlooks another hazard, which is the way satellites that re-enter our atmosphere will leave traces of aluminum particles and other toxic residues behind. These particles will float in the upper atmosphere for many years and could create another source of environmental problems. Max Justice believes that mycelium fungus could address both of these hazards when used to manufacture satellite chassis.

Basically, mycelium fibers are a protein-rich, multi-celled material extracted from the root structure of fungi that grow into macro-structures—the most well-known being mushrooms. As these structures grow, the mycelia release enzymes that convert sugars or plant waste into usable nutrients, which allows them to create extensive networks in whatever substrate they occupy—usually soil.

When dried, mycelium fibers are lightweight, extremely tough, and have tensile strength comparable to that of silk. Because of this, mycelium is one of many organic fibers that are being investigated for the sake of building materials and manufacturing. For instance, multiple designers are investigating mycelium as an inexpensive, durable, and non-toxic means for building eco-friendly housing, insulation, and plastics.

Examples include architecture and design firms Evocative and The Living, which have been using mycelium for years to create materials and finished products. In the construction industry, mycelium has also been shown to have applications for removing harmful chemicals in building waste. When paired with 3D printing, mycelium can also be used to fabricate chairs and other pieces of furniture.

Other applications include "mushroom paper," surfboards, "mushroom leather, "mushroom shoes," bacon, and even coffins that turn human remains into compost. When actor Luke Perry passed away in 2019, his daughter indicated that he was interred in a "mushroom suit." As Justice told Universe Today via email, this natural fiber occupies an important place in the revolution currently taking place in manufacturing and materials:

"People are realizing every day how mushrooms (in particular, mycelium) can be used as a replacement for bacon (as well as pork, cow, and chicken), leather (and they're finding it's stronger), shoes, hats, clothes, as building/construction materials such as bricks, soundproofing, fire retardant insulation, as well as packing materials, furniture, bolts of threads, handbags, pet food, the sky is the limit. There are even several mycologists and other scientists working with mycelium to eat oil and plastic. It's pretty amazing."

But what about commercial space, another industry that is undergoing a seismic shift in terms of purpose and practices? This is where Justice's

efforts are ultimately directed, and which were inspired by research that is currently being conducted by Sumitomo Forestry and Kyoto University in Japan. Under the direction of Takao Doi, a former JAXA astronaut and a professor of Aerospace Engineering at the University of Kyoto, this collaborative effort seeks to build the first "wooden satellites."

The idea is to use layers of cellulose fiber (wood) that are highly resistant to temperature changes and direct sunlight. "We are very concerned with the fact that all the satellites which re-enter the Earth's atmosphere burn and create tiny alumina particles which will float in the upper atmosphere for many years," said Doi in a recent interview with the BBC. "Eventually, it will affect the environment of the Earth."

But as Justice indicated, mycelium is not only a stronger and more flexible material than wood is, it's also much more renewable and sustainable as a resource. And that's just the tip of the iceberg, as he explained:

"Depending on the type of mycelium used, it can be more flexible than wood and/or stronger than wood, it's lighter than wood, and naturally much more fire-retardant. I even took a propane torch to one of my mycelium blocks for over 5 minutes and all it did was smoke.

"Mycelium is very light in weight, it naturally floats on water, it can withstand the cold of space where we don't have to worry about cold welding, and we can add in fine strains of metal material which is used to transmit almost any type of signal. As you can see, there are numerous reasons why mycelium is quite suitable for our satellites in space, on land, and in the air on its way to space.

Of course, there's also the all-important issue of space debris, which is projected to become a severe hazard to satellites and spacecraft in low

earth orbit (LEO) in the coming years. According to the SDO, more than 560 break-ups, explosions, collisions, or anomalous events that resulted in fragmentation have taken place since the launch of the first artificial satellite in 1957 (Sputnik 1). With the proliferation of small satellites and the mega-constellations that are (or soon will be) deployed, the risk of collision rises considerably.

This could result in a phenomenon known as "Kessler syndrome," in which collisions and breakups lead to more collisions and more still, and so on. For decades, space agencies and astronomers have feared this prospect and have been looking for mitigation measures to prevent and clean up "space junk." As Justice indicated, materials like mycelium fibers would constitute a mitigation measure at the production end.

"Well, space debris is space debris," he said. "And when flying around at 26,875 km (16,700 mph), it can still ruin someone's day. Because mycelium has such strong bonds and is what some consider fire-proof, it will take a lot of energy in space to break it apart, which is actually a good thing because it is the small pieces of space junk that are the real killer."

Given the advantages and the ways in which mycelium has caught on with several different industries, one has to wonder why the space sector is lagging behind in the adoption of this material. While there are some examples—for instance, Mars City Design (MCD) is exploring the use of mycelium to create habitats for Mars—there currently isn't a similar effort to develop mycelium satellites.

As it stands, Justice describes himself as an "army of one when it comes to making mycelium-based satellites." The operation, known as Setas Mushrooms located in Falling Waters, West Virginia, specializes in growing and delivering fresh, fully organic edible mushrooms. In addition, they grow and deliver 0.45, 2.25, and 4.5 kg (1, 5, and 10 lbs)

blocks of mycelium, which typically take less than two months to create and can be grown into any required shape. Said Justice:

"I've been working in the space industry (predominately with the NGO [Natiopnal Reconnaissance Office], NGA [National Geospatial-Intelligence Agency], and NASA) for over 15 years and no one else is doing this or talking about it. Until they meet me, then people are blown away about the uses for mycelium. I'd love to see NASA, other government agencies, or the private sector, like SpaceX, Bigelow, ISISpace, Visioneering, or many others, get interested in this low-cost, lightweight, fire-retardant, and highly sustainable product."

At present, there are about 4,000 functioning satellites in orbit, with new ones being added all the time. SpaceX began launching batches of its Starlink broadband internet satellites in May of 2019, starting with batches of 60 a few times a month. Since March of 2021, they are averaging about 300 a month and now have a constellation of 1,443 satellites—with plans for a megaconstellation of 12,000.

Meanwhile, multinational e-commerce giant Amazon has plans of its own for a constellation of 3,236 broadband satellites. Since 2012, Viasat and Hughes (a subsidiary of EchoStar) have also offered broadband internet services through their telecom satellite constellations. With internet access expected to reach 8.73 billion people worldwide by 2050 (that's 90% of the global population), there is considerable growth (no pun) to be had in this sector.

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