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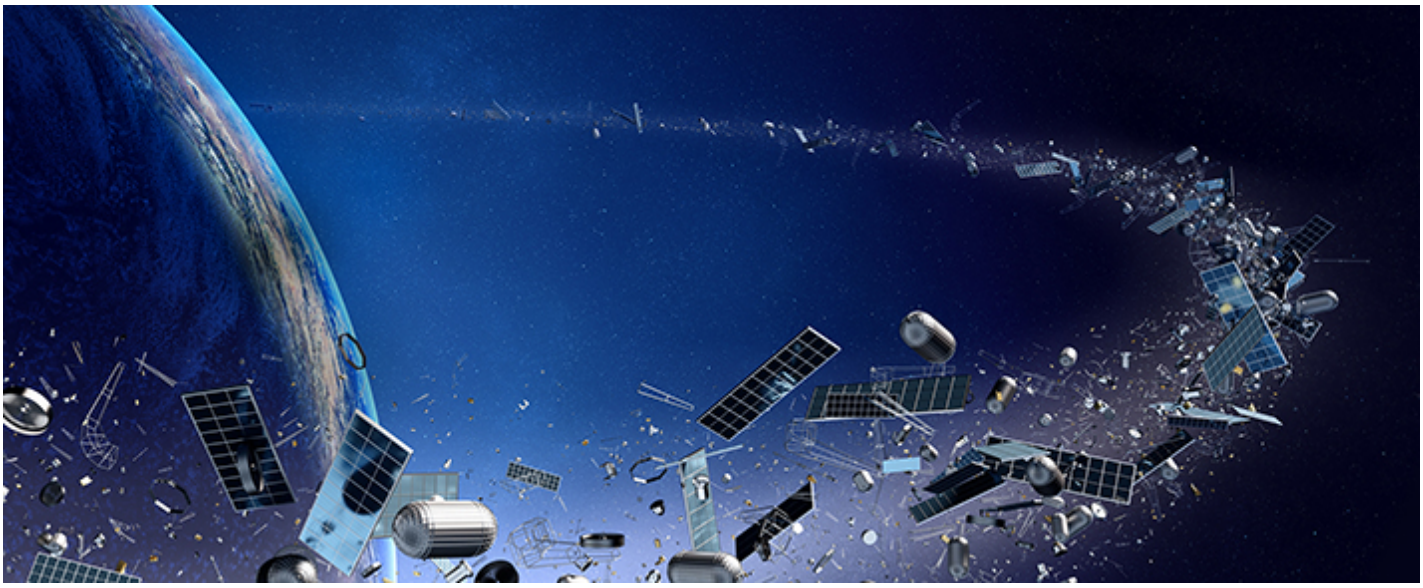

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Lost in Space

Curbing the orbital debris threat
By Lucy Birmingham
While gazing at the twinkling night sky, it's hard to imagine the astronomical accumulation of human-made detritus orbiting Earth at thousands of kilometers per hour. Millions of objects—from flecks of paint to derelict satellites as big as a soccer field—are posing a threat to astronauts and live satellites we depend on every day. Groups such as the National Aeronautics and Space Administration (NASA), the Japan Aerospace Exploration Agency (JAXA) and the intergovernmental European Space Agency (ESA) are developing mitigation technologies. Now, private-sector businesses are also entering the space cleanup race.

"The film *Gravity* called attention to this very real problem in a very dramatic way," said Alice Hoffman, a director at the National Space Society in Washington and program manager for the Enterprise in Space educational project, which is building an orbiter that will carry student experiments. In the 2013 film, the International Space Station (ISS) is decimated by space junk. "NASA actually has to adjust the orbit of the International Space Station several times a year to avoid detectable debris," she added.

In fact, the space station gets hit by tiny debris at orbital speeds of about 8 kilometers per second—about 10 times the speed of a bullet—making the impacts visible and threatening. In May 2016, it was likely a fleck of paint that was responsible for leaving a chip measuring 7 millimeters in diameter in an ISS window. Hits like this have punched the space debris hazard out of science fiction and into reality.

The reality check includes live satellites. If you've used GPS, sent a text message, checked the weather, or watched TV, a satellite has provided your connection. According to the US Department of Defense Strategic Command, there are more than 1,000 active satellites currently orbiting the earth, launched by some 50

countries. Uses include mobile phone service, transmission of television signals, weather forecasting, and military surveillance.

Satellite collisions and explosions are the biggest source of debris. Not all orbiting in the same direction, the debris creates a chaotic space environment.

CREATING RISK

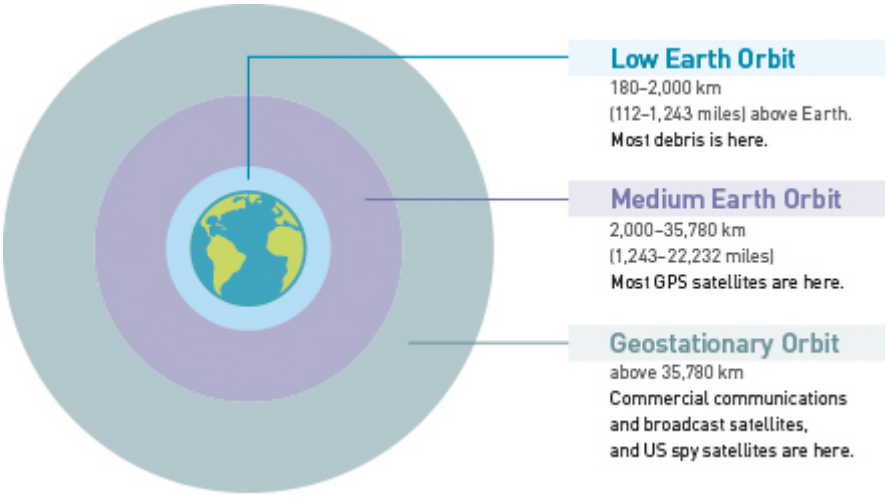
In 2009, a satellite owned by communications provider Iridium, based in McLean, Virginia, accidently smashed into a derelict Russian Cosmos satellite. The result was more than 1,700 pieces of debris. In 2007, China deliberately destroyed one of its defunct weather satellites, known as Fengyun-1C, using a ground-based, medium-range ballistic missile. The US military called it an anti-satellite weapons test. The action was widely condemned internationally. It left in its wake an estimated 1,500 pieces of debris. These two incidents account for one-third of all cataloged orbital debris.

Since the launch of Sputnik by the Soviet Union in 1957, debris orbiting Earth has grown to include about 21,000 pieces larger than 10 centimeters, 500,000 fragments from particles between one and 10 centimeters in diameter, and more than 100 million particles smaller than one centimeter.

Most of the debris is in Low Earth Orbit, defined as 180–2,000 kilometers (112–1,243 miles) above Earth's surface. The 700–1,000 kilometer (435–621 mile) zone is the most congested. This is also where many live satellites are orbiting, partly because operational costs are reduced at lower altitudes. Satellites in this orbit are typically used for earth observation. The ISS, for example, orbits at an altitude of about 400 kilometers (249 miles).

Medium Earth Orbit, stretching from 2,000 to 35,780 kilometers (1,243–22,232 miles), is where GPS satellites typically live. Geostationary Orbit—above 35,780 kilometers—has been called "the most valuable real estate in space." It's where most commercial communications and broadcast satellites are parked, and where the US keeps its most sensitive national security satellites. (The moon, by contrast, orbits at a distance of about 384,000 kilometers or 238,607 miles.)

Space junk will eventually fall back toward Earth, and in most cases burn up as it re-enters the atmosphere. But it takes time: Several years for debris left in orbits below 600 kilometers; decades for debris at altitudes near 800 kilometers; and over a century for debris circling higher than 1,000 kilometers.



MITIGATION

Tracking large space debris has involved research institutions, the military, space agencies, and defense contractors for decades. New, high-precision technology that tracks and gathers data on small debris is not only improving space situational awareness (SSA)—knowledge about what's happening in space—but also increasing commercial opportunities for private-sector businesses.

"The need for SSA data is going to grow tremendously," says Brian Weeden in *Via Satellite* magazine. A technical advisor for the Secure World Foundation, Weeden works on space sustainability issues. "The US military's tracking network is already stretched thin, and can't track smaller objects." He added, "With plans to potentially launch thousands of new satellites over the next several years, we are going to need a lot more data—and from a lot more diverse sources of data—than we have now in order to keep using space in a safe and efficient manner."

Ongoing military projects include Space Fence, which uses a ground-based radar tracking system built by aerospace giant Lockheed for the US Air Force. It will be based on the island of Kwajalein, in the Marshall Islands in the North Pacific. Testing has started and operations are slated to begin in 2018. Space Fence will be tasked with tracking small space objects, perhaps down to a few centimeters in size. The data can be used to provide satellite operators with warnings about potential collisions. It could also be used to detect hostile threats to US military satellites, and those of its allies.

TAKING ACTION

Private-sector companies are betting on SSA business opportunities. Singapore-based Astroscale has opened a satellite manufacturing facility in Tokyo and is planning to launch its data-gathering IDEA OSG1 satellite in March 2017. "We're hoping to attract customers among space agencies, private satellite firms, and universities who want tracked data on small-size debris for mapping purposes," said Miki Ito, president of Astroscale Japan. "They'll be able to use the information to protect satellite equipment."

The human-made detritus they're targeting are pieces less than a millimeter in size, probably making Astroscale the first space debris service of its kind. The timing is right. Satellite operators are used to getting debris data from the US government at no cost, but complaints have been growing about the volume and quality of the data.

Astroscale will also launch its active debris removal (ADR) satellite ADRAS 1 in 2018. The debris will be captured using panels covered with adhesive specially formulated by a Japanese maker. "Adhesive is the best material," said Ito. "There's no need for mechanical or electrical parts, so the satellite is very simple and lightweight."

The company raised about $43 million (¥4.4 billion) in venture capital from private and public sources for its two satellite projects. "We cannot rely on a one-time subsidy from the government, so making a business model is the key," explained Astroscale CEO Nobu Okada, who founded the company in 2013. "The government sector has to think about lots of coordination. We still have a lot to solve, but we can keep moving forward inch by inch. This is the competitive advantage of the private sector."

With their business model and multi-purpose technology in hand, Astroscale is also hoping to ride a new wave

of internet satellite launches that are likely to need servicing. Since 2015, about 10 companies have announced plans to launch a constellation of cross-linked satellites into low Earth orbit. In four to five years, these will provide high-speed Internet service. Most are not government-backed projects and rely on venture capital.

“Costwise, some are more realistic than others,” said Philippe Moreels, Astroscale’s head of strategy and business development. “We believe they might need some support making sure that they remove their satellites after usage to make room for new replenishment satellites.” The companies include OneWeb with plans to launch 900 satellites, LeoSat with 100, SpaceX with 4,000, and Samsung with 4,600.

Other private-sector players joining the space cleanup competition include California-based Global Aerospace Corporation. The company is now developing its Gossamer Orbit Lowering Device (GOLD), designed to de-orbit satellites and large orbital debris. The patented system uses an ultra-thin balloon “envelope” that attaches to debris and inflates with gas. The resulting atmospheric drag enables the ultralight balloon to lower the object from its orbital path and descend into the atmosphere, where it burns up.

“We are leveraging the scalability properties of GOLD to make it applicable to space objects of all sizes, from CubeSats [miniaturized research satellites] to large space platforms,” said Vice President and Business Development Manager Dr. Nicola Sarzi-Amade. “We also expect to help develop new technology related to orbital debris detection and tracking, which would be in support not only of GOLD but also of various other orbital debris mitigation and remediation approaches.”

REACHING CONSENSUS

Space agencies remain the biggest market for debris-related contracts, but government interest and budgets appear to be shrinking. Some big-budget projects still in the works include: NASA’s ElectroDynamic Debris Eliminator, a spacecraft that would maneuver into position next to an object in space and lasso the debris with a lightweight net; JAXA’s electrodynamic space tethers; European Aeronautic Defence and Space Company subsidiary Astrium’s solar sails; and Earth-based lasers developed by ESA and NASA.

ESA, together with countries such as the United States, Russia, China, Japan, and France have issued guidelines on space debris-related technologies. Many private-sector companies voluntarily adhere to these, but established regulations remain elusive.

“Governments are trying to cope with the lack of regulations,” said Astroscale’s Moreels. “For companies like us involved with debris removal, you have to look at discussions at IADC [Inter-Agency Space Debris Coordination Committee] and UN COPUOS [United Nations Committee on the Peaceful Uses of Outer Space] that take care of international policies for space activities.” A consensus is required, but one or two of the committee’s member countries remain against the discussions for political reasons.

Yet Moreels is optimistic. “We believe in the next six to 10 years that the UN will have reached a consensus. This will allow us to use the technologies we will be mastering by then. So we see the debris removal business as long-term, but the technology that is required for that can already be used very soon.”

Could an international treaty be the silver bullet? “Even if there was a treaty, it would still need to be implemented and enforced by national laws, just like the current voluntary guidelines,” explained Secure World Foundation’s Brian Weeden. “Many countries lack the national legal and policy frameworks to implement the existing guidelines, and others have a lot of legacy satellites that are exempt from the guidelines.”

Some orbital debris technologies, however, are raising concerns and are seen as a cover for ambitious military space powers. “I think it is overblown,” said Weeden. “Every space technology, including the US Space Shuttle, gets hyped as a potential covert weapons or military program. The truth is that the military has been very involved in space from the very beginning, and that every space technology we use for civil and commercial benefits today was pioneered by the military.

“In my opinion, the more pressing concern is not the technology but, rather, how it’s used—behaviors in space,” he added. “We need a lot better space situational awareness capabilities to be able to observe space activities, and to figure out who is doing what in space and whether it is responsible or irresponsible. Greater transparency will go a long way towards tamping down the fears.”