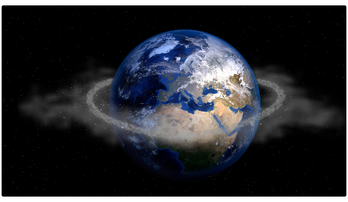
FAQ: Understanding space debris

Alex Miller 5 minutes

Space Sustainability Technology



Q: What is space — or orbital — debris?

A: Orbital debris is any artificial material in space around Earth's orbit. This can include everything from paint flecks and lost bolts up to spent rocket stages and dead satellites. Ever since the advent of the space age, humankind has been creating more and more orbital debris — sometimes by accident when objects break or smash into each other, or intentionally when defunct satellites are left in orbit for years or decades until they de-orbit naturally. More extreme cases have occurred with deliberate actions, such as when Russia tested an anti-satellite weapon in 2021 and created hundreds of thousands of pieces of orbital debris.

Q: Where did all this orbital debris come from?

A: There are many sources for debris ranging from a fleck of paint to a lost wrench to pieces of rocket stages and derelict satellites. According to the European Space Agency (ESA), about 24% of debris in space are satellites and 11% spent upper stages from rockets and other mission-related objects.[1]

But collisions are the biggest contributors, with three incidents accounting for over 30% of orbital debris. The most recent was an anti-satellite missile test conducted by Russia in November, 2021 that struck an inactive Russian satellite causing hundreds of thousands of trackable and untrackable pieces of debris. Another resulted from a missile test conducted by China in 2007 that created more than 3,000 fragments of debris. And in 2009, a Russian satellite collided with an Iridium spacecraft, creating 2,000 pieces of debris of at least 10 cm and thousands more smaller pieces. Much of the debris from these three incidents is expected to remain in orbit for decades.

Q: Where is the orbital debris?

A: Most orbital debris is located in low Earth orbit (LEO), defined as between 500 and 1,500 km (300-900 miles). That's due in large part because the bulk of all space activity occurs in this orbit. NASA estimates the bulk of debris is between 750-1,000 km.[2]

Q: How long does it take for debris to de-orbit on its own?

A: The closer the object is to Earth, the sooner orbital decay will cause it to return to Earth — either burning up in the atmosphere or landing (hopefully) in the ocean. According to NASA, debris at 600 km or lower normally falls back to Earth within several years. Objects above 800 km can take centuries. In geostationary orbit (36,000 km) the highest orbits for artificial satellites, a dead satellite can orbit for millennia. But since there are far fewer of these satellites in a much higher orbit, they're much less likely to cause a problem. Also, operators of these satellites typically reserve enough fuel to push the satellite into a "graveyard orbit" at the end of its life — far above all other satellites.

Q: Space is so huge, how is this a problem?

A: Space is infinitesimally large, but in near-Earth orbits, that space is starting to fill up. In 2023, it's estimated that over 25,000 objects larger than 10 cm are in orbit, with smaller particles between 1 and 10 cm numbering over 500,000 and even smaller ones (<1 cm) numbering over 100 million. With more and more satellites being launched, the problem is only growing. Additionally, in orbits below 2,000 km, these objects are traveling at speeds of 7-8 km/s (15,000-18,000 mph), so the potential for damage can be great even from small objects.[3]

Q: What is orbital carrying capacity?

A: Carrying capacity refers to how much "traffic" a given orbital altitude can safely accommodate. It's arrived at by multiplying the mass of the satellite by the surface area — or cross-sections — times the number of satellites in that orbit. The larger and more massive the satellites, the sooner the orbital carrying capacity will be reached. E-Space believes regulation around orbital carrying capacity can help reduce the risk of collisions, and without it we risk increasing incidents of collisions in space.

Read more about orbital carrying capacity from E-Space CEO Greg Wyler

Q: What is the Kessler Syndrome?

A: The Kessler Syndrome is a theory presented in 1978 describing how one collision can have a cascading effect that never fully ends. That first collision creates even more debris, which then collides with other debris and on and on until the near-space environment is completely degraded. NASA scientist Don Kessler applied the same type of mathematical models used to describe "collision cascading" observed in an asteroid field — or among molecules in a box bouncing around — to describe the effect. If something like the Kessler Syndrome were to take place, it could compromise the space environment for decades or even centuries.

Q: Why is the orbital debris problem getting worse?

A: There are a number of reasons the debris problem is getting worse, but one of the biggest is the sharply increasing amount of activity in LEO. It's gotten much easier and affordable to build small satellites, and the emergence of private launch operators has also driven down the cost of launching them.

In addition to the number of satellites, many of the individual spacecraft have been built without sustainability in mind. With large cross-sections that expose them more to orbiting debris, many "small" satellites are still fairly massive.

Q: Can orbital debris be cleaned up?

A: Yes, but it's not easy, and proposed efforts are mostly confined to larger objects. Japan-based Astroscale is on track to deploy spacecraft that can attach themselves to large pieces of space debris and push them to lower orbits, where they'll burn up in the atmosphere. Another with similar goals is ClearSpace, a partnership between the European Space Agency and Swiss startup ClearSpace SA. Targeted for 2026, the first ClearSpace-1 spacecraft aims to remove the upper stage of a defunct rocket launched in 2013.

Q: Can satellites be designed more sustainably?

A: Yes. In fact, E-Space is doing just that. The spacecraft in our upcoming constellation are design with 6 Tenets to make them more sustainable:

- Fail-safe
- 100% demise
- Small cross-section
- Low mass
- *No* component release
- Entrain and de-orbit

Learn more here.

Footnotes

[1] ESA space debris page

[2,3] NASA Orbital Debris Program Office

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Alex Miller leads editorial at E-Space. Based in Denver, he's a longtime journalist who's been involved with the satellite industry for over a decade.

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