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Space Junk: What's up with space junk?

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Introduction

You know that piece of rubbish you threw out last week? Well, it has probably been picked up by the rubbish truck and recycled or taken to landfill. In space there is no rubbish truck that picks up all the litter we leave behind. Having a junk yard in space does not sound very appealing, so how did all the junk get there, what does it mean for us on Earth and what can we do about it?

So, what is space junk?

Space junk, space debris or orbital debris, whatever you want to call it, is any piece of machinery or debris left by humans in space. Once an object serves its purpose or is damaged and stops working, it becomes space junk. Most space junk comes from rocket stages or retired satellites.

We have been sending scientific instruments into space since 1944 starting with the German intercontinental ballistic missile Vergeltungswaffe (Gorman, p. 47). Since then, there have been many space launches. The problem of space debris first started with the satellite Vanguard 1 which was launched in 1958 by the USA. It stopped transmitting six years later but it is still in medium-Earth orbit (MEO) today. These days space exploration has got cheaper and easier which means private companies can launch their own rockets and satellites, adding even more space junk.

The following table shows how space junk has increased over time. The most dramatic increases begin in the 2000's.

Decade	Amount of space junk
1960's	~ 1,000 objects
1970's	~ 4,000 objects
1980's	~ 6,000 objects
1990's	~ 8,000 objects
2000's	~ 14,500 objects
2010's	~ 25,000 objects
2020's	~ 34,000 objects

Figure 1: Amount of space junk by decade

The image below shows how space junk has increased in Earth's orbit over the decades.

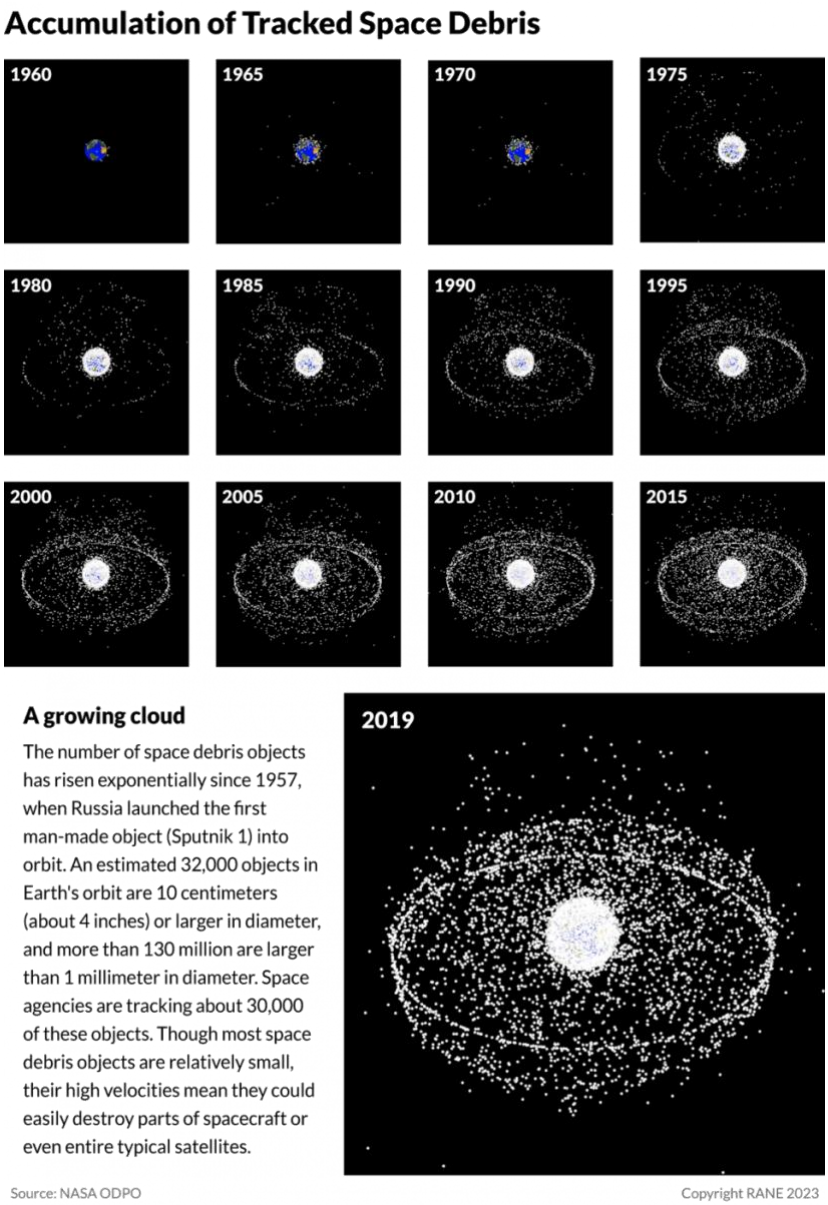


Figure 2: Accumulation of tracked space junk

NASA (2023) *Accumulation of space debris* [photograph], Worldview, accessed 23 June 2024.

How did it get there?

The creation of space junk can be mission related, accidental or intentional (Hall 2014). The different types of space junk are explained below:

- Mission related space junk include shields that protect satellites from incoming particles and explosive bolts which separate the satellite from the launch vehicle.
- Accidental space junk is created when astronauts misplace or lose control of things while they are working outside of the space craft, when space junk collides with other things in space and when orbiting space junk explodes. Some examples of accidental space junk include a pair of pliers which was lost by

Scott Parazynski while repairing solar panels in space in 2007, the collision of an active communication satellite with a decommissioned satellite in 2009 which destroyed both satellites and created large debris clouds (Hall, 2014) and the explosion of fuel tanks containing remnant fuel after they have launched.

- Intentional space junk is created when countries like the USA, China and India carry out anti-satellite tests. This is where they use missiles to blow up their own satellites.

What does it look like?

Space junk comes in all shapes and sizes but most pieces (130 million) are smaller than 1cm and include things like flecks of paint. When space junk is this small it can't be tracked by scientists. There are 1,000,000 pieces of space junk between 1 - 10cm, such as screws. Space junk larger than 10cm in size equals 36,500. The Russian SL-16 rocket body which was part of the Zenit 2 rocket launch is 11 metres long!

The US Air Force's Joint Space Operations Centre (JSpOC) operates the Space Surveillance Network which keeps a record of all trackable objects in orbit. The table below shows space junk by size, number and trackability.

Category	Diameter	Number in orbit	Trackability
Large	>10cm	36,500	Tracked and catalogued
Medium	1cm - 10cm	1,000,000	Trackable with lower reliability
Small	1mm - 1cm	130,000,000	Not currently tracked

Figure 3: Space junk by size, number and trackability

Where in space is it?

Wherever we send spacecraft we leave space junk! Nearly all space junk can be found in Earth's orbit, but some can be found further away like Mars.

Earth's orbits include three main satellite orbits LEO, MEO and GEO. We send satellites into space for telecommunication, broadcasting tv and radio, weather monitoring, GPS tracking and security. These satellites are positioned at various orbits depending on their function.

The table below shows the types of space activities in each satellite orbit around Earth.

Orbit	Altitude (km above Earth's surface)	Space activity
LEO (Low Earth Orbit)	160 - 2,000 km	Earth observation satellites, International Space Station,

		Technology demonstration, scientific missions, small commercial satellites
MEO (Medium Earth Orbit)	2,000 - 36,000 km	Position navigation (GPS), timing services, communication systems
GEO (Geostationary Orbit)	36,000 km and above	Broadcasting & telecommunication systems

Figure 4: Types of space activities in Earth's orbits

Most, (85%) of all space junk, is in LEO. It is made up of three main components: clusters of abandoned rocket bodies, clouds of fragments and constellations of decommissioned satellites and space probes (Hall, 2014). Space junk in MEO orbit is less dense than LEO and GEO orbit has even less space junk than MEO (Shadbolt, 2023).

Even though the Moon's orbit is nine time larger than GEO, it has been damaged by space junk. In 2022, a rocket body crashed onto the surface of the moon and created two craters (Strickland & Hunt, 2022).

Space exploration on Mars has left 7118 kg of space junk on its surface. This junk is made up of 'discarded hardware, inactive spacecraft and crashed spacecraft' (Kilic, 2022).

Figure 5: Protective shell of ejected equipment on mars

NASA/JPL-Caltech (2022) *Protective shell of ejected equipment* [photograph], Space.com, accessed 23 June 2024.

Hazards of space junk

Most space junk moves very fast. In LEO space junk travels at speeds of 7 - 8 km per second. When objects travelling at this speed collide it creates an impact speed of 10 - 15k m per second which is 10 times the speed of a bullet. This means that even the smallest piece of space junk, like a fleck of paint can have a disastrous effect on an operational satellite.

LEO's high space junk density and orbital speeds, means that it has the highest 'collision probability'. This probability was investigated by NASA scientist Donald Kessler who said:

"...If there is too much space junk in orbit, it could result in a chain reaction where more and more objects collide and create new space junk in the process, to the point where Earth's orbit became unusable". (O'Callaghan, 2021).

This means that when earth's orbit becomes too crowded with spacecraft and space junk, the probability of them colliding with each other is higher. This would result in more pieces of space junk, making access to space costly and difficult but not impossible (Aerospace, n.d.).

Managing Space Junk

In 2015, astronauts aboard the International Space Station (ISS) were evacuated to a space capsule because a piece of satellite space junk was heading towards them. The space junk missed the ISS, but this shows how important it is that space junk is tracked and managed.

At the moment, some space junk in LEO has the possibility of returning to Earth and burning up when it re-enters Earth's atmosphere. However, in MEO there is no clear way satellites can be disposed of. Whereas when satellites in GEO have completed their mission, they can be moved to the 'graveyard orbit' 300km above the GEO orbit (Shadbolt, 2023).

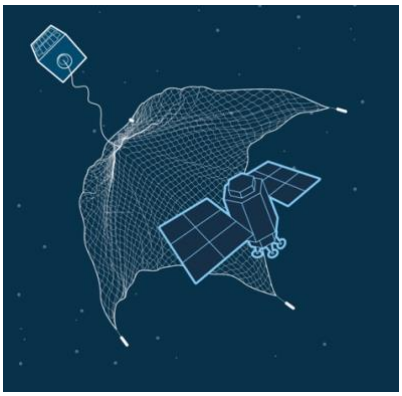
In the future space junk will be managed by guidelines developed by space agencies and the United Nations to minimise the creation of space junk. These include:

- Adding shields to protect space craft from collisions
- Strengthening fuel systems to avoid explosions
- Making spacecraft manoeuvrable to avoid collisions
- Adding extra fuel supplies so that old spacecraft can be deorbited (Shadbolt, 2023).

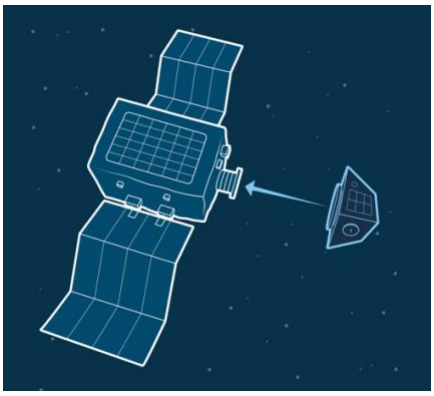
Scientists are researching and testing different ways to remove space junk. These include:

- Active Debris Removing (ADR) vehicles to remove space junk using harpoons and nets, robotic arms and magnetic systems.

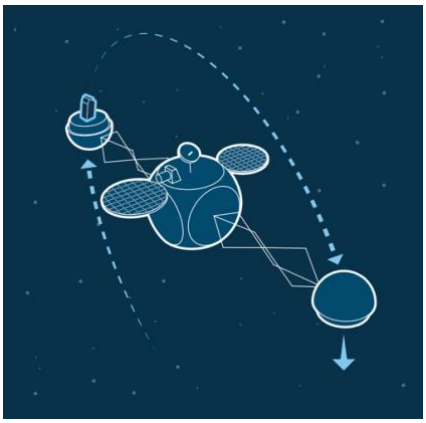
- A sling shot system developed by Texas A&M University that would fling space junk down to burn up in Earth's atmosphere.
- Lasers to push space junk on a collision course out of the way or into Earth's atmosphere to burn up (McKinsey for Kids, 2022)



Harpoons and nets



Magnetic systems



Sling shots

Lasers

Figure 6: New technologies being researched to remove space junk

McKinsey for Kids (2022) *New technologies being researched to remove space junk* [illustration], McKinsey for Kids, accessed 23 June 2024.

Conclusion

By exploring space we have discovered more about Earth, connected people all over the world and developed technologies that enrich our lives. Space technologies help us study climate change, save lives after natural disasters and answer scientific questions.

The increase of space junk makes the accessibility of Earth's orbits difficult and dangerous and affects our ability to continue space research and provide services on Earth. By using guidelines to help reduce space junk and researching ways to remove space junk from Earth's orbit, we can make sure that humans continue to access space in the future.

References

Aerospace (n.d.) *Space Debris 101*, Aerospace, accessed 23 June 2024. https://aerospace.org/article/space-debris-101

Gorman A (2019) *Dr Space Junk vs The Universe: Archaeology and the Future*, Nerwsouth, Sydney, NSW.

Hall L (2014) 'The History of Space Debris', *Embry-Riddle Aeronautical University Scholarly Commons*, 1-12. https://commons.erau.edu/cgi/viewcontent.cgi?article=1000&context=stm

Kilic C (September 2022) *Mars is littered with 15,694 pounds of human trash from 50 years of robotic exploration*, Space.com, accessed 24 June 2024. https://www.space.com/mars-littered-with-human-trash

O'Callaghan J (2021) *What is space junk and why is it a problem?*, Natural History Museum, accessed 23 June 2024. https://zero5g.com/wp-content/uploads/2021/09/What-is-space-junk-and-why-is-it-a-problem-Natural-History-Museum.pdf

Shadbolt L (2023) *Technical Study: Space Debris* [e-book], HDI Global Specialty offices https://www.hdi.global/globalassets/_local/international/newsroom/hdi_global_specialty_study_space_debris_2023_corpv5.pdf

Strickland A, Hunt K (June 2022) *New double crater seen on the moon after mystery rocket impact,*, CNN, accessed 24 June 2024. https://edition.cnn.com/2022/06/27/world/rocket-moon-impact-crater-scn/index.html

Image references

McKinsey for Kids (2022) *New technologies being researched to remove space junk* [illustration], McKinsey for Kids, accessed 23 June 2024. https://www.mckinsey.com/featured-insights/mckinsey-for-kids/space-junk-its-out-of-this-world

NASA (2023) *Accumulation of space debris* [photograph], Worlview, accessed 23 June 2024. https://www.stratfor.com/sites/default/files/styles/wv_large/public/Space-Debis-Accumulation-09012023.png?itok=IWaKpfEb

NASA/JPL-Caltech (2022) *Protective shell of ejected equipment* [photograph], Space.com, accessed 23 June 2024. https://www.space.com/mars-littered-with-human-trash

Bibliography

Anywaves (January 2024) *LEO vs. MEO vs. GEO Satellites: What's the Difference?*, Anywaves, accessed 24 June 2024. https://anywaves.com/resources/blog/leo-meo-geo-satellites-definition-difference/#

Bongers A, Torres J (April 2024) *Low-Earth Orbit Faces a Spiraling Debris Threat* Scientific American, accessed 24 June 2024. https://www.scientificamerican.com/article/low-earth-orbit-faces-a-spiraling-debris-threat/#:~:text=

Canada Space Agency (21 July 2023) *Canada and space sustainability*, Canada Space Agency, accessed 23 June 2024. https://www.asc-csa.gc.ca/eng/sustainability/canada-and-space-sustainability.asp

European Space Agency (n.d.) *About space debris*, European Space Agency, accessed 23 June 2024. https://www.esa.int/Space_Safety/Space_Debris/About_space_debris

European Space Agency (n.d.) *Active debris removal*, European Space Agency, accessed 23 June 2024. https://www.esa.int/Space_Safety/Space_Debris/Active_debris_removal

European Space Agency (10 August 2023) *ESA's Space Environment Report 2023*, European Space Agency, accessed 23 June 2024. https://www.esa.int/Space_Safety/ESA_s_Space_Environment_Report_2023

European Space Agency (June 2024) *Space debris by the numbers*, European Space Agency, accessed 23 June 2024. https://www.esa.int/Space_Safety/Space_Debris/Space_debris_by_the_numbers

Greene B, Colless M (n.d.) *Tackling space junk*, Australian Academy of Science, accessed 24 June 2024. https://www.science.org.au/curious/space-junk

Luke C (September 2021) *Explainer: What Is Space Junk and How Does It Affect the Environment?*, Earth Org, accessed 24 June 2024. https://earth.org/space-junk-what-is-it-what-can-we-do-about-it/

McKinsey for Kids (July 13, 2022) *Space DebrisSpace junk—it's out of this world*, McKinsey, accessed 23 June 2024. https://www.mckinsey.com/featured-insights/mckinsey-for-kids/space-junk-its-out-of-this-world

NASA (2023) *Space Debris*, NASA, accessed 23 June 2024. https://www.nationalgeographic.com/science/article/space-junk

NASA (June 2010) *What Is Orbital Debris? (Grades 5-8)*, NASA, accessed 23 June 2024. https://www.nasa.gov/learning-resources/for-kids-and-students/what-is-orbital-debris-grades-5-8/

National Geographic Education (n.d.) *Orbit*, National Geographic, accessed 24 June 2024. https://education.nationalgeographic.org/resource/orbit/

Phan K (October 16, 2020) *Space Junk*, Time for Kids, accessed 23 June 2023. https://www.timeforkids.com/g56/space-junk-2/?rl=en-870

Tenenbaum L (May 2019) *Space Junk: What Goes Up Might Not Come Down*, Forbes, accessed 24 June 2024. https://www.forbes.com/sites/lauratenenbaum/2019/05/24/space-junk-what-goes-up-might-not-come-down/

World Economic Forum (May 20, 2021) *Space junk: what it is and why cleaning it up matters*, World Economic Forum, accessed 24 June 2024. https://www.weforum.org/agenda/2021/05/space-junk-clean-satellite/