STUDY NOTES · BASIC CONCEPT

What Is Kessler Syndrome? What Is Space Debris? in DETAIL

Science & Technology

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Kessler Syndrome is a scientific theory proposed in 1978 by NASA scientist Donald J. Kessler. It describes a scenario in which the density of objects in Low Earth Orbit (LEO) becomes so high that collisions between satellites and debris create a chain reaction. Each collision produces more debris, which increases the chances of further collisions — eventually making parts of Earth's orbit unsafe or unusable for satellites and space missions.

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What Is Space Debris?

Space debris (also called orbital debris or space junk) includes:

- Defunct satellites
- Spent rocket stages
- Fragments from satellite collisions or explosions
- Paint flakes, bolts, and metal fragments

As of 2024–25:

- Over 36,000 objects larger than 10 cm are tracked in Earth orbit
- Around 1 million pieces between 1–10 cm
- More than 130 million micro-fragments smaller than 1 cm
- Even a 1 cm object can destroy a satellite because orbital speeds reach 7–8 km per second (over 25,000 km/h).

Why Is Kessler Syndrome Dangerous?

If a major collision occurs:

- It creates thousands of fast-moving debris fragments
- Those fragments strike other satellites
- Each new collision creates more debris

- This leads to a self-sustaining chain reaction

Consequences:

- Loss of GPS navigation and timing services
- Disruption of internet, TV, weather forecasting, and military communications
- Threat to astronauts aboard the ISS
- Inability to launch new satellites safely for decades
- Billions of dollars in economic losses

Real Incidents That Raised Alarm

- 2007: China destroyed one of its satellites during a missile test, creating over 3,000 debris pieces.
- 2009: A Russian satellite collided with an Iridium communication satellite, producing thousands of fragments.
- Recent years: Malfunctioning satellites (including some Starlink units) have increased congestion in low-Earth orbit.

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What Is Being Done to Prevent It?

- Tracking systems: NASA, ESA, and SpaceX track over 30,000 objects to avoid collisions.
- Collision avoidance maneuvers: Active satellites adjust orbits when risk increases.
- Post-mission disposal rules: Satellites must deorbit within 25 years after mission end.
- Debris removal projects: Experimental missions aim to capture and deorbit large dead satellites.