Space Pollution: Overview

Introduction

The so-called space race in the 1960s between the two superpowers the US and the Soviet Union accelerated the potential for outer space travel. In the decades following, spacefaring nations launched numerous objects into orbit around Earth, from satellites and probes to crewed spacecraft and space stations. Those efforts proved beneficial to humanity in many ways, facilitating the development of technologies such as satellite-navigation systems and enabling scientists to learn more about both space and Earth itself. However, the presence of human-made objects in orbit also led to the spread of space pollution in the form of disused or damaged spacecraft, satellites, and components that remained in orbit long after their purpose had been served. As early as 1967, the US, the Soviet Union, and over sixty other nations signed the Outer Space Treaty to regulate space exploration, including an article addressing liability for damage caused by space objects. The proliferation of space debris drew particular attention during the 2020s, a period in which multiple countries were actively pursuing space exploration and a host of corporations were launching satellites and other technology into orbit at a rapid pace. Concerned observers debated whether the international community should put more robust regulations in place to limit space objects. Supporters of increased international action called attention to the rapidly accumulating debris and argued that space pollution endangers critical resources such as satellites, which could be damaged or destroyed if a collision with space debris were to occur. In light of such threats, they argued, international bodies should develop stricter regulations governing debris-producing endeavors. Others, however, asserted that the challenges posed by space pollution were overstated, as a great deal of space debris eventually deorbits and burns up in Earth's atmosphere, and that implementing regulations would hinder innovation. Those opposed to a regulatory solution likewise asserted that advancements in areas such as debris tracking and collision avoidance were sufficient to mitigate any lingering problems posed by space pollution.

Understanding the Discussion

Geostationary orbit: The trajectory an object takes around Earth at the same speed and direction as Earth's rotation, thus appearing to remain stationary in relation to Earth's surface.

Global Positioning System (GPS): The US-based system of satellites used to determine the location of receivers on Earth for purposes such as mapping and navigation.

Kessler Syndrome: A proposed scenario in which the proliferation of space debris leads to a cascading series of collisions that in turn create additional debris.

Low Earth orbit (LEO): An orbit range that extends no farther than about 1,200 miles (2,000 kilometers) from Earth's surface.

Space pollution: Disused human-made objects or fragments of objects in orbit; also known as space debris or space junk.

History

The term *space pollution* refers to disused human-made objects, or fragments of destroyed objects, in orbit. Such items are also referred to as space debris or orbital debris, or, more disparagingly, as space junk. Individual pieces of space debris range widely in size and include decommissioned satellites, rocket components, and small fragments created when objects in orbit collide with one another or are otherwise destroyed. The history of space pollution is inextricably linked with the history of space exploration, which began in 1957 with the successful launch of the Soviet artificial satellite Sputnik 1. Over the next decades, national space programs would make numerous major advances, transporting human beings into space and eventually to the moon, and sending uncrewed probes to the distant reaches of the solar system and beyond. In doing so, however, they would likewise set in motion the accumulation of debris in orbit around Earth.

From the mid-twentieth century on, the region of space immediately surrounding Earth became of increasing importance not only to scientists but also to governments, major corporations, and society as a whole. Satellites placed in orbit proved essential for a variety of purposes, including military surveillance, communications, and media broadcasting. Members of the public widely adopted satellite navigation systems such as the US-based Global Positioning System (GPS), the Russian system GLONASS, and later additions such as the European Union's Galileo, all of which used arrays of multiple satellites to determine the position of receivers on the ground. Also orbiting Earth were space stations, from early stations such as the Soviet Salyut 1 and the United States' Skylab to later facilities such as the International Space Station and the Tiangong stations created by China's space program. The bulk of the world's satellites and space stations were placed in what is categorized as low Earth orbit (LEO), a zone that extends to about 1,200 miles (2,000 kilometers) from Earth's surface. Some were specifically placed in geostationary orbit, in which an object orbits Earth at the same speed and direction as Earth's rotation and thus appears to remain stationary in relation to Earth's surface.

As space-based resources gained greater importance to multiple industries, scientists became increasingly aware of the potential risks associated with the decommissioned satellites, discarded rocket parts, and other debris spread throughout Earth's orbit. These were concerning for several reasons, including their potential to cause harm or property damage on Earth if they were to pass through the atmosphere and land on the planet's surface. Also of serious concern was the likelihood that a piece of space debris could collide with another object in orbit, such as an active satellite, a spacecraft, or a space station, and damage or even destroy that object on impact. That impact could, in turn, cause the creation of numerous smaller pieces of space debris, which could themselves go on to collide with other objects and create new clouds of debris, and so on. That worst-case scenario came to be named the Kessler Syndrome after scientist Donald Kessler, who explored the ramifications of debris collisions in a 1978 paper written with fellow scientist Burton Cour-Palais.

In light of such concerns, national agencies such as the United States' National Aeronautics and Space Administration (NASA) began efforts to monitor and

mitigate the risks of space pollution. NASA launched its Orbital Debris Program in 1979 and continued its work in that area in the decades that followed, as did space agencies such as the European Space Agency (ESA), Russia's Roscosmos, and the China National Space Administration (CNSA). Facilitating international cooperation in regard to space debris, space agencies from Asia, Europe, and North America founded the Inter-Agency Space Debris Coordination Committee in 1993. That body produced its *IADC Space Debris Mitigation Guidelines* in 2002 and continued to revise and update those guidelines throughout the next decades, releasing a fourth revision in early 2025. Other international bodies that sought to address the issue of space pollution throughout the early twenty-first century included the United Nations Office for Outer Space Affairs (UNOOSA).

Space Pollution Today

The late 2010s and early 2020s saw a rapid increase in commercial engagement with space. In addition to providing spacecraft and launch vehicles to national space programs, private companies launched their own space initiatives for purposes such as tourism, scientific study, and, perhaps most often, the placement of vast new satellite arrays. The proliferation of privately launched spacecraft and satellites concerned those knowledgeable about space pollution on multiple grounds. First, such initiatives contributed new objects to Earth's increasingly crowded surroundings, both in the form of active satellites and in the form of rocket components and other debris. Second, the spacecraft and satellites launched by private companies were, like the vehicles that came before them, vulnerable to damage from the debris already in orbit. Concerns about space pollution were stoked further by several high-profile incidents that received extensive media coverage and drew public attention to the issue, including a 2024 incident in which a cloud of fragments from a decommissioned satellite passed relatively close to the International Space Station, forcing astronauts and cosmonauts to take shelter in their docked spacecraft as a precaution. Several widely publicized instances of space debris crash-landing on Earth raised awareness of potential harm, including the 2025 crash of a rocket fragment in rural Kenya.

As scientists, policymakers, and corporations debated the best means of addressing space pollution, the number of individual pieces of space debris continued to rise. By late 2025, the ESA estimated there to be more than 50,000 objects larger than ten centimeters in size located in orbit around Earth, a number that included both objects still in use, such as active satellites and space stations, and decommissioned, discarded, or fragmentary items. Smaller objects were even more prevalent; according to the ESA, Earth's orbit was host to about 1.2 million objects between one and ten centimeters in size and another 140 million measuring between one millimeter and one centimeter. Common categories of objects included inactive payloads, rocket debris, rocket bodies, and small fragments of each.

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About the Author

Joy Crelin is a freelance writer and editor based in Wethersfield, Connecticut, USA. She holds a bachelor of fine arts in writing, literature, and publishing from Emerson College.