Taking Action on Orbital Debris

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Orbital debris consists of dead satellites, spent rocket stages, and other remnants of human activity in space that have accumulated in Earth's orbit and present a hazard to current and future space activities. Managing this risk is a collective action problem that will require stakeholders to adopt new practices and accept costs now to forestall large negative impacts on space activities in the future. A U.S. policy approach should be focused on both mitigation and remediation actions related to orbital debris, in the interests of safety and stability for American military, civil, and commercial users of space systems.

Background

Orbital debris—dead satellites, spent rocket stages, and other fragments associated with humanity's nearly seven decades of activity in space—represents a growing threat to active satellites and crewed space missions. The United States is, as of the end of January 2025, tracking about 36,700 pieces of human-generated debris in Earth orbit larger than 4 inches (10 centimeters) in size, each of which could destroy an active satellite in a collision. Statistical modeling indicates there are an estimated 1,100,000 pieces of orbital debris between 0.4 and 4 inches (1 and 10 centimeters) in size that are largely untracked, each of which could severely damage an active satellite in a collision.[1] This existing orbital debris is largely concentrated in the same altitudes that are heavily used by satellites, particularly in low Earth orbit (LEO) between 600 and 900 kilometers (372 and 559 miles) and geostationary Earth orbit at 36,000 kilometers (22,369 miles).

The continued growth of space debris and increasing collision risk in orbit represent a hazard to the economic and societal benefits of space activities. Satellites operating in congested regions already have to manage a growing number of close-approach warnings and potentially expend fuel to avoid potential collisions. If the amount of debris is allowed to grow unchecked, we may see what is described as the "Kessler Syndrome," where, as the amount of debris in orbit grows, the increasing density of space objects will lead to random collisions, which in turn generate debris at a rate faster than can be naturally removed from orbit by the Earth's atmosphere. This could result in some orbits becoming too expensive to operate in, as satellites would have to continually move to avoid being hit by debris.

Since the early 1990s, the main policy focus to deal with orbital debris has been to develop mitigation practices that reduce the creation of orbital debris from space activities. More than a dozen national

1 https://www.space-track.org/

space agencies participate in the Inter-Agency Orbital Debris Coordination Committee (IADC) to develop technical standards for orbital debris mitigation. While the IADC standards themselves are voluntary, a growing number of countries have put in place national policies and regulatory frameworks to implement these debris mitigation standards. A growing number of private sector efforts have also established their own best practices that often go beyond the IADC standards.

While mitigation reduces future growth in the orbital debris population, it does not address the existing debris. Remediation of orbital debris—including active debris removal (ADR)—is also necessary. Remediation of existing debris objects has been, and remains, a difficult technical, political, legal, and business challenge to solve. One of the biggest sources of risk comes from large debris objects in LEO that are part of the legacy of previous governmental space activities—for the most part, that of the United States, Russia (including historical Soviet objects), and China.

Current Policy and Gaps or Shortcomings

In the United States, NASA is the lead agency for developing debris mitigation-related technical standards, which are encapsulated in the U.S. Government Orbital Debris Mitigation Standard Practices (ODMSP). Other federal agencies are expected to apply the ODMSP to their own space activities and implement them in their licensing of U.S. private sector space activities. However, there are differences in how each agency has implemented the ODMSP and concerns that the ODMSP have not gone far enough to address the emerging challenges posed by small satellites and large constellations. In September 2022, the Federal Communications Commission (FCC) adopted a requirement for its licensees in low Earth orbit to dispose of their satellites within five years of completing their missions. This requirement goes beyond what is in the ODMSP but matches with practices many commercial operators are adopting voluntarily, driven by operational and technical needs.

Historically, orbital debris remediation or removal has not been an area of focus for the U.S. government. In January 2021, the first Trump administration released the *National Orbital Debris Research and Development Plan*,[2] which sought to provide a coordinated plan to support research and development efforts related to orbital debris risk management across the federal government. This Plan identifies areas for research and development across the three core elements of orbital debris risk management: promoting design practices that limit orbital debris; improving debris tracking and characterization capabilities; and developing capabilities related to debris remediation and repurposing. In July 2022, the Biden administration issued the *National Orbital Debris Implementation Plan*,[3] which sought to outline tangible implementation actions to build upon the 2021 *Research and Development Plan*.

In March 2024, NASA issued the first volume of its newly created Space Sustainability Strategy.[4] Part of this Strategy included a welcome policy change expanding NASA's ability to fund debris remediation technology, including operationally relevant capabilities, and to apply that technology to remediation of debris from NASA's own missions. Further leadership is required to follow up on implementation support and funding.

2 National Science and Technology Council, "National Orbital Debris Research and Development Plan," The White House, January 2021, https://trumpwhitehouse.archives.gov/wp-content/uploads/2021/01/National-Orbital-Debris-RD-Plan-2021.pdf.

3 National Science and Technology Council, "National Orbital Debris Implementation Plan," The White House, July 2022, https://bidenwhitehouse.archives.gov/wp-content/uploads/2022/07/07-2022-NATIONAL-ORBITAL-DEBRIS-IMPLEMENTATION-PLAN.pdf

4 NASA, "NASA Procedural Requirements for Space Flight Program and Project Management Requirements," NASA, accessed February 8, 2025, https://nodis3.gsfc.nasa.gov/OPD_Docs/NPS_1001_111_.pdf.

The U.S. Space Force (USSF) has awarded several contracts for ADR-related technology development. In January 2022, the USSF announced the "Orbital Prime" mission, to be run by its technology branch, SpaceWERX, in order to use commercial capabilities to "recycle, reuse, or remove" space debris. Kall Morris Inc. (KMI) announced in September 2022 that it had won three USSF contracts under this program, while Turion announced in July 2024 that it had also won a contract under the same program. The optics of the USSF being possibly the most active USG funder of ADR technology are potentially problematic, as this technology is inherently dual-purpose and could be weaponized.

U.S. space industry companies, often with the support of government contracts and/or R&D funds, are advancing work on technologies and services that relate to debris remediation capabilities. Development of adjacent capabilities for in-space servicing, assembly, and manufacturing (ISAM) are helping to advance ADR-related technologies in commercially relevant rendezvous and proximity operations as well as in spacecraft grappling, berthing, and docking capabilities. Commercial space situational awareness (SSA) and non-Earth imaging capabilities and services enhance the ability to conduct characterization of debris objects and inform safe rendezvous operations. Companies are investing in novel debris remediation concepts, such as laser-based ablation and in-space recycling. Additionally, in June 2024, SpaceX was awarded a contract from NASA to develop a "U.S. Deorbit Vehicle" for the purposes of de-orbiting the International Space Station (ISS) at the end of its life.

These initiatives are positive, but there is a need for additional government action, both to sustain and scale existing programs. A number of ADR or debris remediation pilot and technology development programs are underway in Europe, Japan, and the United Kingdom, with efforts led by private companies funded by national space agencies. These programs demonstrate leadership: governments are working to develop capabilities to remove their own debris objects, while also advancing in industry development. The United States has fallen behind other nations in this area and has not made similar levels of investment. The U.S. government overall has invested relatively little in research and development of debris remediation capabilities—despite high-level policy direction to do so—and currently lacks both follow-through on the existing implementation execution strategy and a broader vision to advance space debris remediation capabilities in support of the growing space economy. ●

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Policy Recommendations

→ Harmonize orbital debris mitigation requirements across licensing authorities under one regulatory agency.

Currently, orbital debris mitigation requirements are part of licenses issued by three different U.S. federal agencies: the Federal Aviation Administration, the National Oceanic and Atmospheric Administration, and the Federal Communications Commission. While consolidation of licensing into a single entity is not achievable, the National Space Council or its equivalent should coordinate interagency processes to ensure space debris mitigation requirements are consistent across licensing agencies in order to support efficiency in licensing processes and certainty for operators applying for licensing.

→ Initiate a national active debris removal mission to leverage commercial capabilities.

The United States government—through NASA—should establish a program to fund and conduct the removal of a U.S.-government-owned legacy space debris object, preferably a large rocket body. This mission should be conducted as a public-private partnership through NASA and would leverage existing NASA technical capability and investment related to ISAM as well as emerging industry capabilities related to satellite servicing and in-space logistics. It is important that a national orbital debris removal mission be conducted by a civil government agency (rather than the Department of Defense and/or Space Force) in order to ensure that ADR action is not seen as a threatening or adversarial capability. Such a mission would help to establish U.S. leadership in orbital debris remediation and set an example to both adversary nations and allies of the importance of taking responsible action to remediate national legacy debris objects.

→ Continue to support the development of commercial ISAM capabilities.

Government support for commercial ISAM capabilities—in terms of both contracting and R&D funding—provides important adjacent and complementary technology and services useful to advance debris remediation capabilities. The U.S. government should continue to support this emerging growth area in the space economy, including purchasing commercial services and not developing government capabilities that compete with industry offerings. For both efficiency and economic development purposes, it is also important to leverage and use industry and/or voluntary consensus standards in areas like refueling, docking, and interfaces instead of developing bespoke requirements in government procurements.