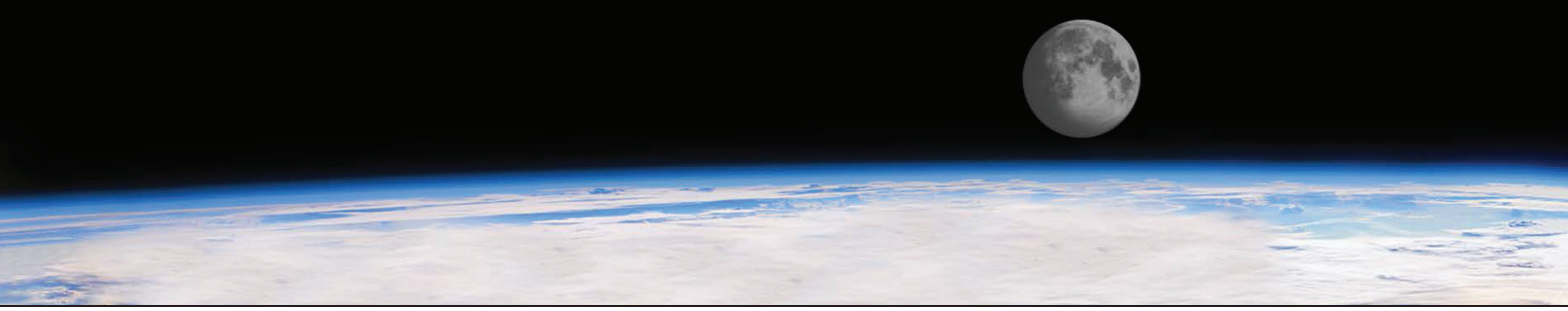

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Commercial Space Activity and Its Impact on U.S. Space Debris Regulatory Structure

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Foreword

Radical shifts in space operations—including the deployment of large constellations and the widespread use of CubeSats and other small satellites—will soon make commercial activity the dominant source of space traffic. The increased traffic will make compliance with space debris mitigation measures more essential. A large number—63%—of satellites launched during 2016 were from companies based in the United States,[1] so the U.S. regulatory system must be ready to accommodate the increased activity and set the right precedents for future debris mitigation decisions.

Background

An understanding of space debris mitigation issues and the associated U.S. policies and regulatory structures have been developing over the last three decades.[2] The Orbital Debris Mitigation Standard Practices (ODMSP), published in 2000, establishes a framework for debris mitigation requirements for U.S. government agencies.[3] The 2010 National Space Policy[4] reaffirmed that government organizations must comply with the ODMSP, while allowing them to impose more specific or more stringent rules in addition to the core ODMSP guidelines. NASA Standard 8619.14[5] and Air Force Instruction 91-217[6] are examples of these more detailed rules.

Several agencies are responsible for regulating orbital debris mitigation in the United States: the Federal Communications Commission (FCC), the Federal Aviation Administration (FAA), and the National Oceanic and Atmospheric Administration (NOAA). These agencies were not explicitly designated to address space debris, as they were formed well before space debris became an issue and even before routine spaceflight was possible; but their regulatory authority has evolved over time as space moved from a domain entirely dominated by governments to one that included commercial activity as well.

Federal Communications Commission

The FCC is the U.S. agency responsible for licensing radio transmissions, including those from satellites, by private companies. Although the FCC was established in 1934, before satellite communications existed, its broad authority to regulate in the "public interest" was interpreted to include debris mitigation issues. The FCC considers debris mitigation plans "relevant in determining whether the public interest would be served by authorization of any particular satellite system or by any particular practice or operating procedure of satellite systems."[8]

The FCC first noted the issue of space debris in 1994 and participated in the development of the government's Interagency Report on Orbital Debris in 1995. The initial proposal for including debris mitigation plans in license applications came in 1999.[7] The initial rules were put in place in 2004 in the Second Report and Order (FCC 04-130) amendments to Parts 5, 25, and 97 of the commission's rules, with an effective date of October 19, 2005.[8] Under these rules, applicants for FCC authorization to operate communication satellites that will transmit to U.S. receiver systems must submit documentation for their debris mitigation strategy, including plans for limiting operational debris produced during the mission and limiting the probability that the satellite will become a source of debris. An end-of-life plan is also required that details the post-mission disposal strategy, including the quantity of fuel, if any, that will be reserved to perform disposal maneuvers. For geostationary satellites, the end-of-life plan must disclose the altitude selected for the disposal orbit, the calculations used in deriving the disposal altitude, and the expectation of casualty if the planned disposal involves atmospheric reentry of the satellite.

Federal Aviation Administration

The Commercial Space Launch Act of 1984, as amended and re-codified by the National and Commercial Space Programs Act of 2010 (51 U.S.C. § 50901–50923), authorizes the Department of Transportation and, through delegations, the FAA's Office of Commercial Space Transportation, to oversee, authorize, and regulate both launches and reentry of vehicles and the operation of launch and reentry sites when carried out by U.S. citizens or within the United States. The act directs the FAA to exercise this responsibility consistent with public health and safety, safety of property, and the national security and foreign policy interests of the United States. The act also directs the FAA to encourage, facilitate, and promote commercial space launches and reentries by the private sector, including those involving spaceflight participants. A major focus of FAA debris mitigation regulation has been on reentry, which may include safety consequences of controlled and uncontrolled reentries.[9]

National Oceanic and Atmospheric Administration

The National and Commercial Space Programs Act (51 U.S.C. § 60101–60162) also stipulates that no U.S. person may operate a private remote sensing space system without a license. The act also authorizes the Secretary of Commerce to license private remote sensing space systems. By law, the Secretary can grant a license only upon determining in writing that the applicant will comply with the requirements of the act as well as any regulations issued pursuant to the act and any applicable international obligations and national security concerns of the United States.[10]

As an additional requirement, 15 CFR § 960.11 states that "a licensee shall dispose of any satellites operated by the licensee upon termination of operations under the license in a manner satisfactory to the President." NOAA has interpreted this to mean that a licensee shall assess and minimize the amount of orbital debris associated with disposal of its satellite. Applicants are required to provide, at the time of application, a plan for post-mission disposition of remote sensing satellites.

Issues Arising From Commercial Activity

The existing U.S. regulatory framework may be challenged in the coming years with the advent of "New Space," the term for numerous space ventures that are being initiated by nontraditional companies and organizations. The sheer amount of space activity proposed by New Space organizations is likely to stress government regulatory structures. New Space efforts already span several major areas. One is the deployment of large constellations—which may include hundreds or thousands of satellites—to provide Earth observation or global communications and Internet coverage. A second involves the rapid increase in the deployment of CubeSats and other small satellites. A third is the development of new commercial launch providers targeting these new satellite markets.

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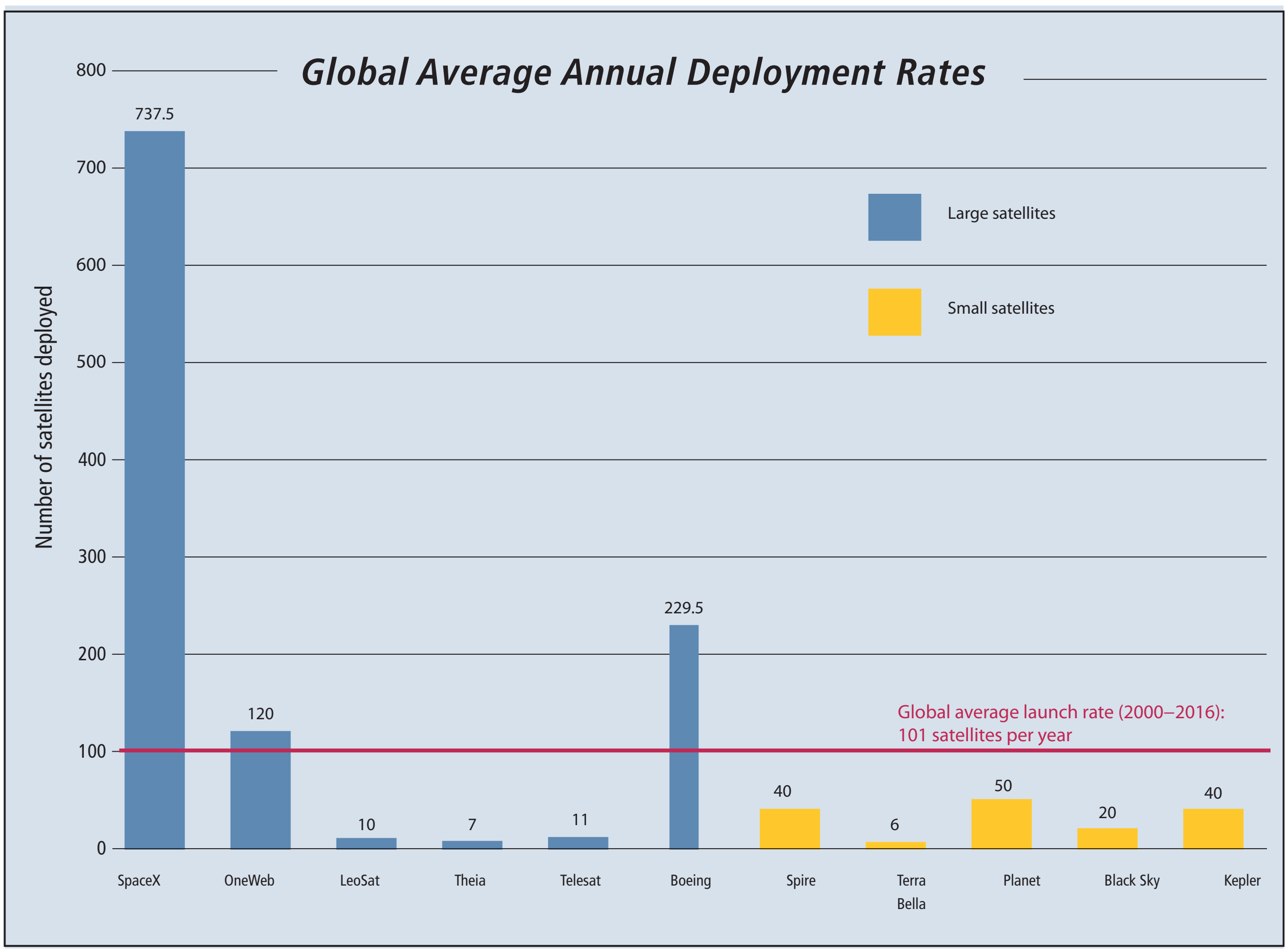
Deploying even a fraction of the proposed large commercial constellations, sometimes referred to as "mega-constellations," would add thousands of new operational satellites into space, increasing space traffic by many times over historic levels. This will magnify the effects of any marginal debris mitigation practices and will add to the burden of collision avoidance for space traffic management.

The emergence of CubeSats and other small satellites has opened up the use of space to many organizations, such as universities, that could not have participated in the past. These new entrants are less likely to be familiar with the requirements for space debris mitigation or have the resources to navigate a complex government regulatory structure and associated reporting procedures. New commercial launch providers are developing lower-cost approaches to space launch and typically operate on tighter margins and with fewer resources than traditional launch providers, which limits both familiarity with and ease of implementing debris mitigation practices.

By virtue of evolution rather than intent, the U.S. regulatory structure for space debris mitigation is distributed among multiple agencies, each having jurisdiction over one or several parts of the satellite's mission life or mission class. An Aerospace Corporation report, "Navigating the Policy Compliance Roadmap for Small Satellites," presents a "roadmap" for policy compliance for satellites from diverse agencies, and identifies areas where further work is underway to address the challenges posed by the evolution of the space industry.[11] This current decentralized arrangement has several disadvantages with respect to New Space:

- It may require commercial operators to deal with multiple agencies with differing levels of familiarity with satellite operations, which is particularly difficult for small operators.
- The rapid pace of change in the commercial sector will prompt newer uses of space and different operational approaches. These approaches may include the use of previously unused or little-used orbits and the advent of on-orbit servicing, which can also include disposal of satellites that have ended their missions recently or long ago. These new developments may fall into "regulatory limbo" or gaps between the different regulatory agencies. This will require some determination of jurisdiction by the government before certification can proceed.
- New Space applications and operations may affect the operation of U.S. government space assets, such as those operated by NASA or DoD. It will be necessary to have a structured process for reviewing proposed systems to identify possible impacts to U.S. government missions and space systems.



The space industry is reaching an inflection point. For example, the replenishment rate for the proposed SpaceX constellation is 737.5 satellites per year. If this constellation actually materializes, it will represent a 630% increase over the current annual launch rate (averaged over the past 16 years) of 101 satellites per year.

Critical Aspects of Debris Mitigation

A number of issues will need to be addressed by any regulatory agency to ensure that the orbital environment can be preserved for safe space operations. Some of these areas are currently addressed in government standards, instructions, and regulations, but the importance of compliance will increase as the level of space activity increases. In some cases, standards may not be stringent enough for a more crowded environment.

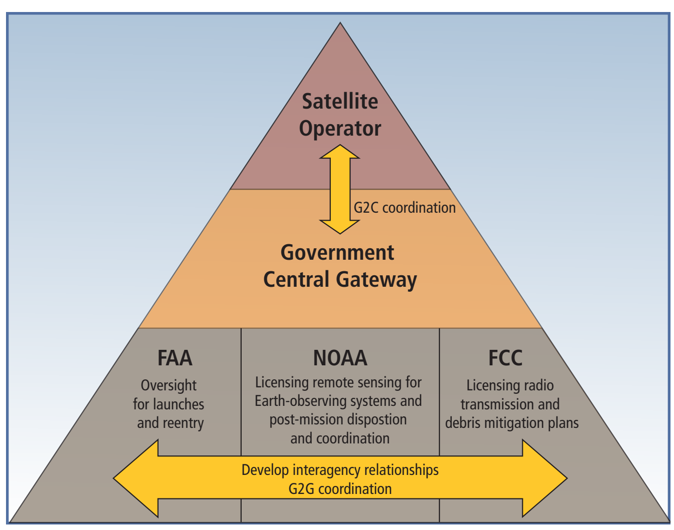
With respect to controlling the debris environment, the most important thing is to prevent the generation of more debris. A successful strategy must address the various sources of debris:

- **Operations.** Space systems may release objects as part of their mission and operations. For example, some types of deployment mechanisms, such as explosive bolts, can generate debris. Discarding unneeded pieces of a spacecraft, such as lens caps, is also a form of mission-related debris. Space missions need to avoid releasing such objects.
- **Explosions.** Explosions of satellites and upper stages have generated thousands of pieces of debris throughout the years. This can be prevented by removing sources of energy from an object at the end of its lifecycle—for example, by venting propellants and pressurized fluids and permanently discharging batteries.
- **Collisions.** The largest source of debris in the future is expected to be accidental collisions. An example of this was the collision of the dead Cosmos 2251 satellite with the active Iridium 33 satellite in 2009, which resulted in more than 3000 objects large enough to be tracked by the U.S. Space Surveillance System. During operations, a spacecraft can maneuver to avoid collisions, but that is not an option once a satellite reaches the end of its life. The chance of accidental collisions can be significantly lowered by reducing the orbital lifetime of a satellite or upper stage after the end of its mission. Essentially, the less time it spends on orbit, the less chance it has to collide with anything else. The "25-year rule" in the ODMSP is the most commonly applied collision minimization technique. Because accidental collisions are expected to increase, this mitigation measure is particularly important.[12] From an economic standpoint, minimizing on-orbit lifetime for the entire population of satellites and upper stages through planned disposal is significantly more efficient than sending additional spacecraft to actively remove them. While standards in some areas may need to be tightened, Aerospace analysis shows that increasing compliance with current standards would have a greater effect on sustainability.

There is an additional issue related to the reentry of objects from orbit. Components of many satellites and upper stages can survive the fall from space and pose a hazard to people and property on the ground. Although this risk has been low, historically, it must be managed along with on-orbit risk mitigation.

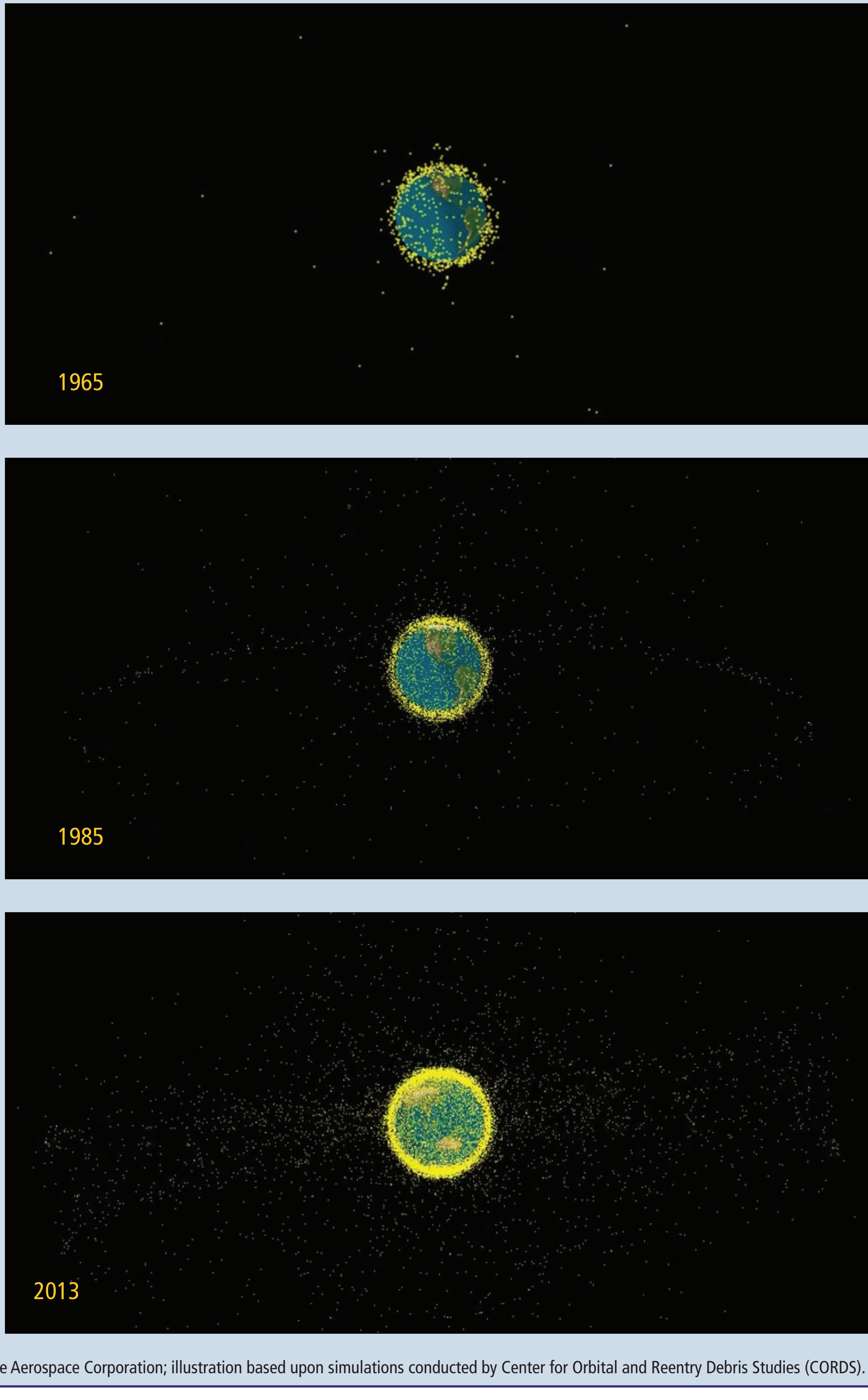
Preparing for the Future

To effectively manage the coming changes in commercial space activity and foster—rather than impede—the potential benefits, the U.S. government will have to rethink the existing regulatory structure for debris mitigation. For example, the government could establish a "one-stop-shop," where any new applicant could start with a single organization that would be the government face to the outside world for regulating debris mitigation or an even broader set of regulatory activities. This concept is similar to other "connected government" models, where users connect through a central gateway to access services that may ultimately be provided by different government agencies. Examples of this include the "311" information service provided by a number of U.S. cities, enabling single-point access to multiple government functions.



Coordinating debris mitigation across the civil space regulatory landscape.

The Debris Environment Through Time



Source: The Aerospace Corporation; illustration based upon simulations conducted by Center for Orbital and Reentry Debris Studies (CORDS).

A single government interface to the commercial world could be implemented in a number of ways. For example, the regulatory functions could be consolidated within a single agency, or they could remain separate, with the primary agency working the coordination among them. Having a single-stop agency would also enable a more efficient path for coordination with other agencies that conduct, but do not regulate, space operations. This would make it possible to develop a robust means to identify, early in the process, any government issues with new proposed commercial systems and allow timely identification and consideration of solutions to minimize impact on both commercial and government operators. If the current distributed authority structure is maintained, it will be necessary to provide an efficient path for determining authority for new concepts and operational approaches that fall within the gaps between agencies. This might be accomplished by allowing the coordinating agency, in consultation with the other agencies, to designate the appropriate agency to take responsibility for gaps in current authorities.

Some changes to the interagency regulatory relationships will require legislative action. The issue has been gaining some attention, particularly through the proposed American Space Commerce Free Enterprise Act of 2017. Given the rapid pace of change within the commercial space sector, it is important that the U.S. government prepare itself now so that it can foster and promote commercial innovation while ensuring compliance with debris mitigation practices to preserve the commons of space for everyone. The consequences of waiting too long will be far more costly to fix.

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