Congressional Research Service
Informing the legislative debate since 1914

IN FOCUS

December 9, 2019

Small Satellite Boom Threatens Congestion in Space

Regulators and policymakers are struggling to keep pace with small satellites, spacecraft the size of shoe boxes that are displacing school bus-sized satellites for many purposes. "Smallsats," as they are known, occupy low Earth orbit (LEO) at an altitude of between about 310 and 1,200 miles above Earth's surface. Many currently in orbit are about 10 centimeters wide and weigh less than 3 pounds. They have been used in government operations, but commercial companies are increasingly building and deploying them for communications, broadband internet, remote sensing, and Earth observation missions.

Smallsats are launched in clusters called constellations that provide coverage and connectivity to greater areas of Earth than a single satellite can. The 328 smallsats launched in 2018—twice the average number launched annually from 2013 to 2017—accounted for 69% of all satellites launched that year. Some market forecasts project that by 2030, the number of smallsats in orbit will multiply exponentially. This trend is largely attributable to advances in microelectronics, shorter development and manufacturing cycles, and lower launch costs. Federal and international regulators have received applications to launch commercial smallsats to LEO by the thousands over the next five years. With more than 1,300 satellites already orbiting there, including the International Space Station (ISS) with humans onboard, congestion is growing, creating potential problems with orbital debris, collision avoidance, and allocation of limited radio frequencies needed for command and control.

Market for Miniaturization

The first satellite launched in 1957 by the Soviet Union—Sputnik—weighed less than 200 pounds, which would qualify it as a smallsat as defined by the National Aeronautics and Space Administration (NASA). Its functions, however, were limited to rudimentary radio transmissions. Most satellites launched in recent decades provide communications transmissions and are far larger. For example, many communications satellites operated by Intelsat weigh almost 14,000 pounds and are more than 100 feet long. These satellites typically cost several million dollars each to build and even more to launch, both because of their size and the need to put them into higher orbits. Many smallsats cost a few thousand dollars and can rideshare on a rocket with other satellites.

During the past 10 years, miniaturization of electronics, optics, and sensors has made much smaller satellites technically feasible, stimulating venture capital and defense industry investments in smallsat companies to meet growing demand for data processing, global connectivity, and remote sensing services used for imagery and weather analysis. In 2018, Boeing, Raytheon, and Lockheed Martin all invested in U.S. startups focused on smallsat development. National security applications have helped secure U.S. government funding for many smallsat design and manufacturing companies, which has enabled them to establish themselves financially and demonstrate their products while seeking to develop business with potential commercial customers.

The ISS has been an important test bed for development of smallsats, especially "cubesats." Cubesats measure a standard 4 inches on each side and are modular for easy scalability depending on mission. Companies began sending prototype commercial cubesat constellations to the ISS in 2012. Test cubesats can rideshare to the ISS aboard resupply missions for a fraction of the cost of an individual rocket launch. From there, robotic arms and special equipment aboard the ISS can eject the satellites into orbit. Between 2013 and 2017, the ISS deployed 725 cubesats, allowing many smallsat manufacturers to demonstrate their on-orbit capabilities to investors.

Figure 1. Cubesat Constructed from Smartphone Parts

Source: NASA Ames Research Center.

Crowded Space

Greater use of smallsats promises to add to communications problems and to increase the risk of collisions in space.

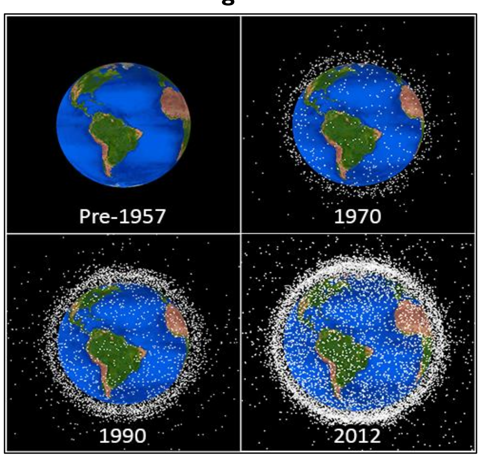
In October 2019, the Federal Communications Commission (FCC) requested the International Telecommunications Union, the international organization that coordinates global radio frequency use, to approve spectrum for 30,000 satellites on behalf of Starlink, a program of Space Exploration Technologies (SpaceX). SpaceX has already received a license to operate a constellation of 12,000 Starlink satellites in LEO to provide internet services. Amazon is also planning a constellation in LEO with more than 3,000 small satellites for high-speed internet service. OneWeb, a company founded in Virginia but headquartered in the United Kingdom, is planning a constellation of at least 650 smallsats that are expected to provide high-speed internet to remote areas like the Arctic. China Aerospace Science and Technology Corporation is planning a 320-satellite constellation in LEO, also for internet coverage, by

2025. Thousands of new satellites in LEO could overtax the frequencies allocated for operators to communicate with their satellites and could interfere with transmissions from higher-orbit communications and weather satellites. The FCC is considering new spectrum sharing regulations and repurposing of certain frequency bands to accommodate these new users.

Increasing the number of smallsats in LEO by thousands would likely increase risk of collisions there. In addition to satellites, NASA estimates 6,000 tons of space debris occupy LEO. In 2009, an abandoned Russian communications satellite collided with an active 1,200-pound satellite owned by Iridium, a U.S. communications company. The U.S. Air Force Joint Space Operations Center monitors objects as small as cubesats in orbit and provides collision warnings to satellite operators worldwide. However, some smallsats are so tiny they cannot reliably be tracked, while others lack propulsion to make changes of course or altitude.

With many companies planning to launch large constellations of smallsats, managing congestion may become a challenge. Given the altitudes at which they orbit, smallsats typically remain aloft for three to six years, although some orbiting close to Earth may fall out of orbit and burn up within as little as six months due to atmospheric drag. For example, Planet Labs, Inc., a smallsat operator, says that of its 351 smallsats successfully launched to LEO since 2012, only about 140 remain in orbit; the rest have already burned up. Because the FCC is responsible for granting licenses to commercial satellite operators for use of frequencies, it is also responsible for approving the altitude at which an operator can place its satellite. Smallsats on shared payloads, however, are often deployed at altitudes other than those designated and must use propulsion to boost themselves lower or higher.

Figure 2. NASA Rendering of Orbital Debris Growth



Source: NASA, Orbital Debris Program Office.

Solutions and Enforcement Challenges

Certain rules govern how a company should operate its satellites, but not all rules are enforceable or clearly understood by companies. For example, Silicon Valley start-up Swarm Technologies makes smallsats that provide internet access. In 2018, Swarm filed an application with the FCC to launch four cubesats to LEO. The FCC denied the application, because it deemed the satellites too small to be tracked. The satellites were launched anyway. Swarm had used a launch brokering company, which claimed not to know about the ruling, to book a spot for its payload on a rocket launched by the commercial arm of India's space agency. The FCC fined Swarm $900,000 for the violation.

Even when companies follow rules, mistakes can happen. In September 2019, orbital data from the U.S. Air Force indicated a European satellite and one of SpaceX's Starlink smallsats could be on a collision course. As the odds of a collision rose to 10 times higher than the threshold for an avoidance maneuver, the European Space Agency (ESA) repeatedly tried to make contact with SpaceX. After receiving no response to its warning messages, the agency quickly boosted its satellite 300 meters out of the collision path. According to SpaceX, the company failed to note ESA's messages due to a computer problem.

Regulatory Developments

In 1967, all countries that had active space programs, and many that aspired to, signed a United Nations treaty establishing standards and norms of international space law. A global gentleman's agreement for space-based activities, the treaty requires that a state must authorize and supervise any activities carried out by its nongovernmental entities and that any objects launched into space must be registered. The U.N. also issued debris mitigation guidelines recommending objects in LEO deorbit within 25 years.

Within the United States, oversight of civilian satellite activities is in flux. Space Policy Directive-3 (SPD-3), signed by the President in 2018, mandated an interagency effort led by NASA to draft a whole-of-government plan for space situational awareness (SSA) and debris mitigation. SPD-3 also directed the Department of Commerce's Office of Space Commerce to take over commercial space traffic management from the U.S. military. The Office of Space Commerce currently resides within the National Oceanic and Atmospheric Administration (NOAA), but the Secretary of Commerce proposed in 2018 to designate it an independent bureau within the department. A bill that would approve such a bureau and assign it responsibility for licensing activities not overseen by the FCC, NOAA, or the Federal Aviation Administration was introduced in the 115th Congress (H.R. 2809) and again in the 116th Congress (H.R. 3610), but has not advanced. A September 2019 Senate Appropriations Committee report (S.Rept. 116-127) expressed concern that an independent space commerce bureau might not be equipped to fully replace the military in providing commercial space traffic management. The committee recommended an independent review by the National Academy of Public Administration.

To address gaps in current space governance, an alliance of commercial, government, and industry stakeholders formed the Space Safety Coalition in 2019 to develop best practices for avoiding on-orbit collisions and frequency interference. This effort to self-regulate has been endorsed by many smallsat companies.

Alyssa K. King, Analyst in Transportation Policy

IF11382

Disclaimer