



November 2022

SATELLITE LICENSING

FCC Should Reexamine Its Environmental Review Process for Large Constellations of Satellites

Accessible Version

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Why GAO Did This Study

Over the last few years, companies have launched large constellations of satellites to provide services such as phone and Internet access. This trend is expected to accelerate, with tens of thousands of additional satellites expected to be launched by the end of the decade. Stakeholders have raised questions about federal consideration of potential environmental and other effects as the number of satellites orbiting the Earth increases.

GAO was asked to review existing policies related to environmental effects of large constellations of satellites. This report examines: (1) how federal agencies consider potential environmental and other effects from large constellations of satellites and (2) how FCC determines whether licensing large constellations of satellites requires an environmental assessment or environmental impact statement. GAO reviewed relevant laws, regulations, and studies, and compared FCC's processes and procedures to the Council on Environmental Quality's regulations and guidance. GAO also interviewed FCC and other agency officials.

What GAO Recommends

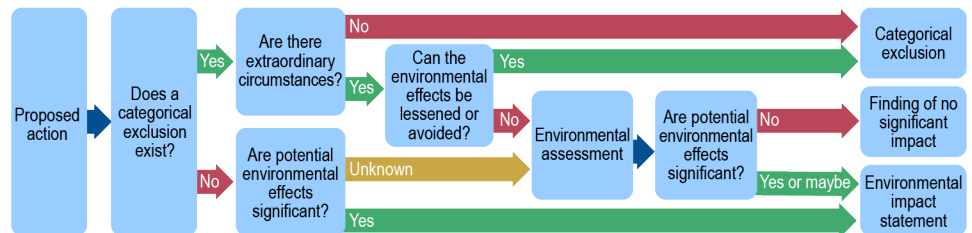
GAO is recommending that FCC (1) review and document whether licensing large constellations of satellites normally does not have significant effects on the environment, (2) establish a timeframe and process for a periodic review of its categorical exclusion under NEPA, and publish both on its website, and (3) identify and make public factors FCC considers when determining if an extraordinary circumstance is present. FCC agreed with our recommendations.

View [GAO-23-105005](#). For more information, contact Andrew Von Ah at (202) 512-2834 or vonaha@gao.gov or Karen Howard at (202) 512-6888 or howardk@gao.gov.

What GAO Found

The National Environmental Policy Act (NEPA) requires federal agencies to consider the environmental effects of major federal actions prior to making decisions and to involve the public. Agencies do so by preparing an environmental assessment or an environmental impact statement, or both, unless a "categorical exclusion" applies. A categorical exclusion may be applicable if the proposed action is in a category the agency has already determined does not normally have significant environmental effects. Even when a proposed action is covered by a categorical exclusion, agencies must evaluate whether the action presents extraordinary circumstances that require preparation of an environmental assessment or environmental impact statement.

Process for Implementing the National Environmental Policy Act's (NEPA) Requirements



Source: GAO analysis of NEPA and Council on Environmental Quality's implementing regulations. | GAO-23-105005

Federal agencies consider potential environmental and other effects from large constellations of satellites through licensing and other efforts. GAO reported that these effects could include sunlight reflections, orbital debris, and launch emissions. The Federal Communications Commission (FCC) and the Federal Aviation Administration consider these potential effects when licensing satellite transmissions and launch and reentry vehicles, respectively. Other federal agencies fund or lead research on these potential effects.

GAO found that FCC has not sufficiently documented its decision to apply its categorical exclusion when licensing large constellations of satellites. In 1986, FCC created a categorical exclusion for all actions except those meeting specific conditions. These conditions are largely focused on environmental effects on the Earth's surface, such as the construction of facilities to be located in an officially designated wildlife preserve. FCC officials told GAO that the agency invokes its categorical exclusion when licensing large constellations of satellites. The Council on Environmental Quality, which oversees agencies' implementation of the National Environmental Policy Act, recommends that agencies periodically review categorical exclusions to ensure they remain current.

FCC has made changes to the categorical exclusion. However, FCC has never reviewed and documented whether it should apply to large constellations of satellites. GAO also found that FCC does not have a process or timeline for periodically reviewing its categorical exclusion and publishing the information on its website. Further, FCC has not identified and made public factors it considers in determining whether extraordinary circumstances are present. Taking these actions would better position FCC to ensure that its decisions to apply its categorical exclusion are current and transparent when licensing large constellations of satellites.

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Abbreviations

CEQ	Council on Environmental Quality
Commerce	Department of Commerce
DOD	Department of Defense

FAA	Federal Aviation Administration
FCC	Federal Communications Commission
MOU	memorandum of understanding
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
NTIA	National Telecommunications and Information Administration
SSN	Space Surveillance Network

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November 2, 2022

The Honorable Tammy Duckworth
Chair
Subcommittee on Fisheries, Water, and Wildlife
Committee on Environment and Public Works
United States Senate

The Honorable Brian Schatz
United States Senate

Over the last few years, companies have launched thousands of commercial satellites into low Earth orbit to provide services such as satellite phone and Internet access, and they have plans to launch more. This trend is expected to accelerate, with tens of thousands of additional satellites expected to be launched by the end of the decade. As more businesses seek approval from the Federal Communications Commission (FCC) and other federal agencies to launch and operate additional commercial satellites, scientists and other stakeholders have raised questions about the potential environmental and other effects of large constellations of satellites.¹ For example, stakeholders have expressed concerns about changes in the temperature of the upper atmosphere from emissions from launches or deorbiting of satellites and effects on astronomical research from radio transmissions or sunlight reflections. They have also expressed concerns about effects on amateur astronomy and astrophotography and the general public from changes to the night sky. Others have raised concerns about disrupted broadband services due to the greater potential for satellites to collide with debris or other satellites as the number of objects in space grows.

These concerns can be considered in various ways throughout the federal government's process for approving the launch and operation of commercial satellites. In particular, the National Environmental Policy Act (NEPA) requires federal agencies to evaluate the potential effects on the human environment of proposed major federal actions prior to making

¹Satellites can operate individually or collectively in groups called satellite constellations. The U.S. Orbital Debris Mitigation Standard Practices categorizes large constellations of satellites as those containing at least 100 operational satellites. U.S. Government, *Orbital Debris Mitigation Standard Practices* (November 2019).

decisions and to involve the public.² Agencies are to do this by preparing an environmental assessment or a more detailed environmental impact statement, or both. Federal agencies may establish categories of actions called categorical exclusions that they have determined normally do not have significant environmental effects and thus do not require an environmental assessment or environmental impact statement. In 1986, FCC categorically excluded from detailed analysis under NEPA all FCC actions except those that meet specific conditions.³ These conditions largely focus on environmental effects on the Earth's surface, such as the construction of facilities that are to be located in an officially designated wildlife preserve.⁴

You asked us to review existing policies related to environmental effects of large constellations of satellites, especially in light of modern technological advancements and practices related to space activities and the use of various Earth orbits. This report examines two objectives:

1. how federal agencies consider potential environmental or other effects from large constellations of commercial satellites, and
2. how FCC determines whether licensing large constellations of commercial satellites is categorically excluded or requires an environmental assessment or environmental impact statement under NEPA.

To inform these objectives and our general understanding of issues related to the potential environmental or other effects from large constellations of commercial satellites, we convened an expert meeting. This meeting was held in conjunction with a complementary technology

²Pub. L. No. 91-190, 83 Stat. 852 (1970) (codified at 42 U.S.C. §§ 4321–47). NEPA analyses may also include consideration of economic and social effects of proposed actions.

³Environmental Rules in Response to CEQ Regulations, 51 Fed. Reg. 14,999, 15,000 (Apr. 22, 1986) (codified at 47 C.F.R. § 1.1306).

⁴While this report discusses potential environmental and other effects of large constellations of satellites in general, it does not determine whether these potential effects must be considered under NEPA or may be significant.

assessment that has been published separately.⁵ With the assistance of the National Academies of Sciences, Engineering, and Medicine, we identified and invited 15 experts from industry, government agencies, and academia to participate in the meeting.⁶ We used information gathered at this expert meeting to help identify potential environmental or other effects of large constellations of satellites and to obtain experts' views on federal policy related to these effects.

To understand how federal agencies consider potential environmental or other effects of large constellations of satellites, we reviewed relevant laws, regulations, and studies. We also interviewed officials from all agencies that have a role in licensing or operating satellites. These agencies include FCC, Federal Aviation Administration (FAA), Department of Commerce (Commerce), Department of Defense (DOD), National Aeronautics and Space Administration (NASA), National Telecommunications and Information Administration (NTIA), and the National Oceanic and Atmospheric Administration (NOAA).⁷ We gathered information about their activities in overseeing, supporting, and researching the environmental and other effects of large constellations of satellites.

To understand how FCC determines whether licensing large constellations of satellites is categorically excluded or requires

⁵The related technology assessment examines: (1) the environmental and other effects introduced or exacerbated by the launch, operation, and disposal of large constellations of satellites; (2) the current or emerging technologies and approaches to evaluate or mitigate these effects; and (3) policy options that might help address challenges to evaluating or mitigating the effects as well as opportunities and considerations associated with those options. See GAO, *Large Satellite Constellations: Mitigating Environmental and Other Effects*, [GAO-22-105166](#) (Washington, D.C.: Sept. 29, 2022).

⁶These experts included: John Barentine, Principal Consultant, Dark Sky Consulting, LLC; Aaron Boley, Canada Research Chair, University of British Columbia; Mat Dunn, Senior Director of Global Government Affairs, SpaceX; Tim Flohrer, Head of Space Debris Office, European Space Agency; Sergio Galluci, Chief Technology Officer, SCOUT, Inc.; Jeffrey Hall, Director, Lowell Observatory; Moriba Jah, Associate Professor, University of Texas at Austin; Christopher Johnson, Space Law Advisor, Secure World Foundation; Erik Larson, Research Scientist II, NOAA Chemical Sciences Lab; Tim Maclay, President, Celestial Insight, Inc.; Darren McKnight, Senior Technical Fellow, LeoLabs; Scott Paine, Senior Physicist, Center for Astrophysics | Harvard & Smithsonian; Meredith Rawls, Research Scientist, University of Washington; Martin Ross, Scientist, Space Systems Group, The Aerospace Corporation; and Tony Tyson, Chief Scientist, Vera Rubin Laboratory.

⁷NTIA and NOAA are within the Department of Commerce.

preparation of an environmental assessment or environmental impact statement under NEPA, we reviewed FCC's regulations implementing NEPA and interviewed FCC officials. We also reviewed the Council on Environmental Quality's (CEQ) regulations and guidance on implementing NEPA to determine if FCC followed CEQ's regulations and guidance when licensing large constellations of satellites.⁸ We compared FCC's NEPA processes and procedures to documentation criteria in *Standards for Internal Control in the Federal Government*.⁹ We also assessed the extent to which FCC followed recommended practices for documenting its decisions for interested parties and the public when determining if licensing large constellations of satellites is categorically excluded or requires preparation of an environmental assessment or environmental impact statement. We reviewed notices for proposed rule-makings and orders regarding large constellations of satellites. We obtained data and information provided by FCC about the number of applications submitted and decisions made regarding licenses for large constellations of satellites since 2016. We reviewed these data and information and compared them to publicly available information about the number of satellites in operation and determined the data to be sufficiently reliable for purposes of our report. In addition, we interviewed CEQ officials to learn about NEPA requirements and recommendations. We interviewed officials from FAA, Commerce, DOD, NASA, NOAA, and NTIA to obtain information about the ways in which NEPA applies to their activities related to launching or operating objects in space. We also interviewed 12 groups or individuals representing trade associations, satellite operators, space-related companies, academia, and a federally funded research and development center that we selected based on their work related to or potentially affected by the potential environmental or other effects of large constellations of satellites to obtain views on FCC's licensing process. The results of these interviews are not generalizable.

We conducted this performance audit from February 2021 to November 2022 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe

⁸See 40 C.F.R. Parts 1500–08; see also Guidance on Establishing, Applying, and Revising Categorical Exclusions, 75 Fed. Reg. 75,628 (Dec. 6, 2010).

⁹GAO, *Standards for Internal Control in the Federal Government*, [GAO-14-704G](#) (Washington, D.C.: September 2014).

that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Since the 1950s, satellites have increasingly provided various services, including communications systems for television and phone service, environmental and weather observations, and the Global Positioning System for navigation. The number of satellites in orbit is expected to increase as technological advancements make satellites more affordable, launch costs decrease, and the demand for space-based capabilities grows. Nearly 5,500 active satellites were in orbit in spring of 2022, and multiple experts have said an additional 58,000 satellites could be launched by 2030. These satellites will primarily be operating in low Earth orbit, which NASA defines as altitudes up to 2,000 kilometers from the Earth's surface.

Potential Environmental and Other Effects

With such unprecedented growth come concerns about the impact such large constellations of satellites may have on the environment, public safety, and satellite operations. In September 2022, we reported on the following potential environmental and other effects as the number of large constellations of satellites continues to grow:¹⁰

- **Rocket emissions.** Rockets used to launch satellites emit gases and particles into the air, which can affect the Earth's temperature and deplete ozone. As we reported, the types of emissions vary because rockets use different types of propellants. However, both gases and particles from rockets could change the temperature of the stratosphere.¹¹ They may also deplete the ozone layer, which would increase the amount of harmful solar radiation reaching Earth's population. The significance of these effects as the number of launches increases is largely unknown due to either no or limited observational data, depending on the type of gas or particle.

¹⁰[GAO-22-105166](#).

¹¹The stratosphere is a layer of the Earth's atmosphere that is above troposphere. The troposphere starts at the Earth's surface and extends approximately 8 to 14.5 km high. The stratosphere starts just above the troposphere and extends to 50 km above the Earth's surface.

- **Radio transmissions.** Communications satellites are authorized to transmit and receive radio frequency signals, and these radio frequency signals occur at signal strengths much stronger than the signals from astronomical phenomena that radio astronomers observe. As we reported, these satellite radio communications could potentially interfere with radio astronomy observations of deep-space objects if they are using the same or adjacent spectrum frequencies used by radio astronomy.¹²
- **Sunlight reflections.** The thousands of additional satellites that companies plan to launch may create sunlight reflections that interfere with other activities. As we reported, satellites can interfere with optical telescopes used to make astronomical observations by reflecting light from the sun and producing streaks or bright spots in images. Of particular concern to scientists is the potential effect on wide-field imaging telescopes. These telescopes look at large swaths of the night sky for long periods of time to generate data that future observations can refer back to—for example, to aid in spotting asteroids, some of which may pass near Earth. Satellites could also increase the overall brightness of the sky, known as diffuse night sky brightness. While this is expected to be a minimal effect, diffuse night sky brightness could negatively affect optical astronomy by making faint objects harder to observe. Sunlight reflections from satellites may also affect the ability of people and communities around the world to interact with a natural sky, which has cultural and religious implications for some Native American and Indigenous communities.
- **Orbital debris.** National space policy defines orbital debris as “any human-made space object orbiting Earth that no longer serves any useful purpose.”¹³ Orbital debris, including inactive satellites, can cause problems when it collides with satellites or other pieces of debris. The consequences depend on the size, mass, and speed of the objects involved. As the number of satellites increases, the potential effect of orbital debris does as well. As a result, it may be more complicated for satellites to coordinate maneuvers to avoid colliding with both active and inactive satellites and other types of orbital debris.
- **Satellite reentry emissions and fragments.** Satellites break apart upon reentry to Earth and begin to disintegrate, which can lead to a

¹²Radio astronomy is the study of objects in space using radio frequencies.

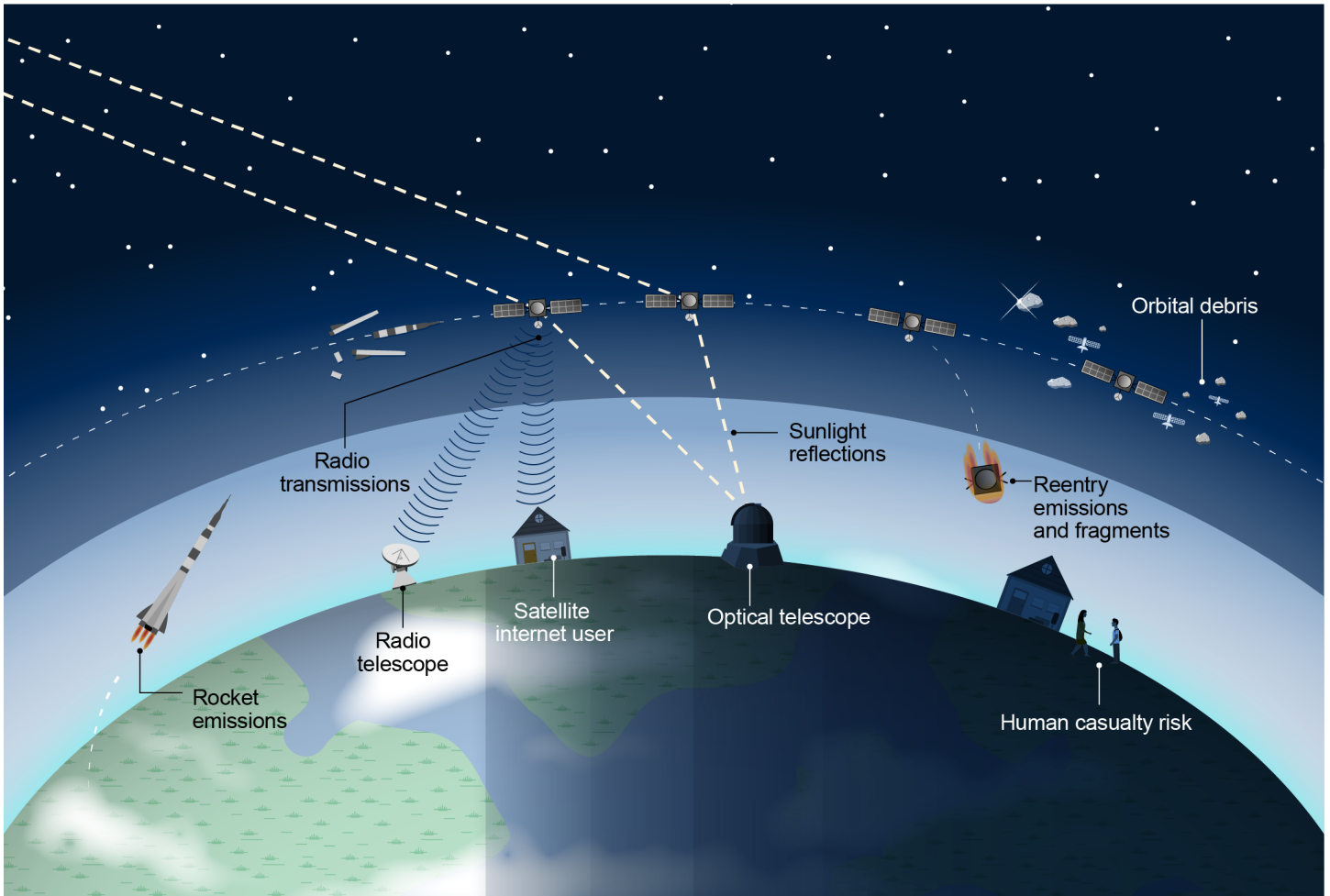
¹³Space Policy Directive-3, National Space Traffic Management Policy, 83 Fed. Reg. 28,969 (June 21, 2018).

risk of human casualties or other damage.¹⁴ The potential for these incidents grows as more satellites are launched and deorbited. As we reported, reentering satellites can produce fragments and emissions when they burn up and begin to disintegrate upon reentry in the atmosphere. Disintegrating satellites could emit materials that warm the stratosphere, deplete ozone, or are hazardous. Satellites that do not completely disintegrate pose a casualty risk on the ground, because the surviving fragments could cause property damage, injury, or death.

These potential environmental and other effects are illustrated in figure 1.

¹⁴Reentry means to purposefully return or attempt to return to Earth from Earth orbit or from outer space.

Figure 1: Categories of Environmental and Other Effects of Constellations of Satellites



Source: GAO. | GAO-23-105005
Note: Image not to scale.

Federal Roles

Various federal agencies manage or oversee satellite operations and may consider these types of environmental and other effects. Rockets (the vehicles) launch satellites (the payload) into space, and satellites use the radio frequency spectrum to communicate with other satellites or to send data to and from terrestrial or Earth stations. Both rocket launch operations and satellite communications require a license from a federal agency:

- FAA issues licenses to operators for the launch of vehicles that are used to launch satellites, including both the launch into space and the planned reentry of these vehicles back to Earth.
- FCC issues licenses to operators of commercial satellites under its authority per the Communications Act of 1934.¹⁵ FCC has authority to regulate, allocate, and assign spectrum for nonfederal use through the notice-and-comment rulemaking process, a process by which FCC proposes and adopts rules with input from the public.¹⁶ The Satellite Division of FCC's International Bureau approves or denies licenses for commercial satellite operators to transmit or receive on specific bands or radio frequencies.¹⁷ As part of its granting of licenses for the use of radio frequencies, FCC grants authority for construction and deployment of these satellites and considers additional factors, such as orbital debris.¹⁸ FCC also oversees commercial launch vehicles' use of radio frequencies.¹⁹
- NOAA, within the Department of Commerce, licenses remote sensing activities of commercial remote-sensing satellites, which are satellites that observe and collect data about the Earth from orbit. However, the radio frequency operations of these satellites are subject to FCC licensing.

¹⁵See 47 U.S.C. §§ 308–09. FCC licenses (authorizes) radio stations, which consist of equipment for engaging in radio communication or radio transmission of energy. FCC calls these stations “space stations” when they are located on objects which are beyond, are intended to go beyond, or have been beyond, the Earth’s atmosphere. FCC’s licensing process includes reviewing factors such as satellites’ orbital locations and orbital debris mitigation plans. This report refers generally to FCC’s space station licenses or authorizations as licensing of satellites.

¹⁶NTIA, within the Department of Commerce, regulates and manages federal spectrum use. FCC and NTIA maintain a memorandum of understanding (MOU) that serves as the main mechanism that guides their overall coordination on spectrum management.

¹⁷Satellite operators may obtain licenses from other countries to launch and operate satellites. If licensed by another country, these satellite operators then must apply to FCC for market access to communicate with Earth stations located in the United States.

¹⁸According to FCC officials, while FCC has authority to regulate the use of radio frequency, it is also required to act in the public interest. FCC officials explained that FCC reviews non-radiofrequency factors, such as orbital debris, as part of its public interest analysis when licensing satellites.

¹⁹FCC currently has an open rulemaking proceeding concerning allocations and requirements for commercial launch vehicles. *See Allocation of Spectrum for Non-Federal Space Operations*, Report and Order and Further Notice of Proposed Rulemaking, 36 FCC Rcd. 7764 (2021).

NEPA Requirements and Categorical Exclusions

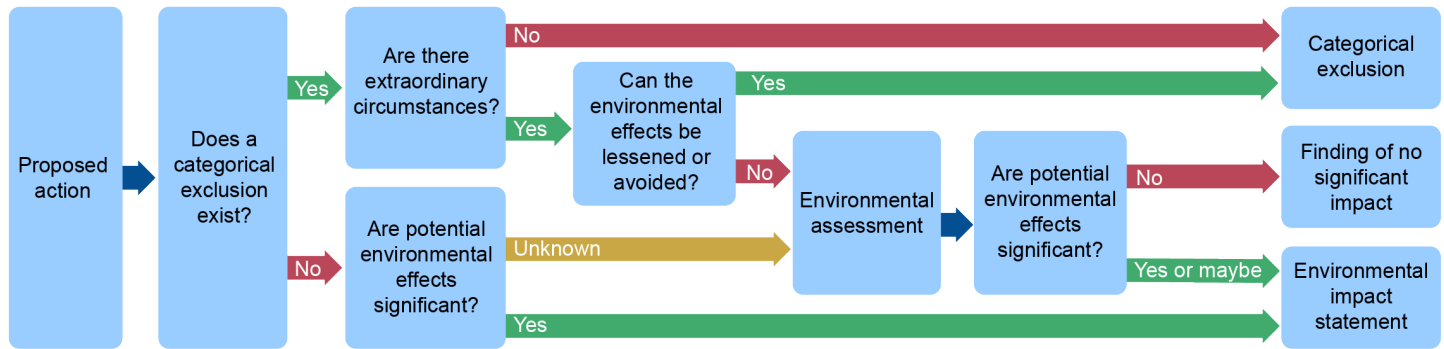
NEPA and CEQ's implementing regulations require federal agencies to consider the environmental effects of major federal actions before proceeding with those actions and to involve the public in that consideration process. As part of this process, NEPA requires federal agencies to prepare a detailed environmental impact statement evaluating environmental effects for major federal actions significantly affecting the quality of the human environment. If the proposed action is not likely to have significant effects or when the significance of the effects is unknown, agencies generally prepare an environmental assessment,²⁰ unless the action is covered by a categorical exclusion established in the agency's NEPA implementing procedures. Categorical exclusions are categories of actions that normally do not have significant effects on the environment.²¹ As determined by CEQ, the use of categorical exclusions can reduce paperwork and save time and resources. Even when a proposed action falls under a categorical exclusion, agencies must evaluate whether it presents extraordinary circumstances such that the normally excluded action may have a significant effect on the quality of the human environment requiring preparation of an environmental assessment or environmental impact statement.²² See figure 2 below for the general process for implementing NEPA requirements.

²⁰Under the CEQ regulations, applicants may prepare but agencies are ultimately responsible for the environmental assessments. See 40 C.F.R. §§ 1501.5, 1506.5. FCC's regulations direct license applicants to prepare the environmental assessment for their proposal and submit it to FCC. FCC then uses the environmental assessment to determine whether the proposal will have significant environmental effects. See 47 C.F.R. § 1.1308.

²¹See 40 C.F.R. §§ 1501.4, 1507.3. CEQ amended its regulations in 2020. Previously, when FCC first established its categorical exclusion, 40 C.F.R. § 1508.4 defined "categorical exclusion" to mean "a category of actions which do not individually or cumulatively have a significant effect on the human environment and which have been found to have no such effect in procedures adopted by a Federal agency in implementation of these regulations." As of the 2020 amendments, CEQ's regulations similarly define "categorical exclusion" to mean "a category of actions that the agency has determined, in its agency NEPA procedures (§ 1507.3 of this chapter), normally do not have a significant effect on the human environment." See Update to the Regulations Implementing NEPA Procedural Provisions, 85 Fed. Reg. 43,304, 43,374 (July 16, 2020) (codified at 40 C.F.R. § 1508.1(d)).

²²Even if an extraordinary circumstance is present, the agency may still categorically exclude the action "if the agency determines that there are circumstances that lessen the impacts or other conditions sufficient to avoid significant effects." 40 C.F.R. § 1501.4(b)(1).

Figure 2: Process for Implementing the National Environmental Policy Act's (NEPA) Requirements



Source: GAO analysis of NEPA and Council on Environmental Quality's implementing regulations. | GAO-23-105005

NEPA also created the Council on Environmental Quality (CEQ) within the Executive Office of the President. CEQ oversees NEPA's implementation, principally through issuing guidance and regulations that implement NEPA's procedural requirements. However, agencies themselves are ultimately responsible for compliance with NEPA and must implement NEPA procedures consistent with CEQ's NEPA regulations.²³

Federal Agencies Consider Potential Environmental and Other Effects from Large

²³Individuals and groups that disagree with how an agency meets NEPA requirements for a given project sometimes challenge the agency's NEPA review in court. For example, in May 2021, multiple parties filed suit in federal court to challenge an FCC order modifying a license for a SpaceX satellite constellation. *Viasat v. FCC*, No. 21-1123 (D.C. Cir. filed May 26, 2021). Among other things, the petitioners argued that the proposed satellite constellation may have significant environmental effects and that FCC therefore violated NEPA when it declined to require an environmental assessment. FCC asserted that the record did not show a need for an environmental assessment. This lawsuit was dismissed by the D.C. Circuit Court of Appeals on August 26, 2022, because the court determined, among other things, the petitioners lacked standing under NEPA and did not have an injury to interests protected by NEPA.

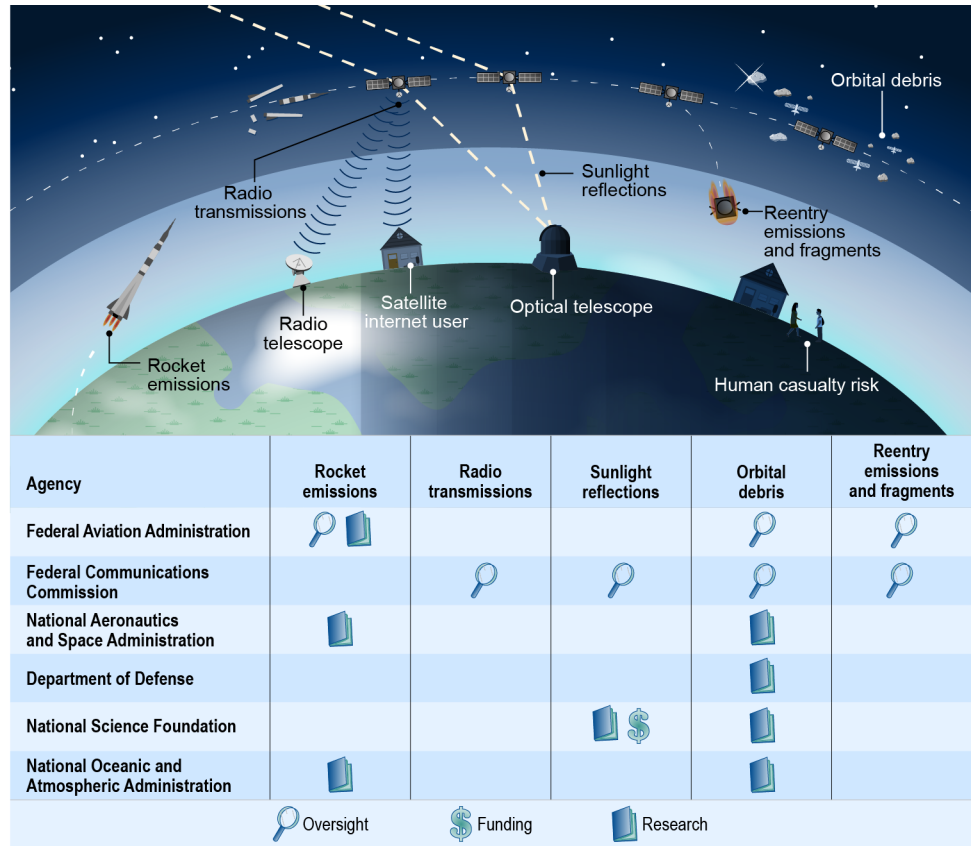
Constellations of Satellites through Licensing Processes and Other Efforts

Federal Agencies Consider Potential Environmental and Other Effects to Varying Extents through Various Licensing Processes

Federal oversight of commercial satellites and related potential environmental and other effects begins during the licensing processes. FAA issues licenses to operators for the launch and reentry of vehicles and FCC licenses satellites and approves launch vehicles to transmit or receive on designated radio frequencies.²⁴ Each agency has separate licensing processes that, together, include some level of examination of each category of potential effect we identified in our September 2022 report: rocket launch emissions, radio transmissions, sunlight reflections, orbital debris, and satellite reentry emissions and debris. Other agencies also engage in funding or research activities to examine or mitigate these potential effects as shown in figure 3.

²⁴Operators may also launch from DOD or NASA property. In this case, operators may have to comply with additional requirements.

Figure 3: Federal Processes That Consider Environmental and Other Effects of Large Constellations of Commercial Satellites



Source: GAO analysis of agency information. | GAO-23-105005

FAA

FAA licenses all commercial launches, purposeful reentries of rockets and reentry vehicles, and the operation of commercial launch and reentry sites. FAA’s stated goal is to protect and enhance the communities and natural environments where launch and reentry activities take place, while at the same time promoting commercial space transportation. The launch/reentry operator applies to FAA for a license or permit to conduct its operations. The application is to include data about the proposed mission, such as mission timing, mission type, payload, and the operator’s plans and processes for ensuring public safety. The application and evaluation processes may occur over months or even years as the applicant is developing the launch or reentry system. FAA officials told us that the applicant is required to update FAA if this information changes.

FAA is to review the application with regard to: safety; the payload (to determine whether a license applicant or payload owner or operator has obtained all required licenses, authorization, and permits); and environmental effects, among other things. Once FAA grants a license or permit, the operator may begin specific planning for the mission including scheduling for specific days and times.

Relative to the categories of potential environmental and other effects, FAA specifically considers rocket launch emissions and orbital debris during its launch licensing process.

- **Rocket launch emissions.** FAA officials told us that the agency's licensing process includes examining estimates of rocket launch emissions up to 3,000 feet to determine whether there would be any violations of any air quality standards, including the National Ambient Air Quality Standards, as well as emissions above 3,000 feet to determine whether there would be an impact on climate.²⁵ As part of its NEPA review, FAA generally requires an environmental assessment for a launch license.²⁶ FAA makes a determination as to whether there is the potential for significant environmental effects, based, in part, on publicly filed comments and on consultation with other federal agencies. FAA officials told us that if they find an action would result in significant effects that cannot be mitigated, they require an environmental impact statement that discusses these significant effects and reasonable alternatives.
- **Orbital debris.** FAA officials told us the agency also generally requires launch applicants to file a collision avoidance analysis, which examines the probability that the launch would result in a collision with orbital debris, active satellites, or human space flight activities that may result in the creation of more orbital debris or the loss of life. The analysis must show that the probability of a collision is less than the acceptable threshold or that the launching or reentering object will

²⁵The Clean Air Act requires the Environmental Protection Agency to set National Ambient Air Quality Standards, which define levels of air quality necessary to protect the public health and welfare from certain pollutants.

²⁶FAA does not have a categorical exclusion for rocket launches.

maintain a required distance from other objects in order for FAA to issue a license.²⁷

In June 2021, we reported that FAA had begun efforts to revise its launch and reentry licensing regulations governing the steps a launch provider must take to prevent dangerous debris that may be “expended” or discharged as the launch vehicle gains altitude and speed.²⁸ In September 2022, FAA officials told us they expected the Notice of Proposed Rulemaking to be published in the Federal Register in the spring of 2023.

FCC

FCC licenses commercial satellites to transmit or receive on radio frequencies. These licenses may also include authorization for construction and deployment. To obtain a license, FCC requires satellite operators to submit detailed information about the satellites, including the radio frequencies that the satellite will use to communicate; the orbital location, including altitudes and inclinations where applicable that the satellites will orbit in; and how the satellite operator will address orbital debris mitigation. When allocating specific radio frequency bands that satellites can use, FCC officials told us they seek to prevent harmful radio frequency interference to other uses of the spectrum. That is, FCC oversees whether an applicant’s proposed satellite or satellite constellation may potentially interfere with other entities that have been authorized to use a radio frequency in that band or other bands.

As part of the satellite-licensing process, FCC has considered the significance of certain potential environmental and other effects from satellites, including those arising out of radio transmissions, sunlight reflections, orbital debris, and satellite reentry debris. FCC officials told us they weigh the merits of an application, such as the potential for increased broadband access, improved public safety, or advances in scientific discovery, against these concerns to determine whether to issue

²⁷14 C.F.R. § 450.169. FAA officials said they only assess the purposeful reentry of intact objects, specifically reusable launch vehicles. According to these officials, once the launch vehicle deploys its payload, FAA has no jurisdiction over the satellite, including its planned or unplanned reentry. Therefore, FAA does not examine reentry debris or emissions from the satellites themselves.

²⁸GAO, *Commercial Space Transportation: FAA Continues to Update Regulations and Faces Challenges to Overseeing an Evolving Industry*, [GAO-21-105268](#) (Washington, D.C.: June 16, 2021).

a license and to determine the requirements that might be placed on an operator as a condition for the license.

- **Radio transmissions.** Before allocating a particular radio frequency to satellite use, the FCC solicits, obtains, and considers comments from third parties about potential radio frequency interference from satellite transmissions.²⁹ FCC also adopts technical rules applicable to satellite operations to minimize radio frequency interference. In recent proceedings, third-party filers have expressed concern over the increased presence of large constellations of satellites and the potential for interference from radio transmissions. In response to these concerns, FCC referenced its standing rules—within certain bands of frequencies—that applicants must coordinate with other operators, specifically radio astronomers, as a condition for receiving a license.³⁰ FCC has also required that some operators have adequate control of radio frequency operations and can immediately cease transmissions that cause any harmful interference consistent with FCC’s rules or conditions in the license. FCC may also mediate in matters of satellite radio transmissions that result in interference involving federal agency systems.³¹
- **Sunlight reflections.** FCC determined in a recent licensing proceeding that the administrative record did not show that satellite sunlight reflections were significant enough to warrant an environmental assessment or environmental impact statement under

²⁹Harmful interference is defined as that which “endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with [the International Telecommunication Union] Radio Regulations.” 47 C.F.R. § 2.1(c).

³⁰For example, FCC has considered this issue in response to third-party petitions noting that in the 14.47-14.5 GHz band, operations are subject to a provision in 47 C.F.R. § 2.106 that all practicable steps must be taken to protect the radio astronomy service from harmful interference. *Space Exploration Holdings, LLC, Request for Modification*, Order and Authorization and Order on Reconsideration, 36 FCC Rcd. 7995, 8048 (Apr. 27, 2021) (*SpaceX Modification*).

³¹FCC officials told us that if a FCC licensee’s radio frequency “spills over” or overlaps with federal spectrum in such a way as to create harmful interference, as a practical matter, FCC would coordinate with NTIA for enforcement. An NTIA official said that federal agencies may raise interference concerns either directly to NTIA staff or within the Interdepartment Radio Advisory Committee. The *Manual for Regulations and Procedures for Federal Radio Frequency Management* includes a process for an agency to notify the FCC directly when it experiences harmful interference from a non-federal system. According to the NTIA official, there had never been an instance when an agency had raised such a concern.

NEPA.³² Specifically, FCC found merit with the applicant's efforts to work with the astronomy community to reduce the visibility of its satellites and to test solutions to reduce satellite reflectivity. FCC reported that it would continue to monitor the situation and the applicant's efforts to achieve its commitments.³³ FCC officials told us they have not otherwise had occasion to consider the effects of sunlight reflections.

- **Orbital debris.** Since 2004, FCC has required operators to submit an orbital debris mitigation plan consistent with the goals of the U.S. Government Orbital Debris Mitigation Standard Practices.³⁴ Operators are required to disclose design and operational strategies they will use to mitigate orbital debris in satellite-licensing applications, including a statement that the operator has assessed and limited the satellite's potential to become a source of debris as a result of collisions with large debris or other operational satellites.³⁵ FCC recently updated its rules regarding orbital debris mitigation.³⁶ Once in effect, these FCC regulations will codify FCC's practice to more specifically require operators to demonstrate that they have limited the probability that the spacecraft will become debris using the NASA Debris Assessment Software or higher fidelity analysis. FCC will also

³²FCC considered this issue in response to third-party petitions. *SpaceX Modification*, 36 FCC Rcd. at 8041–42, ¶ 86. FCC stated that as a threshold matter, it was not clear that all of the issues raised are within the scope of NEPA. FCC observed that several of the issues presented to the Commission raised novel questions about the scope of NEPA, including whether NEPA covers sunlight as a source of "light pollution" when reflecting on a surface that is in space. FCC noted that it did not need to evaluate and determine whether NEPA applies to the novel issues raised in the record, and instead, for purposes of its analysis, and out of an abundance of caution, FCC assumed that NEPA may apply. *SpaceX Modification*, 36 FCC Rcd. at 8037, ¶ 77.

³³*SpaceX Modification*, 36 FCC Rcd. at 8043, ¶ 87.

³⁴The Orbital Debris Mitigation Standard Practices is a comprehensive set of orbital debris mitigation guidelines originally adopted and issued in 2001 and then updated in 2019, by the U.S. Government. The goal of the Practices is to limit the generation of new, long-lived debris by the control of debris released during normal operations, minimizing the debris generated by accidental explosions, the selection of a safe flight profile and operational configuration to minimize accidental collisions, and post-mission disposal of space structures. See U.S. Government, *Orbital Debris Mitigation Standard Practices* (November 2019).

³⁵47 C.F.R. § 25.114(d)(14).

³⁶These amended requirements are currently pending approval by the Office of Management and Budget. See Mitigation of Orbital Debris in the New Space Age, 85 Fed. Reg. 52,422, 52,422 (Aug. 25, 2020).

require operators to certify that in response to collision warnings, they will mitigate the collision risk if necessary through certain steps. These could include contacting the operator of the other spacecraft involved in such a warning; sharing positioning data and other appropriate operational information with any such operator; and modifying satellite orientation, operations, or both. In 2021, FCC denied a petitioner's request asking for a NEPA environmental assessment of a satellite licensee's application related to this issue. FCC noted that it already reviewed the applicant's orbital debris mitigation plan and did not need to review the issue separately in an environmental assessment absent any detailed reasons justifying or circumstances necessitating environmental consideration of the issue.³⁷

- **Satellite reentry emissions and fragments.** As part of the orbital debris mitigation disclosures required by FCC since 2004, operators planning for satellite disposal by re-entry into Earth's atmosphere must provide a casualty risk assessment. The assessment generally should include an estimate as to whether portions of the spacecraft will survive reentry and reach the surface of the Earth, and an estimate of any resulting probability of human casualty.³⁸ FCC's newly amended orbital debris regulations add specificity by codifying FCC's approach of requiring a satellite applicant to demonstrate that the calculated casualty risk is less than 1:10,000 for an individual satellite.³⁹ FCC will require satellite operators to use NASA's Debris Assessment Software or a higher fidelity analysis to assess the casualty risk. FCC officials told us they assess casualty risk associated with large constellations on a case-by-case basis, and have sought comment on what metric for cumulative casualty risk should apply to large constellations as part of its ongoing update to its orbital debris rules. In 2021, FCC determined that a petition related to reentry debris did not require a NEPA environmental assessment for a satellite licensee's application because FCC had already assessed the casualty risk of the proposed satellites and found that they would

³⁷ *SpaceX Modification*, 36 FCC Rcd. at 8044–45, ¶ 89.

³⁸ 47 C.F.R. § 25.114(d)(14)(iv).

³⁹ *Mitigation of Orbital Debris in the New Space Age*, 85 Fed. Reg. at 52,451 (to be codified at 47 C.F.R. § 25.114(d)(14)(vii)(D)(2)). As calculated using the NASA Debris Assessment Software, any surviving objects from reentry must have a kinetic energy higher than 15 Joules to result in a non-zero human casualty risk. For illustration, this level of force would be equivalent to a 2-inch sized hail falling from the sky.

burn up upon entering the atmosphere posing no significant environmental effects.⁴⁰

Some Federal Agencies Fund or Lead Efforts to Address Sunlight Reflections, Orbital Debris, and Rocket Emissions

Some federal agencies are funding or leading efforts to address satellite sunlight reflections and orbital debris, driven, in part, by concerns about the potential effects from increasing numbers of large constellations of satellites. The National Science Foundation (NSF), an independent federal agency that funds a variety of scientific research, has supported multiple collaborative efforts to examine the issue of sunlight reflections from satellites and to define tolerable brightness levels of satellites. In 2020 and 2021, NSF funded the Satellite Constellations Workshops known as SATCON1 and SATCON2, respectively, bringing together astronomers, engineers from commercial operators, and others to consider the issue of sunlight reflections.⁴¹

- SATCON1 yielded recommended actions for observatories and commercial satellite operators to take on their own and in collaboration with each other.⁴² Three recommendations were for observatories and noted the need to develop comprehensive software tools to analyze the impact of data that may be skewed by sunlight reflections from satellite constellations, among other things. Four recommendations were aimed at satellite operators, including asking

⁴⁰*SpaceX Modification*, 36 FCC Rcd. at 8041, ¶¶ 84–85. Because FCC had already assessed the casualty risk as part of its analysis of the applicant's orbital debris mitigation plan, FCC determined that its categorical exclusion applied and that no further environmental review was necessary.

⁴¹NSF's support of these workshops followed a 2020 report it had commissioned examining the impacts of large constellations of satellites. The report included a number of recommendations for NSF to support the optical and radio astronomy community in documenting and mitigating environmental effects from these satellites. For example, the report recommended the agency help the radio astronomy community make quantitative measurements of radio frequency interference (both in protected and unprotected frequency bands) and support the development and public accessibility of software tools that could accurately predict the locations of satellites. See JASON and the MITRE Corporation, *The Impacts of Large Constellations of Satellites* (McLean, VA: Nov. 2020, updated Jan. 21, 2021).

⁴²C. Walker et al., *Impact of Satellite Constellations on Optical Astronomy and Recommendations Toward Mitigations* (SATCON1 report) (Aug. 2020).

operators to consider upfront design modifications to minimize the brightness of satellites. Three recommendations were for observatories and operators to collaborate in developing a comprehensive network of satellite observers that would allow for improved information on satellite position and passages.

- NSF furthered the light reflections research and collaboration of SATCON1 by funding SATCON2, along with the American Astronomical Society. The goals of SATCON2 were to develop specific action steps for carrying out SATCON1 recommendations, explore policy frameworks for operations in low Earth orbit, and engage a wider group of stakeholders.⁴³ As a result, in June 2022, the NSF's NOIRLab⁴⁴ and the UK-headquartered SKA Observatory⁴⁵ began hosting the International Astronomical Union's new Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference. The Centre, as envisioned and recommended within SATCON1 and SATCON2, will provide access to satellite data, software tools, and training resources, as well as hubs for national and international policy advocacy, community engagement, and industry outreach.

Several federal agencies fund or lead efforts to assist with monitoring or mitigation of orbital debris, and additional efforts are under way.

- DOD's Space Surveillance Network (SSN) currently tracks more than 27,000 satellites and pieces of orbital debris, or "space junk"; the United States Space Force maintains a catalog of these objects. For objects in low earth orbit, the SSN is capable of tracking objects as small as 10 centimeters. According to DOD and other federal agencies, many more pieces of orbital debris exist than those that are tracked by SSN. This debris is too small to be tracked, but large

⁴³C. Walker et al., *Report of the SATCON2 Workshop*, SATCON2 Workshop (Oct. 2021), accessed Oct. 26, 2022, <https://noirlab.edu/science/events/websites/satcon2/publications>.

⁴⁴NSF's NOIRLab (formally named the National Optical-Infrared Astronomy Research Laboratory) is a U.S. national center for ground-based, nighttime optical and infrared astronomy. The mission of NOIRLab is to enable breakthrough discoveries in astrophysics by developing and operating state-of-the-art ground-based observatories and providing data products and services for a diverse and inclusive community.

⁴⁵The SKA Observatory is an international intergovernmental organization. Its mission is to build and operate cutting edge radio telescopes to enhance the understanding of the Universe, and to deliver benefits to society through global collaboration and innovation.

enough to threaten human spaceflight and robotic missions.⁴⁶ Further, according to DOD, it currently assesses and notifies operators of the potential for orbital debris collisions including those involving commercial satellite constellations.

- DOD's Air Force Research Laboratory is working with commercial entities to identify on-orbit servicing and manufacturing technologies with a focus on active debris remediation. According to its website, these technologies focus on repairing, repositioning, refueling, deorbiting, reusing or recycling space objects.
- NASA's Orbital Debris Program Office created and maintains numerous software and modeling tools used in debris mitigation analysis and estimating the debris in the orbital environment. Since the 1990s, NASA has also been a member of the Inter-Agency Space Debris Coordination Committee, an international governmental forum that adopted the "25-year rule" developed by NASA and contained in the U.S. Government Orbital Debris Mitigation Standard Practices. The rule recommends that satellite operators who remove spacecraft from useful and densely populated orbit regions by atmospheric reentry do so within 25 years after mission completion.
- NASA's Space Technology Mission Directorate funds research of early-stage technology for removal of orbital debris. The agency continues to research orbital debris remediation by routinely receiving and evaluating orbital debris removal concepts through partnership activities and solicitations. According to NASA officials, the agency is particularly interested in supporting early stage concepts for capturing and removing debris that is tumbling, uncontrolled, and not designed to be grappled, making this debris not easily collected.
- NOAA's Office of Space Commerce, within the Department of Commerce, is developing a system to inform civil and commercial satellite operators of potential collisions pursuant to its emerging role as described in Space Policy Directive-3.⁴⁷ This policy directive

⁴⁶Debris smaller than 10 cm is generally not trackable with existing sensors, so NASA estimates the population of these debris using statistical methods. According to the NASA Orbital Debris Program Office, there are approximately 500,000 particles of orbital debris between 1 and 10 cm in size and over 100 million particles larger than 1 mm in size. These smaller debris can pose risks such as puncturing fuel tanks or wearing down solar panels.

⁴⁷Space Policy Directive-3 is one of a series of directives that describe federal space policy and procedures. This directive lays out the goals, priorities, guidelines, and roles and responsibilities for the planning and coordination of space traffic management.

specifies that the Department of Commerce is to take over civil space traffic management.⁴⁸ Specifically, Space Policy Directive-3 directed the Department of Commerce to conduct the data-sharing and collision-avoidance support services required by the increasingly congested orbital environment. In March 2022, the Office of Space Commerce requested information from commercial space satellite tracking providers for data, services, and capabilities to support development of a database that could be used for space situational awareness.

- FCC has also supported in-space servicing activities to remove space debris and other repairs of satellites. In 2021, the FCC authorized certain U.S. earth station communications to support testing of spacecraft capabilities for orbital debris removal.⁴⁹

Federal agencies have also conducted research on rocket emissions. This research has been motivated, in part, by the use of rockets to launch large constellations of satellites. NOAA's research has included the effects of hydrogen rocket engines on the atmosphere, as well as black carbon from kerosene rocket engines. NASA's research is focusing on the use of environmentally friendly rocket propellants.

FCC Generally Invokes a 1986 Categorical Exclusion That Predates Large Constellations

⁴⁸Pursuant to congressional direction, the National Academy of Public Administration assessed a number of federal departments and agencies to determine which would be best suited to handle space traffic management. See S. Rep. No. 116-127, at 67 (2019) (directing the National Academy of Public Administration to conduct a review); see also 165 Cong. Rec. H10961 (daily ed. Dec. 17, 2019) (incorporating by reference Senate Report 116-127). The report issued in 2020, identified the Office of Space Commerce for this role in overseeing non-military situational space awareness and STM tasks.

⁴⁹See FCC, Report No. SES-02420, at 5 (2021) (public notice regarding grants of special temporary authority to provide telemetry, tracking, and command services and communication services for Astroscale's demonstration of rendezvous and proximity operations, capture, and deorbit of a mock debris); see also FCC, Report No. SES-02356, at 25 (2021).

of Commercial Satellites and Has Not Revisited It

FCC Generally Invokes a 1986 Categorical Exclusion when Licensing Large Constellations of Satellites

Under NEPA, agencies must establish categorical exclusions for categories of actions agencies have found normally do not have a significant effect on the human environment.⁵⁰ If an action is covered by an agency's categorical exclusion, it generally does not require an environmental assessment or environmental impact statement. In 1986, FCC categorically excluded all of its actions that did not meet specific conditions.⁵¹ These conditions largely focus on environmental effects on the Earth's surface, such as the construction of facilities that are to be located in an officially designated wildlife preserve.⁵² FCC officials told us that the agency invokes this categorical exclusion when licensing large constellations of satellites.

Even when an action is covered by a categorical exclusion, the CEQ regulations require agencies to evaluate whether the action presents an extraordinary circumstance in a given instance.⁵³ Extraordinary circumstances exist when the normally excluded action may have a significant effect on the quality of the human environment and therefore may require an environmental assessment or environmental impact

⁵⁰40 C.F.R. §§ 1501.4(a), 1507.3(e)(2)(ii).

⁵¹Environmental Rules in Response to CEQ Regulations, 51 Fed. Reg. 14,999, 15,000 (Apr. 22, 1986) (codified at 47 C.F.R. § 1.1306).

⁵²FCC categorically excludes all activities from detailed analysis except for those Commission actions with respect to facilities that (a) will be in a wilderness area or wildlife preserve, (b) might affect listed or proposed threatened or endangered species or designated or proposed critical habitats, (c) might affect properties that are included or eligible for inclusion in the National Register of Historic Places, (d) might affect Indian religious sites, (e) will be in a flood plain, (f) will involve 'significant change in surface features' from construction, (g) involve certain antenna structures over 450 feet in height; (h) involve high-intensity lighting in residential areas; or (i) would cause radio frequency emissions exposure in excess of FCC limits. 47 C.F.R. §§ 1.1306, 1.1307.

⁵³40 C.F.R. § 1501.4(b).

statement.⁵⁴ When licensing large constellations of satellites, FCC has considered arguments regarding sunlight reflection and orbital debris, among other factors, in connection with particular license applications, and has determined that there were no extraordinary circumstances requiring an environmental assessment for these license applications. As of October 2022, FCC has not required an environmental assessment or environmental impact statement for any license it has issued for large constellations of satellites.

FCC Has Not Reviewed Its 1986 Categorical Exclusion Specifically with Regard to Large Satellite Constellations

We found that FCC has not explained and documented how its decision to categorically exclude licensing large constellations of satellites is current and appropriate. When FCC established its categorical exclusion in 1986, it was “[b]ased upon the Commission’s experience,”⁵⁵ but because large constellations of satellites did not exist at that time, FCC’s experience up to that point would not have involved the consideration of this technology. Additionally, although other FCC rules governing satellite licensing and operations have changed in subsequent years (including those addressing risks from orbital debris), FCC has not revisited its NEPA procedures to consider whether or how they should be revised for large constellations of satellites as the space industry has evolved.⁵⁶

CEQ guidance from 2010 recommends that agencies periodically review their categorical exclusions at least every 7 years to ensure they remain current and appropriate.⁵⁷ This guidance is particularly relevant in the

⁵⁴Even if extraordinary circumstances exist, the agency may still categorically exclude the action “if the agency determines that there are circumstances that lessen the impacts or other conditions sufficient to avoid significant effects.” 40 C.F.R. § 1501.4(b)(1).

⁵⁵Environmental Rules in Response to CEQ Regulations, 51 Fed. Reg. at 14,999.

⁵⁶While CEQ stated in 2020 that all then-existing categorical exclusions in agency regulations (which include FCC’s) were consistent with CEQ’s NEPA rules, CEQ explained that this language was added to the regulations to make clear that agencies could continue to use their existing categorical exclusions despite CEQ’s amended regulations that required other changes in agencies’ NEPA procedures. Update to the Regulations Implementing NEPA Procedural Provisions, 85 Fed. Reg. 43,304, 43,340 (July 16, 2020). This statement does not negate CEQ’s recommendation that agencies periodically review their categorical exclusions.

⁵⁷Guidance on Establishing, Applying, and Revising Categorical Exclusions, 75 Fed. Reg. 75,628, 75,637 (Dec. 6, 2010).

case of whether the categorical exclusion should apply to large constellations of satellites since this development is a new and rapidly growing technological development. Moreover, *Standards for Internal Control in the Federal Government* calls for agencies to document key decisions to provide transparency to internal and external stakeholders.⁵⁸ Documentation from FCC of a determination regarding whether licensing large constellations of satellites should continue to be categorically excluded because it normally does not have significant environmental effects could ensure that FCC is giving the appropriate level of environment review to this activity.

FCC officials told us that they are always considering whether the categorical exclusion is current and appropriate and that they have a process in place for interested parties to raise concerns when applications are submitted. However, FCC officials were not able to provide documentation demonstrating that they specifically looked at the categorical exclusion as it applies to licensing large constellation of satellites. When we asked for documentation of FCC's efforts to review its categorical exclusion, FCC provided information about six notice and comment rulemakings in which it reviewed and revised aspects of its categorical exclusion. These six reviews were focused on specific types of actions and effects on the Earth's surface such as ensuring that environmental effects of proposed communications towers, including their effects on migratory birds, were fully considered. However, FCC never looked at whether the categorical exclusion should apply to licensing large constellations of satellites. Without a documented determination from FCC as to whether licensing large constellations of satellites normally has significant effects on the human environment, Congress and the public lack reasonable assurance that FCC's application of the categorical exclusion remains appropriate for licensing large constellations of satellites in light of technological changes and advances. Further, given that federal agencies are conducting research and learning more about potential environmental effects of large constellations of satellites, it is important for FCC to consider this information in its decision-making going forward.

⁵⁸[GAO-14-704G](#).

FCC Does Not Have a Process or Timeline for Periodically Reviewing Its Categorical Exclusion

FCC has not developed or documented a process and timeline for conducting periodic reviews for its categorical exclusion in general. CEQ guidance from 2010 recommends that agencies periodically review their categorical exclusions at least every 7 years to ensure they remain current and appropriate. The guidance also (1) recommends that agencies develop a process and timeline for the periodic reviews and (2) notes that if the agency determines that a timeframe other than 7 years is appropriate, the agency should articulate a sound basis for that determination. The CEQ guidance also suggests that the agency publish its review time period and process, along with its articulation for a basis for periods over 7 years, on the agency's website and notify CEQ where on the website the review procedures are posted.

FCC officials told us that they do not have a timeline for reviewing FCC's categorical exclusion because they are always considering the categorical exclusion in response to market and technology changes. FCC has reviewed certain aspects of its categorical exclusion. FCC officials said that this demonstrates that the agency reviews the categorical exclusion "on an ongoing basis." However, these examples do not demonstrate that the agency has undertaken and documented a full examination of its categorical exclusion to ensure it is current and appropriate. Further, FCC does not have a documented process or timeline for conducting periodic reviews of the categorical exclusion as recommended by the CEQ guidance. By documenting the process and timeline for regular periodic review of the categorical exclusion, stakeholders would have more assurance that FCC's implementation of its NEPA responsibilities will be adapted to changing technologies and their uses, such as the increased use of large constellations of satellites, and that FCC is undertaking the appropriate level of environmental review for major federal actions.

FCC Has Not Articulated Guidance on Extraordinary Circumstances That Might Require an Environmental Assessment

FCC rules provide that potential extraordinary circumstances can be identified by FCC staff independently or determined after review of a

petition FCC receives from an interested party.⁵⁹ While FCC generally invokes a 1986 categorical exclusion when reviewing license applications for large constellations of satellites, FCC also requires that applicants self-identify significant environmental effects, and FCC staff review license applications to determine whether there are extraordinary circumstances that would require an environmental assessment. However, we found that FCC has not provided guidance for doing so by documenting either internally or for the public what may constitute an extraordinary circumstance, other than those circumstances identified in its categorical exclusion.⁶⁰

According to FCC officials, as of October 2021, none of the 24 applications for large constellations of satellites received since 2016 was determined to need an environmental assessment. Specifically, FCC has not identified, either on its own initiative or in response to an interested party's petition, an extraordinary circumstance requiring an environmental assessment in an application for a large constellation of satellites. Further, none of these applicants self-identified a significant environmental effect.

FCC's NEPA procedures reiterate FCC's responsibility to determine whether an extraordinary circumstance is present. FCC officials told us that the agency's written guidance about extraordinary circumstances is

⁵⁹47 C.F.R. § 1.1307(c)–(d).

⁶⁰FCC identifies circumstances that might cause an FCC action to have significant environmental effects as exceptions to the categorical exclusion in 47 C.F.R. § 1.1307(a) and (b). See *also* Note to 47 C.F.R. § 1.1307(d) (requiring environmental assessments under certain circumstances for towers over 450 feet in height above ground level). FCC evaluates for extraordinary circumstances under 47 C.F.R. § 1.1307(c)–(d). Under 47 C.F.R. § 1.1307(c), an interested person may submit a petition alleging that a specific action will have a significant environmental effect even though it would otherwise be categorically excluded. FCC will review the petition, and it will require an environmental assessment if it determines that the action may have a significant environmental effect. Similarly, under § 1.1307(d), FCC may, on its own initiative, determine the action may have a significant environmental effect and therefore require an environmental assessment.

in FCC's regulations and its accompanying checklist.⁶¹ They also said that staff use professional judgment and past licensing decisions to determine if a license application presents extraordinary circumstances that would require an environmental assessment. However, FCC's regulations merely state—and the checklist restates—what actions are covered by the categorical exclusion and define specific exceptions, but do not list additional factors to explain what may constitute an extraordinary circumstance.⁶²

Consistent with *Standards for Internal Control in the Federal Government* and CEQ guidance, other agencies—such as NOAA, NASA, and FAA—have NEPA procedures or policies that provide examples of extraordinary circumstances that staff and the public can use to guide their decision-making process. For example, NOAA's extraordinary circumstances are listed in its "Policies and Procedures for Compliance with the National Environmental Policy Act and Related Authorities" and include actions with "the potential to generate, use, store, transport, or dispose of hazardous or toxic substances, in a manner that may have a significant effect on the environment" and "highly controversial environmental effects," among other things. NOAA officials told us that this guidance was developed in response to questions that NOAA's NEPA experts received from NOAA staff. They said that the guidance was intended to help resolve any uncertainty about how best to apply categorical exclusions and extraordinary circumstances and is useful in making decisions. FAA officials noted that written guidance or examples of extraordinary circumstances would help the decision maker recognize common factors or circumstances that may have a significant environmental impact that then requires further analysis in an environmental assessment or an environmental impact statement.

Standards for Internal Control in the Federal Government calls for the use of effective documentation as a means to meet operational needs, retain organizational knowledge, and mitigate the risk of having that knowledge

⁶¹ See <https://us-fcc.app.box.com/s/f2rbaxbka6ni4e30jwun4nms6l6k18kf>. Providing guidance can take a variety of forms; for example, federal internal control standards, which provide standards for effective management of programs, note the importance of procedures and training in achieving an agency's objectives. Other agencies have used different vehicles to document factors used to identify extraordinary circumstances. For example, NOAA provides this information in a policy manual, FAA provides information in an order, and NASA provides information in its regulations.

⁶² See 47 C.F.R. §§1.1306, 1.1307.

limited to a few personnel, as well as a means to communicate that knowledge as needed to external parties. Moreover, CEQ guidance provides that agencies should identify extraordinary circumstances when establishing categorical exclusions in their NEPA procedures.⁶³ Documentation from FCC on what FCC will consider when determining what constitutes an extraordinary circumstance under NEPA and the factors that FCC considers when licensing large constellations of satellites could serve these purposes. Clarity regarding extraordinary circumstances is especially important for FCC because FCC has categorically excluded all of its actions that do not meet certain conditions. Additionally, given that FCC relies on information provided by applicants and interested third parties to identify extraordinary circumstances, it is important for FCC to provide transparent guidance on what may present an extraordinary circumstance. Further, basing decisions on professional judgment without written guidance could result in uncertainty and inconsistency among staff about how to identify extraordinary circumstances.

Conclusions

As companies increasingly launch large constellations of satellites into orbit to provide important services, such as satellite phone and internet service, some stakeholders have questioned whether existing policies and processes are adequately addressing the constellations' environmental or other effects. FCC established a categorical exclusion in 1986 that it currently applies to licensing large constellations of satellites, which did not exist at that time. However, there is no documentation demonstrating that FCC has revisited this categorical exclusion to make sure it is still current and appropriate for large constellations of satellites and in consideration of the research being conducted by federal agencies on their potential environmental effects. Further, FCC has not established a timeframe and a process to periodically review its categorical exclusion more generally to ensure it is still appropriate nor published them on its website, as recommended by CEQ. This provides Congress and the public little assurance that the agency is undertaking the appropriate level of environmental review for major federal actions. In addition, FCC relies on outside parties and its staff to make judgments about whether proposed actions involve an extraordinary circumstance and thus might require further environmental analysis, but has not provided guidance on

⁶³Guidance on Establishing, Applying, and Revising Categorical Exclusions, 75 Fed. Reg. 75,628, 75,633 (Dec. 6, 2010).

factors staff should use to identify such circumstances. Written guidance would help ensure that FCC is consistently carrying out its NEPA responsibility in evaluating actions for extraordinary circumstances and would provide transparency to Congress and the public regarding how FCC is reaching its decisions.

Recommendations for Executive Action

We are making three recommendations to FCC:

The Federal Communications Commission should review whether licensing large constellations of satellites normally does not have significant effects on the human environment and document FCC's resulting decision. (Recommendation 1)

The Federal Communications Commission should establish a timeframe and process for a periodic review of its categorical exclusion under NEPA and publish both on the FCC website. (Recommendation 2)

The Federal Communications Commission should identify the factors that FCC will consider in determining whether an extraordinary circumstance is present when reviewing licenses for large constellations of satellites and make the results available to the public. (Recommendation 3)

Agency Comments

We provided a draft of this report to FCC, CEQ, DOD, DOT, NASA, and Commerce for review and comment. In its comments reproduced in appendix I, FCC agreed with the recommendations. We received technical comments from FCC, CEQ, and DOT, which we incorporated as appropriate. DOD, NASA, and Commerce did not provide comments.

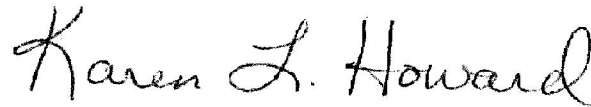
We are sending copies of this report to the appropriate congressional committees, the Chairwoman of FCC, the Chair of the Council on Environmental Quality, the Secretary of Defense, the Secretary of Transportation, the Administrator of NASA, the Secretary of Commerce, and other interested parties. In addition, the report is available at no charge on the GAO website at <https://www.gao.gov>.

If you or your staff have any questions about this report, please contact us at vonaha@gao.gov or (202) 512-2834 or howardk@gao.gov or 202-

512-6888. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix II.

A handwritten signature in black ink, appearing to read "Andrew Von Ah". The signature is fluid and cursive, with a long horizontal stroke at the end.

Andrew Von Ah, Director, Physical Infrastructure

A handwritten signature in black ink, appearing to read "Karen L. Howard". The signature is cursive and clearly legible.

Karen L. Howard, PhD, Director, Science, Technology Assessment, and Analytics

Appendix I: Comments from the Federal Communications Commission

**Appendix I: Comments from the Federal
Communications Commission**



Federal Communications Commission
Washington, D.C. 20554

October 12, 2022

Andrew Von Ah
Director, Physical Infrastructure

Karen L. Howard
Director, Science, Technology Assessment and Analytics

Government Accountability Office
441 G St., NW
Washington, DC 20548

Dear Directors Von Ah and Howard:

We have reviewed GAO's draft report, entitled "Satellite Licensing: FCC Should Reexamine Its Environmental Review Process for Large Constellations of Satellites." The Federal Communications Commission (FCC or Commission) is committed to ensuring that its actions, including satellite licensing activities are in compliance with the requirements of the National Environmental Policy Act (NEPA).¹ The FCC regulates the use of non-federal spectrum by space and earth stations in the public interest as an independent multimember Commission established by Congress in the Communications Act of 1934.² The Commission has established rules and processes to promote United States leadership in the emerging space economy, and it assesses the suitability of these rules and processes for the increasing number of satellites and new activities in space.³

¹ Section 101 of NEPA sets forth a national policy "to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans." 42 U.S.C. 4331(a).

² The majority of the rules governing these stations, including space stations, are found in the Part 25 of the Commission rules. See 47 CFR part 25.

³ See *Orbital Debris in the New Space Age, Report and Order and Further Notice of Proposed Rulemaking*, 35 FCC Rcd. 4156 (2020) (updating the Commission's orbital debris mitigation rules and seeking further comment on proposals for further mitigation); *Space Innovation; Mitigating Orbital Debris in the New Space Age, Second Report and Order*, FCC 22-74 (2022) (adopting a rule requiring operators to dispose of their satellites in low-Earth orbit within five years after mission completion). See also *Space Innovation; Facilitating Capabilities for In-Space Servicing, Assembly, and Manufacturing, Notice of Inquiry*, FCC 22-66 (2022) (a notice of inquiry seeking to establish a record on the current state of the industry regarding in-space servicing, assembly, and manufacturing capabilities, including orbital debris remediation and active debris removal, and seeking comment on what FCC processes are most appropriate for efficiently licensing these missions and what, if any, changes may need to be made to FCC rules to facilitate development of these technologies).

Appendix I: Comments from the Federal Communications Commission

The draft report makes three recommendations to the FCC. These are (1) the FCC should review whether licensing large constellations of satellites normally does not have significant effects on the human environment and document FCC's resulting decision; (2) the FCC should establish a timeframe and process for a periodic review of its categorical exclusion under NEPA, and publish both on the FCC website; and (3) the FCC should identify the factors that FCC will consider in determining whether an extraordinary circumstance is present when reviewing licenses for large constellations of satellites and make the results available to the public.

The first and third recommendations are interrelated and involve applicability of NEPA to activities undertaken primarily in an outer space environment, which the FCC has recognized as presenting a new and novel issue.⁴ The FCC reviews each satellite application or petition, including those filed under its part 25 rules,⁵ part 5 experimental licensing rules,⁶ and part 97 amateur satellite rules,⁷ on a case-by-case basis, evaluating facts specific to each filing to determine whether the grant of such application or petition would serve the public interest. In this context, we coordinate with other government agencies on issues of mutual interest, including those involving environmental and other effects, and benefit from their input and expertise. The FCC will continue to review applications and petitions on a case-by-case basis under its rules, including the rules implementing NEPA.

In evaluating potential future actions to implement the three recommendations, we anticipate that the FCC will consider such actions in a manner consistent with the Council on Environmental Quality's (CEQ) regulations for implementing NEPA.⁸ CEQ is in the process of revising its NEPA regulations, and we expect that those rules will require Federal agencies to update their NEPA implementing procedures to conform to the new CEQ regulations.⁹ We anticipate that the

⁴ *Space Exploration Holdings, LLC, Request for Modification of the Authorization for the SpaceXNGSO Satellite System*, Order and Authorization and Order on Reconsideration, 36 FCC Rcd. 7995, 8037, para. 77 (2021) (SpaceX Third Modification Order). Some parties filed a lawsuit in federal court to challenge the SpaceX Third Modification Order, among other issues raising NEPA-related issues. The United States Court of Appeals for the D.C. Circuit dismissed the petition for review of the NEPA-related issues on August 26, 2022, finding that one of the NEPA petitioners lacked standing and the other had not demonstrated an injury to an interest protected by NEPA. *Viasat, Inc. v FCC*, 47 F.4th 769 (D.C. Cir. 2022).

⁵ 47 CFR Part 25.

⁶ 47 CFR Part 5.

⁷ 47 CFR Part 97.

⁸ See <https://ceq.doe.gov/laws-regulations/regulations.html> (stating that CEQ oversees NEPA implementation, principally through issuing guidance and interpreting regulations that implement NEPA's procedural requirements. CEQ also reviews and approves Federal agency NEPA procedures. CEQ is responsible for developing procedures for Federal agency implementation of NEPA. CEQ's NEPA implementing regulations are found at 40 CFR Parts 1500-1508. These procedures were initially promulgated in 1971 as guidelines, and were then issued as regulations in 1978).

⁹ In July 2020, CEQ made wholesale revisions to the NEPA regulations for the first time in more than 40 years. That final rule was published on July 16, 2020, and became effective on September 14, 2020. CEQ is now engaged in a comprehensive review of the 2020 rule pursuant to E.O. 13990 (January 20, 2021). CEQ issued an Interim Final Rule on June 29, 2021, which extended the deadline by two years (to September 14, 2023) for Federal agencies to develop or update their NEPA implementing procedures to conform to the CEQ regulations. On April

**Appendix I: Comments from the Federal
Communications Commission**

FCC will conduct a review of its NEPA rules following the issuance of the revised CEQ rules, including a review of whether licensing large constellations of satellites normally does not have significant effects on the human environment and, if such actions remain subject to a categorical exclusion, the factors that the FCC will consider in determining whether an extraordinary circumstance is present. We expect that, as part of that assessment, the Commission will consider whether to establish a timeframe and process for periodic review of our existing categorical exclusion.

Thank you for the opportunity to review GAO's recommendations. We look forward to continuing to work with GAO in the future.

Sincerely,



Thomas P. Sullivan
Chief
International Bureau



Joel Taubenblatt
Acting Chief
Wireless Telecommunications Bureau



Ronald T. Repasi
Acting Chief
Office of Engineering and Technology

20, 2022, CEQ issued the Phase 1 Final Rule. The rule finalizes a narrow set of changes to generally restore regulatory provisions that were in effect for decades before the 2020 rules modified them for the first time. *Id.* Separately, CEQ is developing a Phase 2 rulemaking to propose comprehensive revisions to the 2020 regulations and has stated that it intends to issue a second proposed rule for notice and public comment.

Accessible Text for Appendix I: Comments from the Federal Communications Commission

Federal Communications Commission Washington, D.C. 20554

October 12, 2022

Andrew Von Ah
Director, Physical Infrastructure

Karen L. Howard
Director, Science, Technology Assessment and Analytics

Government Accountability Office
441 G St., NW
Washington, DC 20548

Dear Directors Von Ah and Howard:

We have reviewed GAO's draft report, entitled "Satellite Licensing: FCC Should Reexamine Its Environmental Review Process for Large Constellations of Satellites." The Federal Communications Commission (FCC or Commission) is committed to ensuring that its actions, including satellite licensing activities are in compliance with the requirements of the National Environmental Policy Act (NEPA).¹ The FCC regulates the use of non-federal spectrum by space and earth stations in the public interest as an independent multimember Commission established by Congress in the Communications Act of 1934.² The Commission has established rules and processes to promote United States leadership in the emerging space economy, and

¹ Section 101 of NEPA sets forth a national policy "to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans." 42 U.S.C. 4331(a).

² The majority of the rules governing these stations, including space stations, are found in the Part 25 of the Commission rules. See 47 CFR part 25.

it assesses the suitability of these rules and processes for the increasing number of satellites and new activities in space.³

The draft report makes three recommendations to the FCC. These are (1) the FCC should review whether licensing large constellations of satellites normally does not have significant effects on the human environment and document FCC's resulting decision; (2) the FCC should establish a timeframe and process for a periodic review of its categorical exclusion under NEPA, and publish both on the FCC website; and (3) the FCC should identify the factors that FCC will consider in determining whether an extraordinary circumstance is present when reviewing licenses for large constellations of satellites and make the results available to the public.

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³ See *Orbital Debris in the New Space Age*, Report and Order and Further Notice of Proposed Rulemaking, 35 FCC Rcd. 4156 (2020) (updating the Commission's orbital debris mitigation rules and seeking further comment on proposals for further mitigation); *Space Innovation; Mitigating Orbital Debris in the New Space Age*, Second Report and Order, FCC 22-74 (2022) (adopting a rule requiring operators to dispose of their satellites in low-Earth orbit within five years after mission completion). See also *Space Innovation; Facilitating Capabilities for In-Space Servicing, Assembly, and Manufacturing*, Notice of Inquiry, FCC 22-66 (2022) (a notice of inquiry seeking to establish a record on the current state of the industry regarding in-space servicing, assembly, and manufacturing capabilities, including orbital debris remediation and active debris removal, and seeking comment on what FCC processes are most appropriate for efficiently licensing these missions and what, if any, changes may need to be made to FCC rules to facilitate development of these technologies).

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Thank you for the opportunity to review GAO's recommendations. We look forward to continuing to work with GAO in the future.

Sincerely,

Thomas P. Sullivan
Chief
International Bureau

⁸ See <https://ceq.doe.gov/laws-regulations/regulations.html> (stating that CEQ oversees NEPA implementation, principally through issuing guidance and interpreting regulations that implement NEPA's procedural requirements. CEQ also reviews and approves Federal agency NEPA procedures. CEQ is responsible for developing procedures for Federal agency implementation of NEPA. CEQ's NEPA implementing regulations are found at 40 CFR Parts 1500-1508. These procedures were initially promulgated in 1971 as guidelines, and were then issued as regulations in 1978).

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from the Federal Communications
Commission**

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Appendix II: GAO Contacts and Staff Acknowledgments

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