



February 2024

COMMERCIAL SPACE TRANSPORTATION

FAA's Oversight of Human Spaceflight

Accessible Version

GAO Highlights

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Highlights of [GAO-24-106184](#), a report to congressional requesters

February 2024

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Why GAO Did This Study

The number of commercial launch and reentry operations carrying humans is a small proportion of the overall number of commercial space operations—about 10 percent in 2023—but it is growing. This growth has been driven both by space tourism and by government missions conducted by commercial launch and reentry operators. This includes transporting National Aeronautics and Space Administration astronauts to and from the International Space Station. FAA forecasts that the number of commercial operations with humans onboard will continue to increase over the next several years.

GAO was asked to review issues related to FAA's oversight of commercial launch and reentry operations with humans. This report describes how FAA (1) oversees the safety of commercial operations with humans onboard, and (2) is preparing for expanded oversight of human spaceflight, which may include regulations directed at protecting the health and safety of humans onboard.

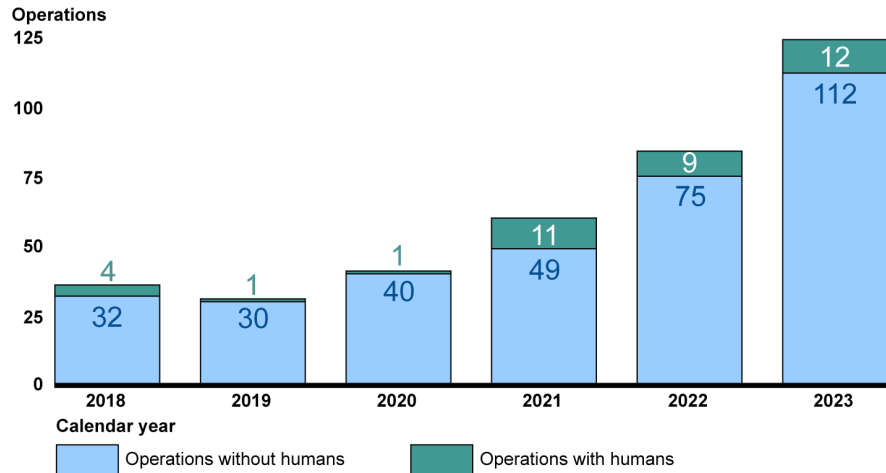
GAO reviewed relevant statutes, regulations, and FAA and industry documentation. GAO interviewed FAA officials and conducted semi-structured interviews with all seven launch operators that, as of December 2022 (during GAO's review), had conducted or planned to conduct operations with humans before 2026.

What GAO Found

The Federal Aviation Administration (FAA) oversees commercial space operations with humans onboard under its broader licensing framework. FAA requires commercial launch operators to obtain a license before conducting any operation within U.S. borders—whether they carry humans or payloads, such as satellites. To obtain a license, operators must demonstrate that they can conduct the operation without jeopardizing the safety of the people and property not involved in the operation. FAA has additional licensing requirements for operations with humans onboard, such as crew training and the ability to suppress cabin fire. These requirements are intended to address risk to the uninvolved public. FAA is currently prohibited from issuing regulations directed at protecting the safety of humans onboard, with some exceptions, due to a moratorium that Congress established in 2004 to limit

certain regulatory burdens on an emerging industry. This moratorium is set to expire on March 8, 2024.

Number of U.S. Commercial Space Operations, 2018 – 2023



Source: GAO analysis of Federal Aviation Administration (FAA) information. | GAO-24-106184

Accessible Data for Number of U.S. Commercial Space Operations, 2018 – 2023

Calendar year	Operations without humans	Operations with humans
2018	32	4
2019	30	1
2020	40	1
2021	49	11
2022	75	9
2023	112	12

Source: GAO analysis of Federal Aviation Administration (FAA) information. | GAO-24-106184

FAA is preparing for expanded oversight of human spaceflight—if the moratorium were to expire—by working with industry to develop future regulations and building FAA’s workforce capacity. For example, FAA:

- chartered a rulemaking committee in April 2023 to solicit industry’s input on a future regulatory framework aimed at protecting the safety of humans onboard, and
- is leveraging the expertise of current staff and recruiting new staff to support human spaceflight safety efforts.

However, FAA has ongoing hiring challenges and workforce constraints, which have affected these efforts. For example, FAA reported it did not receive an adequate candidate pool for four of the 10 human spaceflight-related positions for which it has been actively recruiting. To help address

this challenge, officials said in February 2024 that they are devising a new recruitment strategy for these positions.

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Abbreviations

AST	Office of Commercial Space Transportation
C.F.R.	Code of Federal Regulations
DOT	Department of Transportation
FAA	Federal Aviation Administration
NASA	National Aeronautics and Space Administration

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February 21, 2024

The Honorable Rick Larsen
Ranking Member
Committee on Transportation and Infrastructure
House of Representatives

The Honorable Steve Cohen
Ranking Member
Subcommittee on Aviation
Committee on Transportation and Infrastructure
House of Representatives

The U.S. commercial space transportation industry is undergoing an unprecedented period of growth that expands the scope of what is possible in space and who is involved, according to industry reports.¹ What once was an exclusive government-led activity is now open to commercial companies and private individuals.

In 2004, the first commercial launch vehicle with a human onboard successfully flew into space. That same year, Congress mandated the Department of Transportation (DOT) to promote the continuous improvement of the safety of commercial launch vehicles designed to carry humans to and from space. Congress also provided DOT the authority to issue certain regulations to carry out this mandate.² DOT delegated this authority to the Federal Aviation Administration (FAA).

At the same time, however, Congress restricted this authority in specific ways. Congress established a moratorium that prohibited FAA from issuing regulations directed at protecting the health and safety of humans

¹See, for example, Aerospace Corporation, Space Safety Institute, *2022 Space Safety Compendium Guiding the Future of Spaceflight* (El Segundo, CA: Apr. 2023).

²Commercial Space Launch Amendments Act of 2004, Pub. L. No. 108-492, § 2, 118 Stat. 3974, 3979 (2004) (codified as amended at 51 U.S.C. § 50903).

onboard these launch vehicles, outside of specific limited exceptions.³ This moratorium provided the commercial space transportation industry a “learning period” and prevented FAA from imposing certain regulatory burdens on an emerging industry. Congress most recently extended this moratorium through March 8, 2024.⁴

The number of commercial space transportation operations carrying humans is a small proportion of the overall number of commercial space operations (about 10 percent in 2023), but it is growing. The past few years, in particular, have experienced accelerated growth in the number of commercial operations carrying humans, such as government astronauts and private citizens, to and from space. Specifically, in 2020, there was a single commercial operation with humans onboard, whereas there were 12 of these operations in 2023.

This growth has been driven both by space tourism and government missions conducted by commercial operators, such as transporting National Aeronautics and Space Administration (NASA) astronauts to and from the International Space Station. FAA forecasts that the number of commercial operations with humans will continue to increase over the next several years.

You asked us to review how FAA carries out current oversight responsibilities for commercial launch and reentry operations with humans and how it is preparing to expand its oversight—should the moratorium expire—to include more protections for the health and safety of the humans onboard. This report describes

- how FAA oversees the safety of commercial launch and reentry operations with humans onboard; and

³FAA may issue regulations regardless of the moratorium that prohibit design features or operating practices that are known to have resulted in a human fatality or serious injury, or when the practice or design “contributed to an unplanned event or series of events...that posed a high risk of causing a serious or fatal injury...” Commercial Space Launch Amendments Act of 2004, Pub. L. No. 108-492, § 2, 118 Stat. 3974, 3978-79 (2004) (codified as amended at 51 U.S.C. § 50903).

⁴The moratorium was established in statute in 2004. Commercial Space Launch Amendments Act of 2004, Pub. L. No. 108-492, § 2, 118 Stat. 3974, 3979 (2004). Originally set to expire in 2012, it was extended by statute multiple times. As of December 26, 2023, the moratorium will expire March 8, 2024. 51 U.S.C. § 50905(c)(9).

- how FAA is preparing for expanded human spaceflight oversight that may include regulations directed at protecting the health and safety of humans onboard.

To address both objectives, we reviewed laws, including the Commercial Space Launch Competitiveness Act, as amended, and regulations governing commercial launch and reentry operations with humans (human spaceflight regulations).⁵ We also reviewed FAA documentation related to its evaluations of license applications for operations with humans and internal policies and procedures for licensing and oversight of operations with humans. In addition, we reviewed five FAA reports on human spaceflight submitted to Congress between 2017 and 2023.⁶ We reviewed industry documentation, including two FAA-commissioned reports prepared by independent research organizations and documents developed by FAA's advisory committee for commercial space transportation.⁷

For both objectives, we interviewed management and staff from FAA's Office of Commercial Space Transportation to discuss FAA's oversight of commercial operators' compliance with human spaceflight regulations. We also discussed challenges FAA faced in conducting its oversight, and

⁵FAA's human spaceflight regulations are directed at protecting the safety of people and property that are not involved in supporting the launch, as opposed to the health and safety of humans onboard the launch or reentry vehicle.

⁶2015's Commercial Space Launch Competitiveness Act required the Secretary of Transportation to submit reports to Congress at various time intervals between 2016 and 2022 on topics including the status of developing voluntary industry consensus standards, key industry metrics, activities appropriate for a new safety framework. U.S. Commercial Space Launch Competitiveness Act, Pub. L. No. 114-90, § 111, 129 Stat. 704, 709-710 (2015) (codified at 51 U.S.C. § 50905(c)(5)-(7)). The five reports we reviewed that FAA prepared pursuant to the requirements are as follows. Federal Aviation Administration, *Report to Congress: U.S. Department of Transportation Evaluation of Commercial Human Space Flight Activities Most Appropriate for New Safety Framework* (Washington, D.C.: Sept. 29, 2023); *Report to Congress: Final Report on Voluntary Industry Consensus Standards Development – December 2021* (Washington, D.C.: Dec. 20, 2022); *Report to Congress: Interim Report on Voluntary Industry Consensus Standards Development – January 2022* (Washington, D.C.: Jan. 14, 2022); *Report to Congress: FAA Evaluation of Commercial Human Space Flight Safety Frameworks and Key Industry Indicators*, (Washington, D.C.: Oct. 20, 2017); and U.S. Department of Transportation, *Report to Congress: U.S. Department of Transportation Evaluation of Commercial Human Space Flight Activities Most Appropriate for New Safety Framework* (Washington, D.C.: Feb. 26, 2019).

⁷The Aerospace Corporation, *Commercial Human Spaceflight Safety Regulatory Framework* (El Segundo, CA: Sept. 28, 2022); RAND Corporation, *Assessing the Readiness for Human Commercial Spaceflight Safety Regulations, Charting a Trajectory from Revolutionary to Routine Travel* (Santa Monica, CA: 2023).

actions it is taking to prepare for an expanded human spaceflight safety framework that may include regulations directed at protecting the health and safety of humans onboard, should the moratorium expire.

We conducted semi-structured interviews with all seven operators that, as of December 2022 (during our review), had conducted or planned to conduct commercial operations with humans onboard before 2026.⁸ We discussed how operators comply with FAA regulations, their perspectives on FAA's oversight of operators' compliance with regulations, and challenges they face in implementing and FAA faces with overseeing human spaceflight safety. The views of these commercial operators are representative of companies that during our review had conducted or planned to conduct commercial launch or reentry operations with humans onboard before 2026.

We conducted this performance audit from August 2022 through February 2024 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 that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

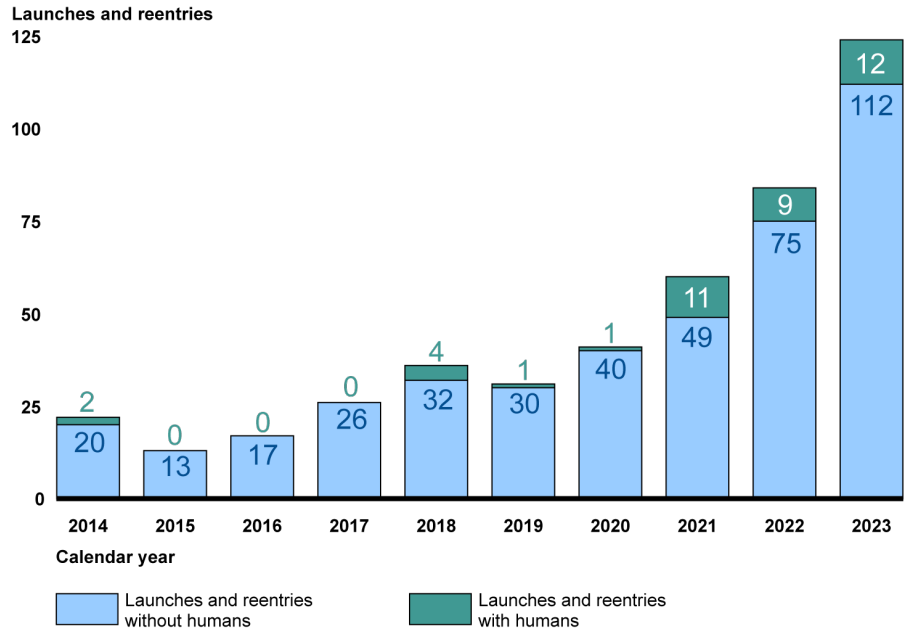
The Commercial Space Transportation Industry

Since 2014, the total number of commercial launch and reentry operations has trended upwards, including those with humans onboard (see fig. 1).⁹

⁸We interviewed Blue Origin, Boeing, Sierra Space, SpaceX, Space Perspective, Virgin Galactic, and World View. As of November 2023, one of these operators has delayed plans to conduct operations with humans onboard past 2026. However, we have included this perspective in our report because we believe this operator's experiences to date provide valuable information related to the topics we discuss.

⁹FAA defines a commercial launch or reentry operation as one in which the contract for the launch of its main payload (e.g., cargo or humans) was open to international competition or the launch was privately financed without government support. Any commercial launch or reentry operation in the U.S. is licensed by the FAA.

Figure 1: Total Number of U.S. Commercial Launch and Reentry Operations, 2014 – 2023



Source: GAO analysis of Federal Aviation Administration (FAA) information. | GAO-24-106184

Accessible Data for Figure 1: Total Number of U.S. Commercial Launch and Reentry Operations, 2014 – 2023

Calendar year	Launches and reentries without humans	Launches and reentries with humans
2014	20	2
2015	13	0
2016	17	0
2017	26	0
2018	32	4
2019	30	1
2020	40	1
2021	49	11
2022	75	9
2023	112	12

Source: GAO analysis of Federal Aviation Administration (FAA) information. | GAO-24-106184

Commercial operators are the entities that conduct launch and reentry operations—with and without humans. Operations vary in vehicle design and mission. For example, some operators use vehicles designed to carry

cargo or humans to and from orbit around Earth.¹⁰ Other operators use vehicles designed for suborbital operations, including vehicles that launch horizontally from a runway or vertically from a launch pad, as well as balloons that travel to the stratosphere.¹¹

Commercial operators provide services for commercial missions, such as carrying communications satellites to space that provide broadband internet. They also support government missions for national security purposes. Other missions include research and human space tourism.

FAA Roles and Responsibilities

FAA's Office of Commercial Space Transportation is responsible for regulating and overseeing the commercial space transportation industry. FAA does this primarily by licensing commercial launch and reentry operations. FAA regulations require a license or permit for all commercial launches taking place within the United States as well as for those conducted abroad by U.S. entities. The license application outlines how the operator plans to comply with FAA's regulations governing launch and reentry operations, which we refer to in this report as FAA's licensing regulations.¹² FAA also monitors commercial operators' compliance with applicable commercial space transportation laws and FAA's licensing regulations. It also oversees the terms of the operator's license, such as by conducting safety inspections of launch operations.

FAA's oversight of commercial launch and reentry operations is focused on protecting the safety of people and property that are not involved in supporting the operation, as opposed to the safety of humans onboard

¹⁰Orbital operations use vehicles that can accelerate a spacecraft to a speed that can enter and remain in orbit around Earth.

¹¹Suborbital operations reach space but are not intended for the vehicle to enter orbit.

¹²FAA currently has two sets of regulations related to launch and reentry requirements: (1) legacy regulations, generally applicable to licenses issued prior to March 2021; and (2) streamlined regulations implemented as part of extensive revisions to FAA's commercial space regulations in 2021. Under a 5-year transition period, all FAA-issued licenses for launch and reentry operations will be subject to the set of streamlined regulations no later than March 10, 2026. Streamlined Launch and Reentry License Requirements, 85 Fed. Reg. 79,566, 79,567 (Dec. 10, 2020).

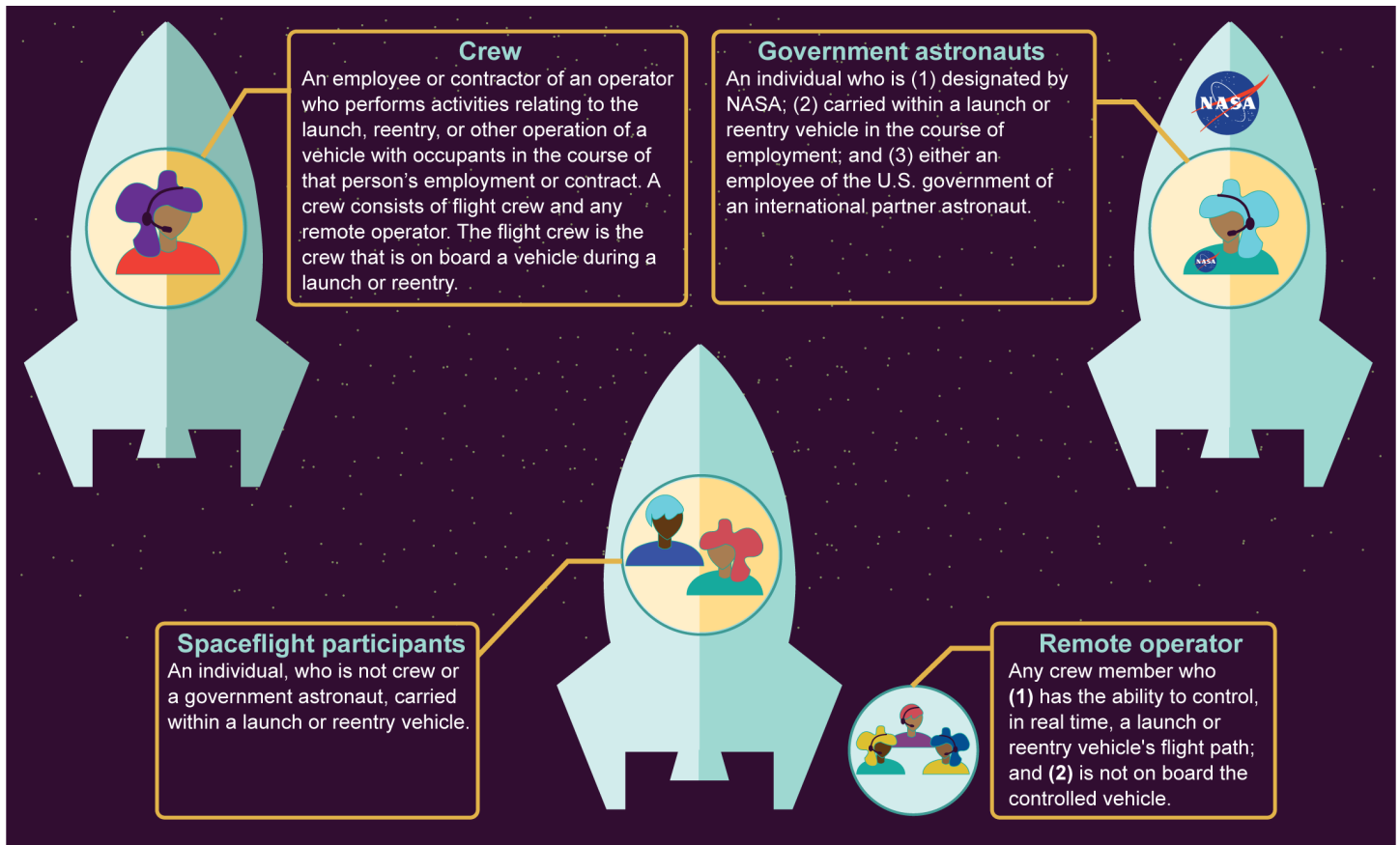
the launch or reentry vehicle.¹³ FAA's regulations are designed to ensure that people on the ground will not be harmed by a launch vehicle's operation or its failure. According to FAA, this includes (1) areas surrounding the launch site, such as structures, transportation vehicles, and recreational areas, and (2) people and property within the boundary of a launch site, such as visitors and individuals providing goods or services unrelated to the launch operation.

FAA's Office of Commercial Space Transportation carries out its public safety goals using a safety management system framework. According to FAA, this system is a top-down, organization-wide approach to managing safety risk and assuring the effectiveness of safety risk controls. It includes systematic procedures, practices, and policies for the management of safety risk. The purpose of FAA's safety management system is to obligate FAA offices, such as the Office of Commercial Space Transportation, to manage safety at the same priority level as other core business processes, such as conducting timely license application evaluations.

As noted above, under the moratorium that Congress first established in 2004, FAA is prohibited from issuing regulations directed at protecting the health and safety of humans onboard a launch or reentry vehicle, except in limited circumstances. The roles for humans involved in commercial operations, including crew, spaceflight participants, and government astronauts, may vary by the type of operation (see fig. 2).

¹³Congress mandates DOT to both: (1) encourage, facilitate, and promote commercial space launches and reentries by the private sector, including those involving spaceflight participants; and (2) encourage, facilitate, and promote the continuous improvement of the safety of launch vehicles, including those designed to carry humans. 51 U.S.C. § 50903.

Figure 2: Examples of Roles for Humans Involved in Commercial Launch and Reentry Operations



Source: GAO icons and analysis of Federal Aviation Administration (FAA) documentation. NASA logo; nasa.gov. | GAO-24-106184

Accessible Text for Figure 2: Examples of Roles for Humans Involved in Commercial Launch and Reentry Operations

Role	Role description
Crew	An employee or contractor of an operator who performs activities relating to the launch, reentry, or other operation of a vehicle with occupants in the course of that person's employment or contract. A crew consists of flight crew and any remote operator. The flight crew is the crew that is on board a vehicle during a launch or reentry.

Role	Role description
Government astronauts	An individual who is (1) designated by NASA; (2) carried within a launch or reentry vehicle in the course of employment; and (3) either an employee of the U.S. government or an international partner astronaut.
Spaceflight participants	An individual, who is not crew or a government astronaut, carried within a launch or reentry vehicle.
Remote operator	Any crew member who (1) has the ability to control, in real time, a launch or reentry vehicle's flight path; and (2) is not on board the controlled vehicle.




Source: GAO icons and analysis of Federal Aviation Administration (FAA) documentation. NASA logo; nasa.gov. | GAO-24-106184

In addition, FAA's authority over commercial space transportation activities does not extend to non-commercial operations, such as national security missions contracted by the Department of Defense. Its authority also does not extend to commercial space operations unrelated to launch or reentry, such as activities outside the spacecraft while in orbit around Earth. Yet, in some cases, government-contract operations are subject to FAA's licensing regulations, including operations with humans onboard. For example, under NASA's Commercial Crew Program, NASA contracts with commercial operators to carry government astronauts to and from the International Space Station for government missions. Through this program, FAA has partnered with NASA during these missions to oversee public safety through its commercial space licensing process. According to the program's management plan, FAA's role is focused on public safety, while NASA's contract requirements are focused on the success of the mission and astronaut safety.

FAA-Licensed Operators Conducting Operations with Humans Onboard

As of November 2023, three commercial operators have an active FAA license allowing operations with humans onboard their vehicles: Blue Origin, Virgin Galactic, and SpaceX (see fig. 3).

Figure 3: Commercial Operators with a Federal Aviation Administration (FAA) License to Conduct Launch and Reentry Operations with Humans, as of November 2023

Blue Origin	Virgin Galactic	SpaceX
Description of operations		
<p>Blue Origin's New Shepard suborbital vehicle flies humans above the internationally recognized boundary of space. The fully reusable rocket launches into space, where the booster detaches from a crew capsule that can carry up to six humans.</p>	<p>Virgin Galactic's VSS Unity suborbital vehicle is designed to carry humans to space by launching a winged spacecraft from a carrier vehicle. The spacecraft carries up to six humans.</p>	<p>SpaceX's Dragon capsule carries up to four humans into orbit for multiple day missions. The Dragon capsule is launched on top of a reusable Falcon 9 rocket.</p>
		
Mission specifications		
<p>Launch direction: Vertical Vehicle operation: Autonomous Type: Suborbital Mission type: Commercial Mission duration: 11 minutes Landing: Crew capsule descends to ground via a parachute system.</p>	<p>Launch direction: Horizontal Vehicle operation: Onboard crew operation Type: Suborbital Mission type: Commercial Mission duration: about 2 hours Landing: Glides to a runway</p>	<p>Launch direction: Vertical Vehicle operation: Automated vehicle operation with some onboard crew control Type: Orbital Mission type: Commercial and government Mission duration: 3 days to several months, depending on mission Landing: Crew capsule descends to water via a parachute system</p>

Source: GAO analysis of Blue Origin, Virgin Galactic, and SpaceX documents. | GAO-24-106184

Accessible Text for Figure 3: Commercial Operators with a Federal Aviation Administration (FAA) License to Conduct Launch and Reentry Operations with Humans, as of November 2023

Commercial operator	Description of operations	Mission specifications
Blue Origin	Blue Origin's New Shepard suborbital vehicle flies humans above the internationally recognized boundary of space. The fully reusable rocket launches into space, where the booster detaches from a crew capsule that can carry up to six humans.	<ul style="list-style-type: none"> • Launch direction: Vertical • Vehicle operation: Autonomous • Type: Suborbital • Mission type: Commercial • Mission duration: 11 minutes • Landing: Crew capsule descends to ground via a parachute system.
Virgin Galactic	Virgin Galactic's VSS Unity suborbital vehicle is designed to carry humans to space by launching a winged spacecraft from a carrier vehicle. The spacecraft carries up to six humans.	<ul style="list-style-type: none"> • Launch direction: Horizontal • Vehicle operation: Onboard crew operation • Type: Suborbital • Mission type: Commercial • Mission duration: about 2 hours • Landing: Glides to a runway
SpaceX	SpaceX's Dragon capsule carries up to four humans into orbit for multiple day missions. The Dragon capsule is launched on top of a reusable Falcon 9 rocket.	<ul style="list-style-type: none"> • Launch direction: Vertical • Vehicle operation: Automated vehicle operation with some onboard crew control • Type: Orbital • Mission type: Commercial and government • Mission duration: 3 days to several months, depending on mission • Landing: Crew capsule descends to water via a parachute system

Source: GAO analysis of Blue Origin, Virgin Galactic, and SpaceX documents. | GAO-24-106184

As of June 2023, FAA is consulting with nine commercial operators planning to conduct human spaceflight operations that have not yet applied for or been issued an FAA license authorizing operations with humans onboard.¹⁴

¹⁴We interviewed four of these nine operators—in addition to the three operators with an active FAA license allowing operations with humans onboard their vehicles—about their vehicle operations with humans onboard that, as of December 2022 (during our review), were planned to occur before 2026.

FAA Oversees Operations with Humans under Its Broader Licensing Framework

Under FAA’s licensing framework, operators must satisfy a range of requirements. These requirements include submitting documentation to FAA for review and approval to obtain a launch or reentry license for any commercial operation, regardless of whether humans are on board the vehicle. For operations with humans onboard, FAA regulations have some additional licensing requirements, commonly referred to as human spaceflight regulations. In line with FAA’s broader licensing framework, human spaceflight regulations focus on public safety. And though, with limited exceptions, the moratorium prohibits FAA from issuing regulations directed at protecting the health and safety of humans onboard a vehicle, commercial operators reported taking additional actions to protect the safety of humans onboard.

FAA’s Licensing Framework Includes Additional Requirements for Operations with Humans

Licensing Framework

Under FAA’s licensing framework, FAA requires a commercial operator to obtain a license before conducting any commercial launch or reentry operation—including those carrying satellites, research equipment, or humans—within U.S. borders.¹⁵ These requirements are described in FAA’s licensing regulations, Part 450 of Title 14 of the *Code of Federal Regulations* (14 C.F.R. Part 450)—Launch and Reentry Requirements.¹⁶ To obtain a license, operators must demonstrate that they can conduct the launch or reentry without jeopardizing the safety of people and property that are not involved in supporting the operation. Operators must also obtain authorizations for their payloads and provide information on the potential environmental effects of the operation, among other things. 14 C.F.R. Part 450 requires that operators submit documentation

¹⁵FAA also requires a license for operators conducting a launch or reentry operation outside of U.S. borders if the operator is a U.S. entity.

¹⁶14 C.F.R. Part 450 consists of streamlined regulations implemented in 2021. Under a 5-year transition period, all FAA-issued licenses for launch and reentry operations will be subject to the set of streamlined regulations no later than March 10, 2026. Streamlined Launch and Reentry License Requirements, 85 Fed. Reg. 79,566, 79,567 (Dec. 10, 2020).

demonstrating their ability to satisfy these requirements to FAA for review and approval as a prerequisite for obtaining a launch and reentry license.

As laid out in FAA's internal guidance, it is the operator's responsibility to submit the information and analyses required to comply with the regulations.¹⁷ FAA then examines the assumptions and methodologies used by the license applicant for their reasonableness, according to this guidance. FAA might conduct its own analyses to verify the reasonableness of any analyses submitted by the applicant.

14 C.F.R. Part 450—FAA's updated licensing regulations—contains four subparts, as shown in figure 4. Many of the requirements within these four subparts relate to FAA's various reviews, including that operators submit an analysis of the flight hazard area as part of FAA's safety review.

¹⁷Federal Aviation Administration, Office of Commercial Space Transportation. *SOP-002 Evaluations – License, Permit, and Safety Element Approval Evaluation and Issuance Procedures, Version 1.7* (Oct. 4, 2022).

Figure 4: Overview of FAA’s Updated Regulations for Launch and Reentry Licensing



Source: GAO icons and analysis of Federal Aviation Administration (FAA) regulations (14 CFR Part 450). | GAO-24-106184

Accessible Text for Figure 4: Overview of FAA’s Updated Regulations for Launch and Reentry Licensing

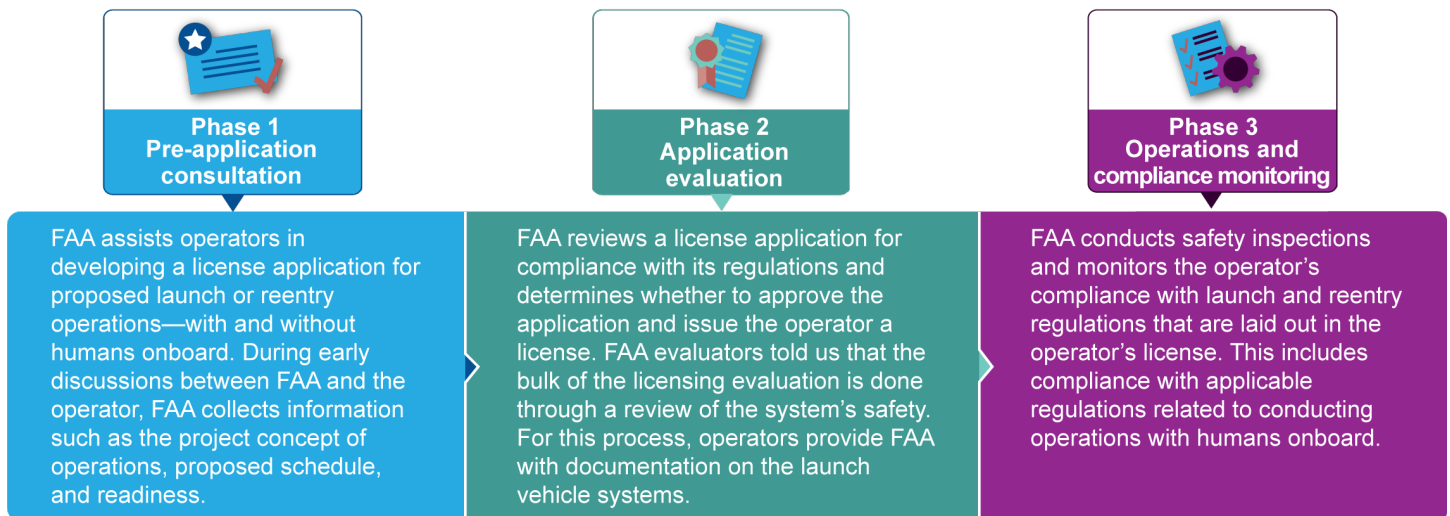
Regulation	Regulation description
General information	An operator must comply with licensing regulations prescribing requirements for obtaining and maintaining a license to launch, reenter, or both launch and reenter, a vehicle. Launch and reentry includes pre- and post-flight ground operations.

Regulation	Regulation description
Review requirements	An operator must obtain various reviews and approvals from FAA to obtain a license, including payload, policy, and safety reviews. A safety review involves FAA determining if the launch or reentry operation might jeopardize public health and safety and safety of property.
Safety requirements	As a part of the safety review, an operator must conduct several analyses to meet the licensing safety requirements, including a flight hazard area analysis. This analysis involves the operator identifying any region of land, sea, or air that must be surveyed, publicized, controlled, or evacuated in order to control the risk to the public.
Terms and conditions	An operator must conduct licensed activity in accordance with the terms and conditions of the license. When humans are onboard, one term and condition is an additional set of human spaceflight requirements.

Source: GAO icons and analysis of Federal Aviation Administration (FAA) regulations (14 CFR Part 450). | GAO-24-106184

According to FAA guidance, FAA’s process for licensing launch and reentry operations includes three general phases (see fig. 5). This process applies to operations with and without humans onboard.

Figure 5: The Three General Phases for Obtaining an FAA License for Launch and Reentry Operations



Source: GAO icons and analysis of Federal Aviation Administration (FAA) documentation. | GAO-24-106184

Accessible Text for Figure 5: The Three General Phases for Obtaining an FAA License for Launch and Reentry Operations

Phase number	Phase title	Phase description
One	Pre-application consultation	FAA assists operators in developing a license application for proposed launch or reentry operations—with and without humans onboard. During early discussions between FAA and the operator, FAA collects information such as the project concept of operations, proposed schedule, and readiness.
Two	Application evaluation	FAA reviews a license application for compliance with its regulations and determines whether to approve the application and issue the operator a license. FAA evaluators told us that the bulk of the licensing evaluation is done through a review of the system's safety. For this process, operators provide FAA with documentation on the launch vehicle systems.
Three	Operations and compliance monitoring	FM conducts safety inspections and monitors the operator's compliance with launch and reentry regulations that are laid out in the operator's license. This includes compliance with applicable regulations related to conducting operations with humans onboard.

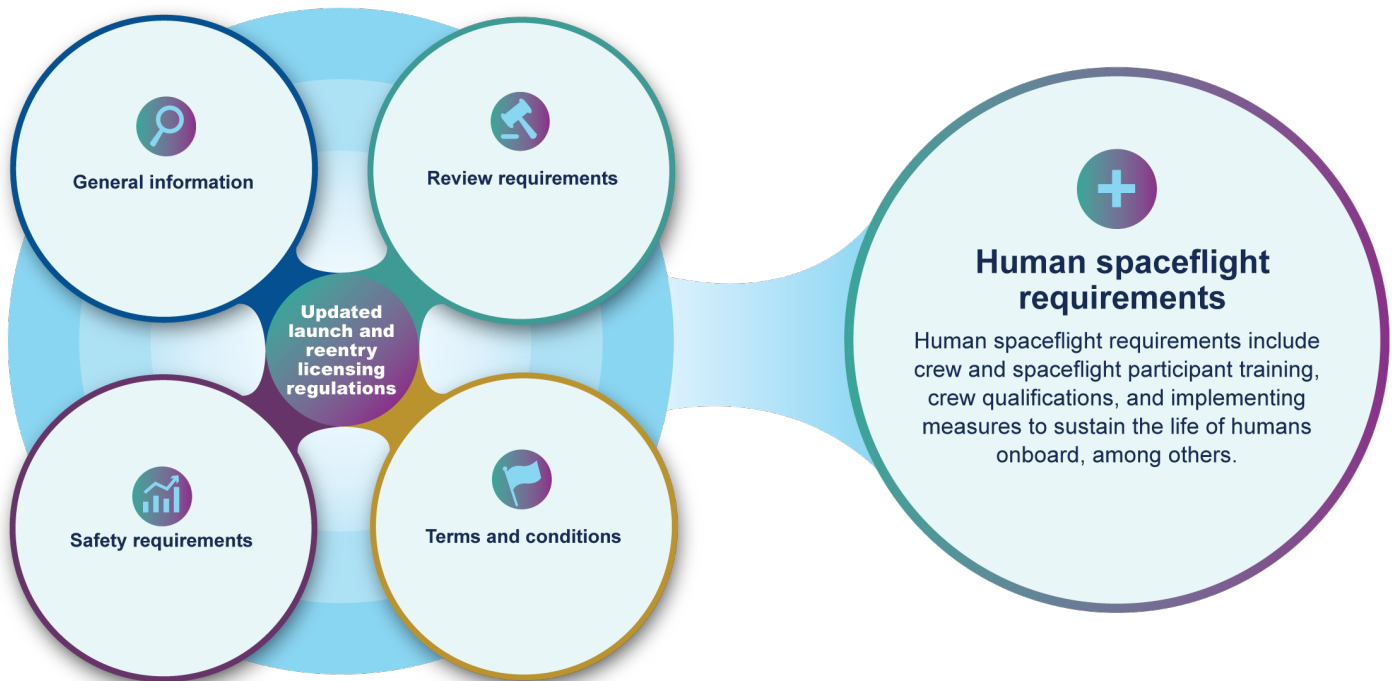
Source: GAO icons and analysis of Federal Aviation Administration (FAA) documentation. | GAO-24-106184

Additional Requirements for Human Spaceflight

FAA's licensing regulations include additional requirements for any commercial operator seeking to conduct operations with humans onboard. These requirements are found in 14 C.F.R. Part 460—Human Spaceflight Requirements. Additional requirements include crew training

and the ability to detect smoke and suppress cabin fire.¹⁸ FAA officials told us that they view the human spaceflight regulations as a “module” in FAA’s broader licensing regulations, as shown in figure 6.

Figure 6: FAA Has an Additional Set of Requirements for Launch and Reentry Operations with Humans



Source: GAO icons and analysis of Federal Aviation Administration (FAA) regulations. | GAO-24-106184

¹⁸Under the moratorium, except in limited circumstances, FAA is prohibited from issuing regulations directed at protecting the health and safety of humans onboard during commercial operations. However, the Commercial Space Launch Amendments Act of 2004 directed FAA to take some regulatory actions related to operations with humans onboard. Commercial Space Launch Amendments Act of 2004, Pub. L. No. 108-492, § 2, 118 Stat. 3974, 3978-79 (2004) (codified at 51 U.S.C. § 50905). FAA finalized a set of requirements in 2006. Human Space Flight Requirements for Crew and Space Flight Participants, 71 Fed. Reg. 75,616, 75,643-75,645 (Dec. 15, 2006) (codified at 14 C.F.R. pt. 460).

Accessible Text for Figure 6: FAA Has an Additional Set of Requirements for Launch and Reentry Operations with Humans

Requirement	Requirement description
Human spaceflight requirements	Human spaceflight requirements include crew and spaceflight participant training, crew qualifications, and implementing measures to sustain the life of humans onboard, among others.

Source: GAO icons and analysis of Federal Aviation Administration (FAA) regulations. | GAO-24-106184

Consistent with FAA’s licensing regulations, the human spaceflight regulations also are generally designed to protect the safety of people and property that are not involved in supporting the launch. In other words, the human spaceflight regulations mainly seek to address any additional risks to the safety of the uninvolved public that may be introduced due to the presence of humans onboard. These requirements include:

- **Crew qualifications and training.** Crew members must be qualified and trained so that the operation of the vehicle will not harm the public. These crew must train in normal operations and emergency and abort situations. In addition, crew members must meet relevant FAA certifications, depending on their role. For example, each crew member with a safety-critical role must possess and carry an FAA second-class airman medical certificate.¹⁹ All crew members must also demonstrate an ability to withstand the stresses of spaceflight (e.g., high acceleration) so that they can carry out their safety-critical duties so that the “vehicle will not harm the public.”
- **Smoke detection, fire suppression, and environmental controls.** An operator or crew must have the ability to detect smoke and suppress a cabin fire on the launch or reentry vehicle to prevent incapacitation of the flight crew. The operator or crew must monitor and control atmospheric conditions of the vehicle (e.g., oxygen levels)

¹⁹Safety-critical role means essential to safe performance or operation and ensuring public safety. 14 C.F.R. § 401.7.

to sustain life and consciousness of humans onboard or provide an alternative approach that provides an equal level of safety.²⁰

- **Verification program.** An operator must successfully verify the integrated performance of a vehicle's hardware and any software in an operational flight environment before allowing any human onboard during a flight.²¹ This verification must include flight testing. According to FAA officials, if an operator makes any modification to the vehicle's system, it must submit additional analyses to FAA demonstrating that the modification will not affect public safety.
- **Human factors.** An operator must take the precautions necessary to account for human factors that could affect the ability of the crew to perform safety-critical roles.²² For example, an operator must take precautions in the design and layout of controls, human interaction with equipment, restraint and stowage of humans and objects in the vehicle, and vehicle operations.

In addition, although FAA regulations are not designed to protect the safety of humans onboard, the human spaceflight regulations do require operators to inform spaceflight participants of the risks and hazards involved. This requirement is known as "informed consent" and is

²⁰The operator or crew must monitor and control the following atmospheric conditions: oxygen and carbon dioxide; pressure, temperature, and humidity; contaminants that include harmful concentrations of gases or vapor; and ventilation and circulation. 14 C.F.R. § 460.11 (a). However, an operator may bypass monitoring and controlling these conditions demonstrating "...through the licensing or permitting process that an alternate means provides an equivalent level of safety." The operator must provide secondary oxygen supply for the crew; prevent cabin depressurization; and prevent incapacitation of any crew in the event of loss of cabin pressure. 14 C.F.R. § 460.11(b)(c).

²¹Verification means an evaluation to determine that safety measures derived from a system safety process are effective and have been properly implemented. Verification provides measurable evidence that a safety measure reduces risk to acceptable levels. 14 C.F.R. § 401.7.

²²Human factors is the scientific discipline concerned with understanding interactions between humans and other elements of a system. Human factors involves applying theory, principles, data, and other methods to a design to optimize human well-being and overall system performance, according to FAA. Federal Aviation Administration, Office of Commercial Space Transportation, *Recommended Practices for Human Space Flight Occupant Safety, Version 2.0* (Sept. 2023).

required by law.²³ Operators must inform spaceflight participants, in writing and plain language, of the following:

- The safety record of all the launch and reentry vehicles that have carried humans onboard.
- The safety record of the operator's vehicle type.
- That spaceflight participation may result in death, serious injury, or total or partial loss of physical or mental functions.
- The known hazards and risks that could result in a serious injury, death, disability, or total or partial loss of physical and mental function.
- That there are unknown hazards.
- The number of individuals who have been in orbital or suborbital flight and the number that have died or have been seriously injured.
- The number of launch and reentry operations conducted with humans onboard and the number of catastrophic failures of those operations.
- That the U.S. government has not certified the launch or reentry vehicle as safe for carrying humans.²⁴

After the operator informs participants of risks, the regulations require that the operator provides an opportunity for participants to ask questions to better understand the hazards and risks of the operation. The participant must provide written consent before participating in the launch or reentry.²⁵

²³The Commercial Space Launch Amendments Act of 2004 required that FAA include specific requirements related to informed consent as conditions of a vehicle operator license. Commercial Space Launch Amendments Act of 2004, Pub. L. No. 108-492, § 2(c)(6), 118 Stat. 3974, 3977-78 (2004) (codified as amended at 51 U.S.C. § 50905).

²⁴14 C.F.R. § 460.45. The operator must also inform the crew that the U.S. government has not certified the launch and reentry vehicle as safe for carrying humans. 14 C.F.R. § 460.9.

²⁵14 C.F.R. § 460.45. In addition, under these regulations, FAA and the participant must enter into an agreement in which both parties waive most legal claims one party might have against the other resulting from the flight operations, regardless of fault. 14 C.F.R. § 460.49; 14 C.F.R. pt. 440, app. D; 14 C.F.R. pt. 440, app. E. FAA and each crew member must enter into the same type of agreement. 14 C.F.R. § 460.19. Commercial operators are also required by regulation to demonstrate financial responsibility, such as by obtaining liability insurance that protects the licensee against third-party claims of bodily injury or property damages resulting from a licensed activity. 14 C.F.R. § 440.9.

Application of Human Spaceflight Regulations

FAA officials told us that FAA's human spaceflight regulations are written to accommodate variation in vehicle design and operations. This provides the operator flexibility in determining what it should submit to FAA to demonstrate compliance with the regulations, according to commercial operators and FAA officials. For example, FAA's verification program requirement states that operators must verify the integrated performance of the hardware and software. However, it does not specify how the operator should verify the integrated performance, apart from requiring flight testing.

Given the flexibility in the regulations, the license application evaluation phase can result in extra time and effort to determine how an operator can comply with the human spaceflight regulations. One operator said they had multiple back-and-forth conversations with FAA during the license evaluation process to satisfy a means of compliance for each requirement within the regulations. In addition, FAA officials said that they sometimes need more time to deliberate internally to clarify how FAA should evaluate operators' method of compliance with the regulations. As FAA gains more experience applying its human spaceflight regulations, officials told us that they might update their internal procedures and documents for overseeing licensing and inspections with examples of how operators have demonstrated compliance.

Our review of FAA documentation and discussions with operators found that how FAA determines operators' compliance or how operators comply with the human spaceflight regulations reflects the flexibility built into the regulations. For example:

- FAA determined that some of the requirements were not applicable to operations using Blue Origin's New Shepard vehicle. For example, because the vehicle is mostly autonomous, it requires no interaction from crew or participants for any system that affects the vehicle's flight path. As a result, FAA determined that the related crew qualification and training requirements of the regulations were not applicable, and FAA approved a license for New Shepard.
- FAA determined that SpaceX complied with all the requirements of the human spaceflight regulations by primarily reviewing information SpaceX had previously submitted to NASA. Specifically, FAA approved SpaceX's license for its first operation with humans onboard in 2020 in collaboration with NASA through the Commercial Crew Program. Under this program, SpaceX generally cited NASA safety

standards as the means of compliance for FAA's human spaceflight regulations. FAA officials told us that NASA's safety standards generally met or exceeded the level of safety required by FAA's human spaceflight regulations. For subsequent commercial operations with humans onboard, SpaceX generally adopted NASA standards when demonstrating compliance with FAA requirements, according to SpaceX representatives and FAA officials.²⁶

Operators can modify an existing launch and reentry license to allow operations with humans, rather than apply for a wholly new license. Four of the seven operators we spoke to said they have modified, or plan to modify, their existing license. These four operators stated that they made, or planned to make, these modifications after they conducted tests and operations without humans under an existing license. For example, FAA granted Virgin Galactic a license for launch and reentry operations in 2016, which FAA then modified in 2021 to allow spaceflight participants onboard.

FAA officials said that the type and level of work involved in evaluating operators' applications for license modification for human spaceflight also varies. For example, FAA officials told us they looked at changes to one vehicle system to allow humans onboard, which involved re-evaluating and verifying the safety of the integration of the vehicle's hardware and software systems. Yet, at other times, FAA officials said that evaluating an application for a license modification could involve the same level of work required for evaluating a wholly new license.

Despite the variation in how an operator may demonstrate compliance during license evaluation, FAA officials told us that its oversight during the post-licensing, compliance monitoring phase, is generally similar. That is, FAA's oversight is designed to ensure that the operator is following the conditions laid out in its license. FAA officials said that, from a technical perspective, they do not necessarily consider operations with humans as a higher public safety risk.

FAA officials told us that inspectors may conduct oversight by reviewing documentation from the operator or observing the operator's activities. For example, these officials said that, when possible, FAA inspectors observe the operator's testing and trainings in person, regardless of

²⁶FAA officials told us that NASA's safety standards focus on the success of the mission, including the safety of the occupants on board, and generally are considered as meeting or exceeding the level of safety required by FAA's human spaceflight regulations, which are focused on public safety.

whether it is for an operation with humans onboard. To conduct oversight for the informed consent requirements, FAA inspectors told us they either (1) observe the operator discussing informed consent with spaceflight participants or (2) review the operator's plan and documentation for such discussions.

Operators Reported Taking Actions to Protect the Safety of Humans Onboard outside of FAA Regulations

With the moratorium in place, FAA generally cannot issue regulations directed at protecting the safety of humans onboard. However, all seven commercial operators we spoke with described actions they take, or plan to take, to protect the health and safety of humans onboard. Some explained that taking action to protect the safety of humans onboard is the company's ethical duty, and it is also good business practice. One of these operators told us that if an operation resulted in fatalities, it could have negative effects on the entire space tourism industry. Some actions the operators we spoke with reported taking or planning to take to protect the safety of humans onboard include:

- **Additional crew and participant training.** Six of the seven operators said they provide or plan to provide crew and participants with additional training and certification beyond the training FAA requires. One operator reported providing training in additional topics, such as gravitational forces humans can expect to experience during space travel. Another operator reported using NASA training to help ensure that crew and participants are prepared for the flight.
- **Vehicle design.** Four of the seven operators said that they designed or plan to design vehicles with features beyond those explicitly required by regulation, to protect the safety of humans onboard. For example, one operator designed a vehicle with redundant separation systems and parafoils which are used to return the humans onboard back to the ground safely.²⁷ This redundancy provides a backup in case the primary system or parafoil fails. These secondary systems are not required under the current FAA regulations. Another operator we spoke with discussed designing a spacecraft and launch vehicle that allows humans with average fitness levels to participate without experiencing adverse side effects. For example, the spacecraft is

²⁷A parafoils is a self-inflating fabric device that resembles a parachute, behaves in flight like an airplane wing, is maneuverable, can land a payload at slow speed, and can be launched from the ground like a kite in a high wind.

designed so that participants will not be affected by extreme gravitational forces, which could damage a participant's health.

- **Safety certification model.** Two of the seven operators told us that they have voluntarily adopted a model for certifying vehicle safety. This means that when any design modifications are made to the vehicle, including those made to accommodate humans, the operator voluntarily checks the safety performance of the entire vehicle. FAA's regulations include a "continuing accuracy requirement" that requires an operator to apply for a license modification if, for instance, the operator makes a design change affecting a vehicle's safety-critical system. The regulations also include a requirement that operators must implement and document a system safety program throughout the life cycle of a launch or reentry system that has clearly defined lines of communication and approval authority. However, the key consideration consistently repeated in these regulations is public safety, not safety considerations for humans onboard.
- **Human behavior inflight.** Three of the seven operators reported taking additional safety steps beyond FAA regulations by observing human behavior during operations. For example, one operator said they have implemented a cabin safety program to observe and monitor humans in the cabin via cameras during operations. In addition, the operator introduces unknown hazards or emergency situations during simulation training beyond those required in regulation to observe how the humans onboard and in the mission control center room respond to unknowns. For example, this operator stated that by observing how humans move inside the cabin during flight, they might be able to observe sharp edges of the vehicle that clothing could catch, a potential hazard. FAA regulations do not tell operators to observe human behavior during flights, but this operator said that these observations are valuable for protecting the safety of future spaceflight participants.

Further, industry stakeholders told us that some aspects of the existing regulations directed at ensuring the crew is able to control the vehicle, indirectly provide safety for humans onboard. For example, requirements to maintain adequate oxygen levels and proper cabin pressure also benefit the health and safety of spaceflight participants onboard and the crew itself. In addition, FAA has developed a set of recommended practices on human spaceflight safety to help support improvements in the safety of launch and reentry operations with humans onboard, as discussed further below.

FAA's Preparation for Expanded Human Spaceflight Oversight Includes Collaboration with Industry and Building Workforce Capacity

FAA Is Focused on Three Efforts in Collaboration with Industry

In light of the potential end to the moratorium, FAA announced in September 2022 that it would prioritize three existing efforts to help prepare for an expanded human spaceflight safety framework: (1) chartering an aerospace rulemaking committee, (2) updating its *Recommended Practices for Human Space Flight Occupant Safety* guidance, and (3) participating in the development of voluntary industry consensus standards.²⁸

These efforts have been ongoing for years, with two of them—updating industry guidance and developing industry standards—since 2014. FAA officials told us that regulatory uncertainty, changes in the industry, and FAA resource constraints have played a role in the slower than expected progress of these efforts.

Chartering an aerospace rulemaking committee. FAA finalized the charter for an aerospace rulemaking committee in April 2023 to solicit industry's input on a future regulatory framework aimed at protecting the safety of humans onboard launch and reentry operations.²⁹ The committee is co-chaired by an FAA official and an industry representative. According to the charter, the rulemaking committee is tasked to, within 1 year of the first meeting, submit a consensus report to FAA that includes:

- comments on the scope of future regulations directed at protecting the safety of humans onboard during commercial operations,

²⁸To help identify what efforts to prioritize, FAA established an internal working group in September 2021 to brainstorm human spaceflight issues and identify which of these issues it should prioritize and address, according to the group's charter.

²⁹Aerospace rulemaking committees provide FAA with information, advice, and recommendations on potential rulemakings. They are formed on an ad hoc basis, for a specific purpose, and are typically of limited duration. Members of this committee include commercial operators, training providers, medical research groups, and safety experts. According to the committee's charter, FAA representatives may participate as observers and provide technical support.

- recommendations on how to create a safety regime that includes protecting the safety of humans onboard, and
- estimates of the cost to the industry, related to safety regulations directed at protecting the safety of humans onboard.

The recommendations from this committee will serve to inform potential future regulations directed at protecting the safety of humans onboard, according to FAA officials. For example, FAA requested that the committee identify and make recommendations on approaches to creating a safety regime that goes beyond the current informed consent regime. FAA also requested that the committee analyze the costs to the industry of any proposed regulations, noting that the benefits should justify any costs. FAA will determine if, and when, the committee's final report is made publicly available, according to the committee's charter.

The full committee meets about once per month, according to FAA officials. It has established three working groups focused on specific topics: safety, medical, and regulatory models. Each working group has met about once every two weeks since their establishment in September 2023. FAA officials told us that at least one working group will continue to meet almost weekly until a final report is submitted to FAA, which, according to the charter, is expected in summer 2024.

Updating guidance for industry on the safety of humans onboard. FAA issued an update to its 2014 guidance—*Recommended Practices for Human Space Flight Occupant Safety, Version 2.0*—on September 29, 2023. This was the first update FAA had issued in 9 years. FAA officials told us that as part of its responsibility to promote safety, FAA provides guidance to operators on recommended practices for protecting the safety of humans onboard, including how to accommodate human needs, medical considerations, and training.

FAA developed the 2014 version in collaboration with its commercial space transportation advisory committee and NASA to potentially serve as a starting point for future rulemaking.³⁰ At the time of the 2014 document's publication, the moratorium that prohibits FAA from issuing regulations directed at the safety of humans onboard was set to expire in 2015.

³⁰The purpose of the 2014 guidance was also to provide a compilation of practices to support safety of humans onboard during commercial operations and help identify subject areas that could benefit from industry consensus standards.

The updated 2023 guidance reflects the work and feedback from stakeholders inside and outside of FAA, including extensive involvement from NASA, according to FAA officials. FAA formed three working groups, covering topics related to design, manufacturing, and operations, to ensure practices covered the life cycle of the vehicle system. The groups consisted of members from FAA's Office of Commercial Space Transportation, as well as NASA officials from the Commercial Crew Program office. FAA also solicited input from industry stakeholders through its commercial space transportation advisory committee, as well as feedback on medical portions of the updated guidance from flight surgeons in its Civil Aerospace Medical Institute.

FAA officials told us that they prioritized developing the 2023 update to help inform the deliberations of the rulemaking committee. The update addresses gaps in the original guidance document, and includes lessons learned from commercial operators' human spaceflight experiences. It also includes examples of how operators may comply with potential future regulations related to the safety of humans onboard. For example, the update has a section on flightworthiness, which identifies the minimum system capabilities necessary to maintain safety for humans onboard.

Progress in updating the guidance was slow due to the extended regulatory moratorium and limited resource capacity within FAA, among other things, according to FAA officials. For example, FAA officials told us that uncertainty of when the moratorium will end has made it difficult for FAA to support efforts focused on safety for humans onboard because FAA prioritizes activities for which it has current authority. Further, officials told us that FAA staff assigned to the working groups were also responsible for keeping up with their primary responsibilities for evaluating applications for licenses and overseeing operations conducted under those licenses.

Participating in the development of industry consensus standards.

In 2015, Congress directed FAA to facilitate the development of industry consensus standards to improve the safety of crew, government astronauts, and spaceflight participants and periodically report to Congress on the status of these efforts.³¹ These standards could be adopted by commercial operators and potentially serve as an acceptable

³¹Congress directed FAA to report not later than December 31, 2016, and every 30 months thereafter until December 31, 2021. U.S. Commercial Space Launch Competitiveness Act, Pub. L. No. 114-90, § 111, 129 Stat. 704, 709-710 (2015) (codified at 51 U.S.C. § 50905(c)(5)).

means of compliance for any future FAA regulatory framework, according to FAA officials and industry stakeholders. In 2016, ASTM International, an international standards development organization, formed a committee, with participation from FAA, to lead and coordinate the development and maintenance of voluntary consensus standards and recommended practices for the commercial spaceflight industry, including standards for human spaceflight safety.

Progress on developing standards specific to the safety of humans onboard has been slow. In 2017, FAA reported that ASTM had not yet published new standards specific to human spaceflight safety. In its December 2022 report to Congress, FAA reported that ASTM, as well as other standards development organizations, had made moderate progress by publishing 35 standards that can apply to, although are not necessarily specific to, human spaceflight safety between 2019 and 2021.³² FAA officials told us that they do not know the number or type of voluntary standards in use by commercial operators because FAA does not collect that type of information. However, FAA stated in its December 2022 report that its commercial space transportation advisory committee determined that published standards are in minimal use.

Prior to October 2023, ASTM's committee leading this effort had published a standard on failure tolerance for suborbital vehicles with humans onboard. This was the only new standard specific to protecting the safety of humans onboard published by this committee, according to the standards development organization. In October and November 2023, ASTM published three more standards related to the safety of humans onboard launch and reentry vehicles.³³

FAA officials and operators said the committee's slow progress in developing standards was a result of FAA's limited involvement, among other things. FAA has reported that it participates in ASTM subcommittees and working groups, such as subject matter experts providing input and expertise to the development of standards. Yet, representatives from three operators told us that FAA's presence at the meetings and input to the draft standards was minimal. One operator said

³²This report was due to Congress by December 31, 2021. FAA submitted it on December 20, 2022.

³³These three new standards relate to medical qualifications for suborbital vehicle passengers, crewed suborbital vehicle design, and survivability in humans onboard orbital vehicles.

they believe that FAA's limited presence was due to its constrained resources and limited experience with human spaceflight issues. FAA officials acknowledged those resource constraints and told us in June 2023 that they plan to increase their involvement in standards development efforts. FAA officials told us that they have assigned a newly hired staff member to liaise with the standards committee and attend all the meetings of the working committees.

In addition to these three efforts—chartering a rulemaking committee, updating industry guidance, and developing industry standards—FAA supports research in the area of human spaceflight safety. FAA officials told us this research will help inform FAA's potential future oversight. Between fiscal years 2010 and 2021, FAA funded basic research on a variety of emerging issues, through its Center of Excellence for Commercial Space Transportation, according to the Center's final, August 2022, report.³⁴ Also according to the final report, about \$2.1 million (of about \$14.2 million total funding) was allocated during this 12-year period to human spaceflight safety issues. This research covered such subjects as supporting the development of medical kits for various suborbital and orbital flight scenarios, as well as developing procedures to collect and analyze biomedical data from crew and spaceflight participants to determine unique medical risks.

With the Center of Excellence for Commercial Space Transportation no longer active, FAA has focused on applied, rather than basic, research on commercial spaceflight transportation issues.³⁵ This research, according to FAA officials, includes some human spaceflight-related research, such as spaceflight participant training and simulations to help determine mental fitness for spaceflight. FAA officials said that the focus on applied research could provide immediate support for rulemaking for human spaceflight, at such time as the statutory moratorium expires.

³⁴FAA's funding for this Center of Excellence ceased in August 2022. Since the inception of FAA's Centers of Excellence program in 1993, FAA has designated 13 centers focused on various aviation topics, such as commercial space transportation, alternative jet fuels and environment, and airport technology. According to FAA, the program enables collaboration between government, academia, and industry to advance aviation technologies and expand FAA research.

³⁵Basic research is work undertaken primarily to acquire new knowledge and excludes research directed towards a specific application or requirement. Applied research is undertaken to acquire new knowledge but is directed primarily towards a specific practical aim or objective.

In addition, FAA plans to stand up a new research program for commercial space transportation with topics that could include human spaceflight. The program will bring together an alliance of government agencies, academia, and industry to attract and leverage research money for commercial space transportation. FAA officials said that they do not yet know what proportion of any future funding would be allocated to human spaceflight safety research. FAA officials said that the plan to stand up this program had been on hold due to workforce constraints. In February 2024, FAA officials told us, however, that they had recently hired two staff whose responsibilities will include supporting the applied research program. FAA officials told us they intend for one of these staff to begin developing the program's acquisition and funding strategy using existing funds appropriated for FAA Research, Engineering, and Development.

FAA Has Taken Steps to Build Its Workforce Capacity while Facing Ongoing Constraints

In light of (1) the increasing number of commercial space operations with humans onboard and (2) FAA's potential expanded role in human spaceflight safety and the efforts it has underway to prepare for this potential expansion, FAA has taken steps to build the capacity of its workforce. According to agency officials, FAA is leveraging the expertise of current staff and recruiting new staff to support both current and future human spaceflight safety efforts.

Leveraging Experience of Current Staff

Officials from FAA's Office of Commercial Space Transportation (AST) told us that staff whose current responsibilities include overseeing human spaceflight safety use their relevant expertise gained from prior employment, as well as ongoing experiences with AST. Officials told us that about 20 percent of the total staff that conduct licensing evaluation and oversight for all launch and reentry operations had responsibilities that include oversight of some operations with humans onboard (16 of about 80 staff), as of September 2023. Of those 16 staff, 11 of them work on licensing evaluations and eight have expertise related to human spaceflight safety from past employment at NASA or other relevant entities. The remaining five staff are post-licensing inspectors without past human spaceflight safety work experience. According to officials, however, any of these staff may have gained knowledge in human spaceflight safety through FAA's partnership with NASA on the

Commercial Crew Program, by working with FAA's Civil Aerospace Medical Institute, or through inspector and on-the-job training. AST officials said that they believe any current expertise staff have related to human spaceflight safety could also be applied to AST's responsibilities in any potential future regulations directed at protecting the safety of humans onboard.

Recruiting New Staff

AST officials also told us that they need more people with expertise in areas across human spaceflight safety, such as crew training, environmental controls, and life support systems. In June 2023, AST officials told us they had begun actively recruiting for 10 new positions. Staff in these positions will have responsibilities that include overseeing compliance with FAA's current human spaceflight regulations, as well as preparing for a potential expansion of regulatory duties related to human spaceflight safety, according to AST officials. Specifically, the office is seeking mid-level staff that already have experience in leading a safety program, overseeing research and development, or developing processes, guidance, or training materials for human spaceflight safety. The positions will be split as follows:

- six positions in the Office of Operational Safety, which conducts licensing evaluation and oversight, and
- four positions in the Office of Strategic Management, which supports research and development and policy and rulemaking efforts, including the development of a regulatory framework.

In February 2024, AST officials said they had hired five staff for the 10 positions for which they had been actively recruiting. Staff for one additional position was in the hiring pipeline. These officials also said that they are devising a new strategy for their recruitment effort for the remaining four positions because they had not received an adequate candidate pool for these positions in this specialized field.

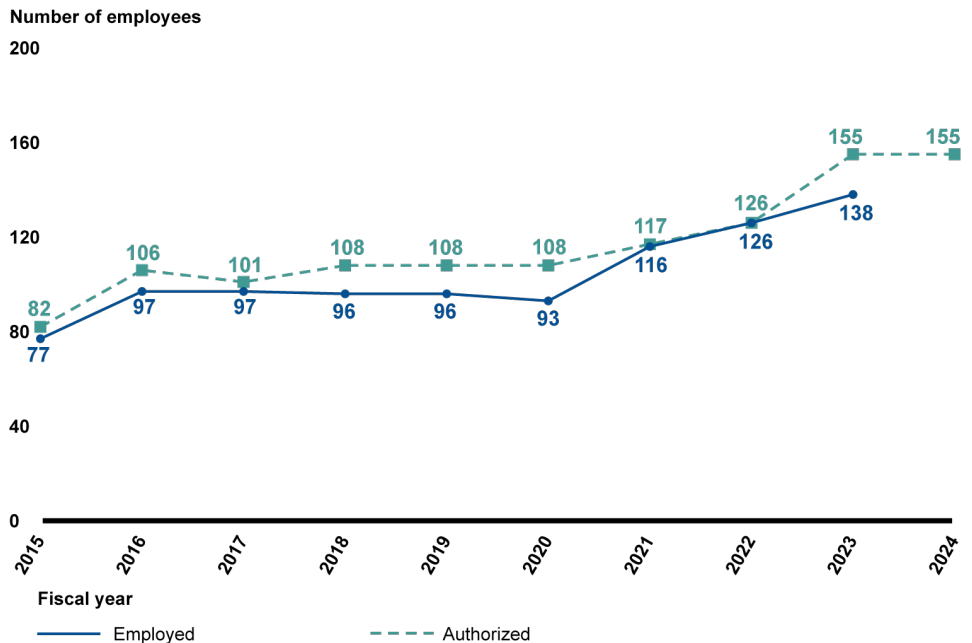
AST officials also said that without knowing what will be included in any possible future regulations or when the moratorium will end, it is difficult to determine all of the specific areas of expertise needed in the future or when that expertise will be needed. AST told us that they cannot hire staff with responsibilities for which AST does not have legal authority, including regulating the safety of humans onboard launch and reentry operations. In the meantime, AST officials said, AST's strong relationship with NASA

has provided opportunities to leverage expertise in this area and that this relationship should continue.

Facing Ongoing Constraints

AST’s efforts to build capacity in the area of human spaceflight safety are taking place alongside ongoing hiring challenges and workforce constraints across the office. According to AST data, in 8 of the last 9 years, the number of AST staff employed has been fewer than the positions authorized, as shown in figure 7. AST told us that one challenge to filling positions is that AST competes with private industry for a finite pool of experienced people, citing two inspectors who recently left AST for private companies.

Figure 7: Office of Commercial Space Transportation Employees Authorized and Employed, Fiscal Years 2015 – 2024



Source: Federal Aviation Administration (FAA) documentation. | GAO-24-106184

Accessible Data for Figure 7: Office of Commercial Space Transportation Employees Authorized and Employed, Fiscal Years 2015 – 2024

Calendar year	Employed	Authorized
2015	77	82

Calendar year	Employed	Authorized
2016	97	106
2017	97	101
2018	96	108
2019	96	108
2020	93	108
2021	116	117
2022	126	126
2023	138	155
2024		155

Source: Federal Aviation Administration (FAA) documentation. | GAO-24-106184

To help address this challenge across all its positions, AST officials said they are leveraging hiring mechanisms available to them, including targeted recruitment and incentives for relocation. These workforce issues are not unique to AST. We have previously reported that other FAA offices have fallen short of their staffing targets. For example, the Office of Aviation Safety has had difficulty hiring enough inspectors and engineers, in part because FAA is competing with industry for these employees.³⁶

GAO Recommendations to Improve the Workforce Planning Efforts of the Office of Commercial Space Transportation (AST) within the Federal Aviation Administration

In 2019, we reported that some of AST’s efforts to determine its current and future workforce needs fell short of key principles on strategic workforce planning. These principles underscore the importance of determining workforce needs and identifying potential gaps in employee skills.

To improve AST’s ability to successfully carry out its mission, we made four recommendations to help the office ensure its workforce has the kinds of skills it will need to oversee the industry and better track and project its workload. AST agreed with our recommendations and has implemented two of them, including collecting information on its workforce’s skills and developing strategies to address skill gaps.

As of November 2023, AST had not implemented our recommendations to develop a plan to periodically conduct skill gap assessments or develop workload metrics that would allow the office to determine an appropriate workforce size and composition. Implementing these recommendations would help AST more strategically manage its workforce as the commercial space industry rapidly evolves and grows.

Source: GAO, Commercial Space Transportation: Improvements to FAA’s Workforce Planning Needed to Prepare for the Industry’s Anticipated Growth, [GAO-19-437](#) (Washington, D.C.: May 23, 2019), and FAA. | GAO 24-106184

While AST is in the process of recruiting and hiring more staff, bringing new hires onboard presents its own challenges. AST officials said that training new staff taxes current staff resources, such as when

³⁶See, for example, GAO, *Aviation Safety: FAA’s Office of Aviation Safety Should Take Additional Actions to Ensure Its Workforce Has Needed Skills*, [GAO-21-94](#), (Washington, D.C.: Nov. 9, 2020).

credentialed inspectors are providing on-the-job training to newly hired inspectors. Officials told us that it can take up to 2 years to train new staff in evaluating license applications for operations with humans. This will continue with at least two of the new human spaceflight positions being filled with staff with no human spaceflight experience who will be shadowing experienced staff to gain skills.

Further, these ongoing staffing challenges have affected how AST carries out some of its licensing and post-licensing oversight responsibilities, including for operations with humans onboard. For example, as a result of limited staff, AST officials told us that the office has decreased the amount of assistance provided to operator consultations prior to license evaluation. AST officials also told us that the office prioritizes the highest risk operations for in-person inspections and conducts other inspections remotely or through reviewing post-activity reports from operators.

Moreover, AST leadership stated publicly to FAA's commercial space transportation advisory committee that if AST's workforce is unable to keep up with the industry's growth, the agency may begin "queuing" license applications. That is, AST will evaluate license applications as they have staff available to do so instead of when they are received. This could affect the economic health and growth of the industry if operators experience delays in obtaining licenses and subsequently conducting operations. And, as operators are delayed in testing and conducting operations without humans onboard, the human spaceflight industry would likewise be affected.

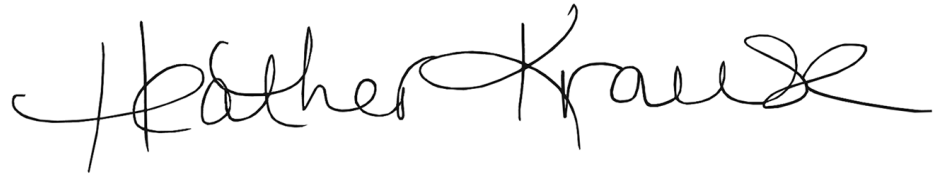
Agency Comments

We provided a draft of this product to DOT for review and comment. DOT provided technical comments, which we incorporated as appropriate.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Transportation, and other interested parties. In addition, the report is available at no charge on the GAO website at <http://www.gao.gov>.

If you or your staff have any questions about this report, please contact Heather Krause at (202) 512-2834 or krauseh@gao.gov. 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 I.

Letter

A handwritten signature in black ink that reads "Heather Krause". The signature is written in a cursive style with a large, stylized 'H' and 'K'.

Heather Krause
Director, Physical Infrastructure

Appendix I: GAO Contact and Staff Acknowledgments

GAO Contact

Heather Krause, 202-512-2834 or krauseh@gao.gov

Staff Acknowledgments

In addition to the individual named above, Heather Halliwell (Assistant Director); Gretchen Snoey (Analyst-in-Charge); Christophe Beaumier; Laura Bonomini; Melanie R. Diemel; Alicia Loucks; Chi L. Mai; Jordan Miller; Meghan Nazareno; Kelly Rubin; and Sandra Sokol made key contributions to this report.

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