U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of the Administrator

800 Independence Ave., S.W.
Washington, DC 20591

September 29, 2023

The Honorable Maria Cantwell
Chair, Committee on Commerce, Science,
and Transportation
United States Senate
Washington, DC 20510

Dear Chair Cantwell:

Enclosed is the Federal Aviation Administration's (FAA) Report to Congress on the Evaluation of Commercial Human Space Flight Activities Most Appropriate for New Safety Framework. As required by Title 51 of the United States Code § 50905(c)(7), License Applications and Requirements, this report identifies the activities most appropriate for a new safety framework that allows for collaborative work with industry on increasing the safety of human space flight.

The Commercial Space Transportation Advisory Committee (COMSTAC) reviewed this report and provided observations and recommendations on July 11, 2023. The recommendations COMSTAC provided do not all directly relate to the written report, but most are general recommendations to the DOT and FAA. They included that the FAA continue to encourage current efforts to develop industry consensus standards and that the FAA seek additional resources as Human Space Flight activity increases. The U.S. Department of Transportation (DOT) appreciates the efforts that went into developing these recommendations and will continue to collaborate with industry and COMSTAC in determining its next steps.

A similar letter has been sent to the Ranking Member of the Senate Committee on Commerce, Science, and the Chairman and Ranking Member of the House Committee on Science, Space, and Technology.

Sincerely,

Polly Trottenberg
Acting Administrator

Enclosure

U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of the Administrator

800 Independence Ave., S.W.
Washington, DC 20591

September 29, 2023

The Honorable Ted Cruz
Ranking Member, Committee on Commerce, Science,
and Transportation
United States Senate
Washington, DC 20510

Dear Ranking Member Cruz:

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800 Independence Ave., S.W.
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September 29, 2023

The Honorable Frank Lucas
Chairman, Committee on Science, Space,
and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Chairman Lucas:

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U.S. Department
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Office of the Administrator

800 Independence Ave., S.W.
Washington, DC 20591

September 29, 2023

The Honorable Zoe Lofgren
Ranking Member, Committee on Science, Space,
and Technology
U.S. House of Representatives
Washington, DC 20515

Dear Ranking Member Lofgren:

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FEDERAL AVIATION
ADMINISTRATION

Report to Congress:

U.S. Department of Transportation Evaluation of Commercial Human Space Flight Activities Most Appropriate for New Safety Framework

51 U.S.C. § 50905the(7)

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I. Executive Summary

This report fulfills the requirement in Title 51 of the United States Code (51 U.S.C.) § 50905(c)(7), License applications and requirements, that the Secretary of the U.S. Department of Transportation (DOT) submit a report to Congress that identifies the commercial human space flight (HSF) activities described in 51 U.S.C. §§ 50905(c) and (d) most appropriate for a new safety framework that may include regulatory action, if any, and a proposed transition plan for such safety framework. Section 50905(c)(7) also requires the Secretary to submit this report in consultation and coordination with the commercial space sector, including the Commercial Space Transportation Advisory Committee (COMSTAC) or its successor organization. The Secretary of Transportation delegated these responsibilities to the Federal Aviation Administration (FAA) Administrator. The FAA consulted and coordinated with COMSTAC and considered COMSTAC recommendations in developing this report.

The activities identified in 51 U.S.C. § 50905(c) and (d) include issuing regulations governing the design or operation of a launch vehicle to protect the health and safety of the crew, government astronauts, and space flight participants. In § 50905(c)(9), Congress placed a restriction on the promulgation of rules to address these activities to provide the industry a learning period or moratorium without significant U.S. Government regulatory oversight.

In an October 20, 2017, report to Congress[1], the FAA developed a list of proposed indicators with the intent to determine if the agency and the commercial space transportation industry were ready to develop and transition to a new safety framework for the safety of human space flight. In 2019[2], the FAA indicated that the industry and the FAA were not ready to transition to a safety framework. Since then, the commercial space transportation industry has evolved substantially, and the FAA believes both the industry and the agency are ready to develop and transition to a new safety framework. To ensure that future regulations are only to the extent necessary, the FAA will work closely with the industry to develop the safety framework. The expiration of the learning period will allow for the adoption and implementation of critical safety principles that are critical to ensuring the success of this new and quickly growing mode of transportation.

Additionally, in accordance with § 50905(c)(3), the FAA has and will continue to work "… to facilitate the development of voluntary industry consensus standards based on recommended best practices to improve the safety of the crew, government astronauts, and space flight participants as the commercial space sector continues to mature." The FAA is supporting multiple Standard Development Organizations (SDOs) in developing commercial space standards and most recently delivered the status of standard development in the latest report to Congress, *Final Report on Voluntary Industry Consensus Standards Development*, in December 2021.

In June 2023, the FAA chartered an Aerospace Rulemaking Committee (SpARC) under 49 U.S.C. § 106(p)(5), with membership represented across the space industry, to assist the FAA in

[1] Available at: https://www.faa.gov/about/plansreports/report-congress-faa-evaluation-commercial-human-space-flight-safety-frameworks

[2] Available at: https://www.faa.gov/sites/faa.gov/files/2021-11/New-Safety-Framework-for-Commercial-Human-Space-Flight-Completed-report.pdf

formulating a safety framework. The SpARC will submit a report of recommendations approximately 18 months after establishment. The FAA is also updating the *Recommended Practices for Human Space Flight Occupant Safety* originally published in 2014.[3] These updates will include an FAA review of existing government and private sector requirements and standards. The FAA is consulting closely with the National Aeronautics and Space Administration (NASA), FAA's Civil Aerospace Medical Institute (CAMI), and COMSTAC to update these recommended practices. Once published, the FAA will work with SDOs to develop voluntary industry consensus standards built around these best practices.

The safety framework will evolve and expand as the industry grows in complexity and increases in launch frequency. The pace of industry will inform the development of the new safety framework, as well as research and development into safety issues and new technologies to mitigate risks to human life, and appropriate oversight to include licensing, inspection, compliance, enforcement, and more importantly, the encouragement of a robust safety culture within the industry.

The human space flight industry is moving at the pace of innovation, and the FAA believes that as the leader in transportation safety, the United States is ready for the sunset of the moratorium. The FAA will work together with industry and other United States Government agencies to establish a new safety framework for space transportation providing for the safety of the crew, government astronauts, and space flight participants.

II. Introduction

The FAA exercised oversight responsibility for certain aspects of commercial space transportation activities since 1995, when the Secretary of Transportation delegated authority to the FAA Administrator, and the FAA established the Office of Commercial Space Transportation (AST). The FAA, through AST, licenses and permits the launch of launch vehicles, the reentry of reentry vehicles, and the operation of launch and reentry sites consistent with public health and safety, safety of property, and the national security and foreign policy interests of the United States. AST's mission is unique within the FAA because it also includes the responsibility to encourage, facilitate, and promote commercial space launches and reentries by the private sector, including those involving space flight participants. Since 1989, the FAA (or its predecessor office in the Office of the Secretary of Transportation) has licensed over 500 launches and reentries, and there have been no fatalities, serious injuries, or significant property damage to the public or space flight participants.

The FAA's responsibilities are not limited to protecting the public. In 2004, Congress granted the Secretary of Transportation authority to oversee the safety of the emerging commercial human space flight industry. Under 51 U.S.C. § 50905(b)(4), no holder of a license or permit may launch or reenter crew unless the crew has received training and satisfied medical or other standards specified in a license or permit, all in accordance with FAA regulations. In addition, section 50905(b)(5) states that a holder of a license or permit may launch or reenter a space flight participant only if the holder of the license or permit has informed each space flight participant in writing about the risks of launch and reentry.

[3] Available at: https://www.faa.gov/space/human_spaceflight

The FAA established requirements for human space flight under Title 14 of the Code of Federal Regulation (14 CFR) part 460, as required by the Commercial Space Launch Amendments Act of 2004. Part 401.7 defines requirements for crew and flight crew and imposes notification, medical, qualification, and training requirements. While these requirements are focused on public safety, part 460 also establishes informed consent requirements for space flight participants. Part 460 became effective on February 13, 2007, and applies to anyone applying for or having a license or permit under 14 CFR Chapter III who conducts a launch or reentry with flight crew or space flight participants on board a vehicle or employs a remote operator of a launch or reentry vehicle with a human on board.

Other than requiring informed consent, the FAA's authority to regulate for the health and safety of crew, space flight participants, and government astronauts is limited. To ensure that the industry has an ample "learning period" to develop, Congress prohibited the Secretary from promulgating any regulations governing the design or operation of a launch vehicle intended to protect the health and safety of crew, government astronauts, and space flight participants until 2012, absent serious or fatal injury, or an unplanned event during a launch or reentry that posed a high risk of causing a serious or fatal injury. Congress has extended this prohibition twice—the FAA Modernization and Reform Act of 2012 extended it to October 1, 2015, and the U.S. Commercial Space Launch Competitiveness Act of 2015 (CSLCA) extended it to October 1, 2023. However, Congress did encourage the FAA to continue to work with industry on ways to improve human space flight safety. The FAA has accomplished this through working with industry in general, NASA, and COMSTAC to develop recommended practices, share information, and develop voluntary consensus standards.

U.S. companies offering HSF opportunities to paying customers are projected to grow as space tourism and other applications increase in popularity. Commercial space travel will include not only suborbital and orbital trips, but also travel to cis-lunar and beyond destinations, travel to space habitats (commercial space stations and other tourist destinations), and, perhaps, point-to-point earth destinations through space. From February 2019, through March 2023, three commercial HSF operators successfully flew humans on suborbital trajectories or in Earth orbit. There have been 18 FAA-licensed commercial HSF launches with no fatalities or serious injury to government astronauts or space flight participants.

The CSLCA requires the Secretary of Transportation to submit a report identifying activities most appropriate for a new safety framework that may include regulatory action, if any, and a proposed transition plan for such a safety framework. Specifically, Section 111(7) of the CSLCA revised 51 U.S.C. § 50905(c) by inserting, among other things, a new paragraph (7), which states:

> *(7) REPORTS.-Not later than March 31 of each of 2018 and 2022, the Secretary, in consultation and coordination with the commercial space sector, including the Commercial Space Transportation Advisory Committee, or its successor organization, shall submit to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Science, Space, and Technology of the House of Representatives a report that identifies the activities, described in this subsection and subsection (d) most*

appropriate for a new safety framework that may include regulatory action, if any, and a proposed transition plan for such safety framework.

III. Review of Readiness Indicators

In the October 20, 2017, CSLCA Section 111(6) report to Congress[4], the FAA produced a list of proposed indicators with the intent to determine if the agency and the commercial space transportation industry were ready to develop and transition to a new safety framework for the safety of human space flight. These indicators did not have specific and measurable metrics associated, but were developed as guides to indicate when a framework should be established. The detailed list of indicators is in the Appendix, and a general discussion is below.

The first set of indicators includes industry's readiness to enter into a safety framework, focusing on three areas:

1. Purpose of people flying in space
2. Size and complexity of the industry
3. Safety of the industry

Commercial human space flight activity has grown and is increasing year over year since the Department submitted its initial report in February 2019. Four operators have launched under an FAA license or experimental permit carrying humans onboard. As of June 1, 2023, SpaceX successfully operated three commercial and six NASA human space flight orbital missions; Scaled Composites flew five suborbital human spaceflight missions of the SpaceShipOne and four SpaceShipTwo flights, the last of which resulted in one injury and one fatality. Virgin Galactic flew nine suborbital missions successfully; and Blue Origin carried out six suborbital missions successfully. Boeing is seeking NASA certification in 2023 to fly government astronauts and seeks a license to fly space flight participants for tourism and other purposes. Sierra Space also is developing a crewed version of its Dream Chaser spaceplane.

The public perception of space flight safety has increased as people are flying for adventure by either a sponsored seat or a purchased ticket to fly. There has been an increase in celebrities and members of the public flying for adventure. Employees of space flight companies also have flown. Government astronauts, through NASA's commercial crew program, fly on FAA-licensed flights to the International Space Station as part of their occupation. At this time, there are no vehicle manufacturers supplying launch or reentry vehicles for other operators; all companies manufacture their own launch and reentry vehicles. In addition, all HSF launches have been from the United States, as opposed to international spaceports.

With the exception of a Virgin Galactic SpaceShipTwo mishap in 2014, all licensed or permitted HSF missions have been completed safely.

The second set of indicators pertains to the industry's progress in developing a safety

[4] https://www.faa.gov/about/plans_reports/congress/media/Sec.-111-Report-to-Congress-Evaluation-of-Commercial-Human-Space-Flight-Safety-Frameworks-and-Key-Industry-Indicators.pdf

framework and focuses on three areas:

1. Voluntary safety reporting
2. Voluntary consensus standards
3. Compliance with standards

This set of indicators points to the extent of industry self-regulation and establishing an industry-led safety regime. There has not been an appetite from industry to establish a voluntary safety reporting system yet. There are several reasons for this reluctance on the part of industry. First, no statutory data protection safeguards are in place for the commercial space transportation industry, in contrast with the aviation transportation industry (49 U.S.C. § 40123). Another reason often cited by industry is that safety issues, if reported, could affect the income or potential venture capital investments for the company reporting an issue. A third reason given is that those safety issues are proprietary knowledge in a nascent industry that is "failing forward" and considers failures as learning opportunities. An expensive lesson learned by one company may give a capital advantage to another company.

The development of robust voluntary consensus standards is another indicator that is not as advanced as expected. The industry has not established a robust set of voluntary industry consensus standards for high-priority areas and therefore, companies do not self-identify adherence to voluntary consensus standards. There are several reasons for this delay in the development and use of standards. First, it is expensive for a company to devote subject matter expert time to discussions about, and to build consensus around, a standard for a mode of transportation that is so divergent. The subject matter expert's time is spent designing, building, or modifying their employer's vehicle; this is a critical issue with the known shortage of engineers and scientists with the background to work in this booming industry. Another reason for the less-than-robust number of published standards is there are no regulatory performance requirements to establish boundaries and direction for the development of standards. Additionally, there is no third-party verification of adherence or compliance with standards.

The final set of indicators pertains to the FAA's readiness to enter into a safety framework and focuses on two areas:

1. U.S. DOT authority to transition to a safety framework
2. U.S. DOT expertise in Human Space Flight Safety

The expiration of the learning period or moratorium will facilitate the first indicator. Other than public safety-focused requirements, the FAA's part 460 is limited to the informed consent of crew and space flight participants.

The FAA engages with the ASTM F47 Committee on Commercial Spaceflight in developing standards and has increased participation with the working groups establishing standards for human space flight. Additionally, the FAA is working to update and publish a new version of the 2014 *Recommended Practices for Human Spaceflight Occupant Safety.* The agency will provide the updated document to COMSTAC for its review, observations, and recommendations before it is published later this year. The FAA originally developed this document to provide a compilation of practices that the agency believes are important and recommends for

commercial human space flight occupant safety. Now the document requires substantial updates, and the update effort includes incorporating lessons learned, adding new recommended practices, and incorporating additional information on how operators can verify the implementation of the recommended practices in the design, manufacture, and operation of launch and reentry vehicles.

Since 2014, when the FAA published the original *Recommended Practices for Human Space Flight Occupant Safety* document, there has been a significant increase in the frequency of commercial human space flight missions, as well as differences in the scope and type of missions compared to those envisioned in 2014. The FAA considered a broad range of human space flight activity in orbital and suborbital flights, from when occupants are exposed to vehicle hazards prior to flight through when they are no longer exposed to vehicle hazards after landing. In the 2014 document, the FAA did not explicitly cover orbital rendezvous and docking, long-duration flights (longer than two weeks), extravehicular activity, and any flights beyond Earth orbit. More specifically, the FAA assumed that any orbital vehicle would stay in orbit for a maximum of two weeks and could return to Earth in under 24 hours if necessary. The FAA also assumed that each member of the flight crew would be safety-critical, and space flight participants may perform limited safety-critical tasks. The updated *Recommended Practices for Human Space Flight Occupant Safety* will address gaps the FAA has identified and will provide a good foundation for the upcoming safety framework discussions with industry.

Based on the review of these readiness indicators, the FAA believes both the industry and the FAA are ready to work together and begin developing a safety framework. As discussed below, the FAA is beginning a formal gathering of industry recommendations by establishing a SpARC this year. The large time gap between the sunsetting of the learning period and the effective date of any new safety framework that includes regulation will allow for the implementation of a safety framework in an appropriate timeframe to meet industry needs.

IV. Activities Most Appropriate for New Safety Framework

The FAA's October 20, 2017, report to Congress[5] outlined several safety elements that a comprehensive set of safety standards for human space flight should address, including:

Design

- Human Needs and Accommodations – the steps necessary to accommodate specific human needs, such as consumables, human waste disposal, etc.
- Human Protection – the steps necessary to keep an occupant's physical and psychological stress at levels that can be considered safe for space flight participants and sufficient for flight crew and government astronauts to execute the flight.
- Flightworthiness – the minimum system capabilities necessary to maintain occupant safety.
- Human/Vehicle Integration – operational and design constraints necessary to integrate humans with a human space flight system.

[5] https://www.faa.gov/about/plans_reports/congress/media/Sec.-111-Report-to-Congress-Evaluation-of-Commercial-Human-Space-Flight-Safety-Frameworks-and-Key-Industry-Indicators.pdf

- System Safety – engineering and management principles, criteria, and techniques to achieve acceptable risk, within the constraints of operational effectiveness and suitability, time, and cost, throughout all phases of the system life cycle.

Manufacturing

- Steps necessary to ensure the system manufactured matches its design, including quality assurance, acceptance testing, and configuration management.

Operations

- Management – program controls necessary to ensure proper implementation of safety requirements.
- System Safety – system safety management and engineering principles, criteria, and techniques applicable during the operational phase of a system's life cycle.
- Planning, Procedures, and Rules – plans and procedures necessary to safely operate a human space flight system.
- Medical Considerations – medical needs and constraints for flight crew and space flight participants.
- Training – training needs of the flight crew, government astronauts, space flight participants, ground controllers, and safety-critical ground operations personnel.

These activities are reflected in the 2014 *Recommended Practices for Human Space Flight Occupant Safety* document. The activities most appropriate for a new safety framework early on most likely will include a number of these activities.

To further investigate activities most appropriate for a new safety framework, the FAA contracted with the Aerospace Corporation (Aerospace), a Federally Funded Research and Development Center, to research the safety frameworks of multiple transportation and leisure sectors and analyze case studies to show any emerging common themes that might be applicable to commercial HSF safety. These case studies came from conventional cars, autonomous vehicles, cruise ships, commercial aviation, and submarines. Aerospace Corporation identified three common components in their research:

i. People
ii. Safety Culture
iii. Data Collection and Analytics

Aerospace Corporation emphasized how human beings, with their potential to make mistakes, are the most fundamental element of any safety framework. Regardless of the exacting nature of risk mitigation strategies, the involvement of people throughout the design, development, and operation of systems will introduce risks. Those risks can be mitigated, but unanticipated hazards can be spotted by humans, who must be empowered to speak up and identify those hazards. This leads to the second element identified—safety culture. A positive safety culture will allow people to "see something and say something" without fear of punishment or retribution. The final key element is data collection and analytics. Aerospace noted, "[w]ithout collecting data on hazards, risks materials, processes, and the subsequent analyses, any reaction

to mishaps or accidents will be retroactive."[6]

Aerospace Corporation found that elements of a sound safety framework include, but are not limited to, industry consensus standards, best practices, regulations, oversight and enforcement, inspections, audits, verifications, certifications or licensing, international agreements and treaties, and accident and mishap investigations. As noted in the Aerospace report,[7] the safety framework for commercial HSF should exhibit the following five characteristics:

1. **Adaptive and evolutionary.** Technologies and safety aspects change through continuous innovation. As such, a framework should be able to evolve and adapt to various transportation and launch methods. It also should be able to adapt to individual operators and companies in all stages of development and maturity.
2. **Innovation permissible.** A safety framework should encourage innovation and be open to new approaches to accomplish safety goals.
3. **Comprehensive.** A framework should consider all system risks and not ignore risks absent of regulatory authorities. Hazards exist along all phases of flight. However, a framework should be flexible enough to address the range of risk factors appropriately.
4. **Quantifiable and technically informed.** Identified hazards and associated risks should be assessed in a quantifiable manner which calls for consistent data collection and analysis. Similarly, best practices, voluntary consensus standards, and regulations need to be technically informed and based on quantifiable data.
5. **Collaborative and transparent.** Safety is a shared interest of all stakeholders. Approaches and solutions to safety issues should be shared as broadly as possible.

These five characteristics will enable the successful and future-proof development of the safety framework.

Aerospace noted that the industry's proactive participation in creating consensus standards, systems for data collection and sharing, and maturing a sustainable industry safety culture will influence the timing and extent of government regulatory involvement significantly. Successful implementation of an industry participatory framework will minimize any regulatory burden on the industry while encouraging the development of increased safety protocols.

In summary, the FAA plans to use the SpARC (discussed below) as a collaboration platform to produce a list of activities most appropriate for a new safety framework. The FAA will use the updated Recommended Practices document, the Aerospace study, and any other relevant input to inform this process.

V. Transitioning from Today to New Safety Framework Tomorrow

As noted earlier, since 2004, Congress has maintained a "learning period" prohibiting DOT from promulgating any regulations governing the design or operation of a launch vehicle intended to protect the health and safety of crew, government astronauts, and space flight participants, absent a serious or fatal injury, or an unplanned event during a launch or reentry

[6] Aerospace Report, p. 1.
[7] Aerospace Report, p. 5.

that posed a high risk of causing a serious or fatal injury to crew, government astronauts, or space flight participants.

The current safety framework is based on an informed consent regime. The FAA requires the operator to inform space flight participants of the risks of a launch or reentry and that the U.S. Government does not certify the safety of the vehicle on which they have purchased or been given a seat to fly into space. The FAA and the commercial operator must provide information on the risks, so the occupants can make the informed decision to fly or not to fly.

The transition from informed consent to a new safety framework will need to occur in phases and must evolve as the industry develops. As Congress noted in 51 U.S.C. § 5090l(a)(l5):

> *The regulatory standards governing human space flight must evolve as the industry matures so that regulations neither stifle technology development nor expose crew, government astronauts, or space flight participants to avoidable risks as the public comes to expect greater safety for crew, government astronauts, and space flight participants from the industry.*

The future of the commercial human space flight industry depends on continual improvement of its safety performance, and the FAA is dedicated to performing its part. Performance-based regulatory regimes can be positive guardrails allowing innovation and development within established bounds for safety. These requirements also allow voluntary consensus standards to be developed to provide a means of compliance and can be the basis for updating or establishing new performance requirements for the industry to increase the safety of participants.

Any new regime will require the development of new performance-based rules, not simply prescriptive rules, giving the industry flexibility to develop new safety approaches at the speed of innovation and the ability to use voluntary consensus standards to meet the performance requirements. At this point in the commercial human space flight industry's evolution, transitioning from the current informed consent regime to a new safety framework should not stifle technological developments; rather, it will help the industry grow safely.

The first phase of a new regulatory framework regime will involve updating and publishing the *Recommended Practices for Human Space Flight Occupant Safety* document. This updated document will be the basis for SDOs, such as ASTM, to create consensus standards for the industry to utilize, and the government to use in establishing performance-based regulations. The FAA is updating this document and additional regulatory or legislative action is not needed.

Also, under 49 U.S.C. § 106(p)(5), the Secretary chartered the SpARC for HSF Occupant Safety (HSFOS).[8] SpARCs are similar to Aviation Rulemaking Committees (ARC), which have been used for many years by the FAA's Aviation Safety organization to gather industry data and feedback on potential aviation regulations. The HSFOS SpARC will assist the FAA in

[8] 49 U.S.C. § 106(p)(5) authorizes the Secretary of Transportation to establish Aerospace Rulemaking Committees that are not subject to the requirements of the Federal Advisory Committee Act.

formulating the first set of rules after the learning period sunsets. Eighteen months after its establishment, the SpARC will submit a report of recommendations to the FAA Administrator. After the Administrator receives the SpARC report, the FAA will draft a Notice of Proposed Rulemaking (NPRM) for public comment, during which time industry, the general public, and other government agencies will have the opportunity to review and comment on the proposed rule. Following the public comment period, the FAA will decide if a final rule can be published or if significant changes need to be made prior to publishing a final rule. This process will follow the Administrative Procedure Act (APA) as codified in 5 U.S.C. §§ 551–559. A final rule is projected to take approximately five years from the start of a SpARC through the publication of the final rule, with an effective date sometime after the rule is published.

The FAA will diligently seek recommendations from industry and other government departments and agencies to develop the final list of activities to include in the initial new safety framework. The FAA is working with industry and others through COMSTAC, SpARCs, and international space agencies, to garner the best ideas for developing the safety framework.

VI. Aerospace Rulemaking Committee

The HSFOS SpARC is comprised of approximately 24 representatives from current and prospective license and permit holders, training providers, industry groups, and academia. The discussions within the HSFOS SpARC meetings will be closed sessions to encourage full participation and open discussion. The FAA will task the HSFOS SpARC to provide consensus comments on two major items.

The first item is to determine the scope of future human space flight occupant safety regulations. The SpARC should also consider the level of safety for the occupants—e.g., how safe should flights be for crew, government astronauts, and space flight participants? A higher level of safety would require a more rigorous and extensive pre-flight evaluation and licensing process.

The second item will be to provide recommendations on how to create a human space flight occupant safety regime. This will be the framework for potential regulations—i.e., how the FAA should monitor and oversee occupant safety on commercial launch and reentry vehicles. The SpARC should consider the extent of the oversight. Regulations for the aviation industry cover the exact design specifications, parts, and materials used on passenger aircraft, and the SpARC will investigate and make recommendations on an approach between the current regime based on informed consent and the regime used for aviation. The SpARC will provide input for the FAA to determine that approach.

The FAA will develop the full plan for transitioning from the current regime based on informed consent to a new regulatory framework after receiving recommendations from the HSFOS SpARC. The plan will be informed by case studies from other transportation modes and likely will be incremental in nature.

VII. Other Actions Being Taken Now

In addition to the actions discussed above, the FAA also has been supporting industry's efforts to develop voluntary consensus standards for HSF, primarily with ASTM. Formed in 2016, the ASTM Committee F47 on Commercial Spaceflight has five technical subcommittees that develop and maintain standards. The scope of the committee is the development and maintenance of voluntary consensus standards and recommended practices for the commercial space flight industry. Among other standards, the committee is developing human space flight safety standards. The FAA supports ASTM through involvement with the subcommittees and working groups. FAA subject matter experts provide input and apply their expertise to assist with the development of ASTM standards.

The FAA is continuing its research and development effort to identify risks and risk mitigations for HSF participants to include equipment safety as well as environmental risks (e.g., space medicine). These projects will identify risks, as well as research tools and methodologies to mitigate the risks identified, informing the regulatory regime as well as standards development and best practices. The FAA has developed a significant body of research through the Center of Excellence for Commercial Space Transportation and is transitioning to an even greater collaborative body of research across the United States Government as well as academia. This body of growing work is informing the update of the *Recommended Practices for Human Space Flight Occupant Safety* document and will support safety framework discussions with industry.

Lastly, the FAA plans to work with appropriate U.S. interagency partners to establish a strategy for commercial space flight participant search and rescue and to clarify international treaty language (e.g., Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched into Outer Space).[9]

VIII. Conclusion

The United States is the world leader in the exploration of the next frontier: space. The HSF industry is moving at the pace of innovation, and the FAA believes both the FAA and industry are ready to work together to establish a new safety framework built on case studies, industry and government experience, research, and public input. The FAA continues to support industry fully in the development of substantial voluntary industry consensus standards as an integral part of any safety framework. The safety framework will not stifle industry's technological development. Rather the safety framework will encourage innovation while guarding the safety of the crew, government astronauts, and space flight participants.

[9] The U.S. is applying the term space flight participant and not using the term astronaut for commercial space travelers. A clarification of the terms needs to be made by the U.S. Government to ensure safe treatment of personnel and return of equipment pursuant to the treaty.

Appendix

Table 1

Industry Readiness Indicators

Readiness Area	Indicators
• Purpose of People Flying in Space	• The extent to which people are flying for adventure purposes. • The extent to which people are flying as part of their occupation. • The extent to which people are flying as a mode of transportation.
• Size and Complexity of the Industry	• The number of suppliers of orbital or suborbital space flight. • The number of suppliers of similar space flight types, such as vertical suborbital, horizontal suborbital, and balloon. • The extent to which there is a broad supplier network. • The extent to which operations occur internationally.
• Safety of the Industry	• The extent to which there is evidence of unsafe operations. • The extent to which the industry is having difficulty attracting new customers. • The extent to which insurance companies are willing to insure human space flight operations.

Table 2

Industry's Progress in Developing a Safety Framework Indicators

Readiness Area	Indicators
• Voluntary Safety Reporting	• The extent to which individual companies have an internal voluntary reporting system to identify and address potential precursors to accidents. • The extent to which industry members share safety data with each other, with a common data format and taxonomy.
• Voluntary Consensus Standards	• The extent to which industry has formed a consensus on top-level performance standards. • The extent to which industry has developed and maintains voluntary consensus standards in high-priority areas. • The extent to which industry has developed and maintains a robust set of voluntary consensus standards.
• Compliance with Standards	• The extent to which individual companies self-verify compliance with voluntary consensus standards. • The extent to which a third party verifies compliance with voluntary consensus standards.

Table 3

U.S. Department of Transportation Readiness Indicators

Readiness Area	Indicators
• USDOT Authority to Transition to a Safety Framework • USDOT Expertise in Human Space Flight Safety	• Status of the "learning period." • The extent to which the FAA has helped create elements of a space safety framework. • The extent to which the FAA has engaged with industry regarding standards development. • The extent to which the FAA has published safety practices related to commercial human space flight. • The extent to which the FAA has experience participating in a space safety framework.

FEDERAL AVIATION ADMINISTRATION

Report to Congress:

U.S. Department of Transportation Evaluation of Commercial Human Space Flight Activities Most Appropriate for New Safety Framework

51 U.S.C. § 50905the(7)

Contents

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I. Executive Summary

This report fulfills the requirement in Title 51 of the United States Code (51 U.S.C.) § 50905(c)(7), License applications and requirements, that the Secretary of the U.S. Department of Transportation (DOT) submit a report to Congress that identifies the commercial human space flight (HSF) activities described in 51 U.S.C. §§ 50905(c) and (d) most appropriate for a new safety framework that may include regulatory action, if any, and a proposed transition plan for such safety framework. Section 50905(c)(7) also requires the Secretary to submit this report in consultation and coordination with the commercial space sector, including the Commercial Space Transportation Advisory Committee (COMSTAC) or its successor organization. The Secretary of Transportation delegated these responsibilities to the Federal Aviation Administration (FAA) Administrator. The FAA consulted and coordinated with COMSTAC and considered COMSTAC recommendations in developing this report.

The activities identified in 51 U.S.C. § 50905(c) and (d) include issuing regulations governing the design or operation of a launch vehicle to protect the health and safety of the crew, government astronauts, and space flight participants. In § 50905(c)(9), Congress placed a restriction on the promulgation of rules to address these activities to provide the industry a learning period or moratorium without significant U.S. Government regulatory oversight.

In an October 20, 2017, report to Congress[1], the FAA developed a list of proposed indicators with the intent to determine if the agency and the commercial space transportation industry were ready to develop and transition to a new safety framework for the safety of human space flight. In 2019[2], the FAA indicated that the industry and the FAA were not ready to transition to a safety framework. Since then, the commercial space transportation industry has evolved substantially, and the FAA believes both the industry and the agency are ready to develop and transition to a new safety framework. To ensure that future regulations are only to the extent necessary, the FAA will work closely with the industry to develop the safety framework. The expiration of the learning period will allow for the adoption and implementation of critical safety principles that are critical to ensuring the success of this new and quickly growing mode of transportation.

Additionally, in accordance with § 50905(c)(3), the FAA has and will continue to work "… to facilitate the development of voluntary industry consensus standards based on recommended best practices to improve the safety of the crew, government astronauts, and space flight participants as the commercial space sector continues to mature." The FAA is supporting multiple Standard Development Organizations (SDOs) in developing commercial space standards and most recently delivered the status of standard development in the latest report to Congress, *Final Report on Voluntary Industry Consensus Standards Development*, in December 2021.

In June 2023, the FAA chartered an Aerospace Rulemaking Committee (SpARC) under 49 U.S.C. § 106(p)(5), with membership represented across the space industry, to assist the FAA in

[1] Available at: https://www.faa.gov/about/plansreports/report-congress-faa-evaluation-commercial-human-space-flight-safety-frameworks

[2] Available at: https://www.faa.gov/sites/faa.gov/files/2021-11/New-Safety-Framework-for-Commercial-Human-Space-Flight-Completed-report.pdf

formulating a safety framework. The SpARC will submit a report of recommendations approximately 18 months after establishment. The FAA is also updating the *Recommended Practices for Human Space Flight Occupant Safety* originally published in 2014.[3] These updates will include an FAA review of existing government and private sector requirements and standards. The FAA is consulting closely with the National Aeronautics and Space Administration (NASA), FAA's Civil Aerospace Medical Institute (CAMI), and COMSTAC to update these recommended practices. Once published, the FAA will work with SDOs to develop voluntary industry consensus standards built around these best practices.

The safety framework will evolve and expand as the industry grows in complexity and increases in launch frequency. The pace of industry will inform the development of the new safety framework, as well as research and development into safety issues and new technologies to mitigate risks to human life, and appropriate oversight to include licensing, inspection, compliance, enforcement, and more importantly, the encouragement of a robust safety culture within the industry.

The human space flight industry is moving at the pace of innovation, and the FAA believes that as the leader in transportation safety, the United States is ready for the sunset of the moratorium. The FAA will work together with industry and other United States Government agencies to establish a new safety framework for space transportation providing for the safety of the crew, government astronauts, and space flight participants.

II. Introduction

The FAA exercised oversight responsibility for certain aspects of commercial space transportation activities since 1995, when the Secretary of Transportation delegated authority to the FAA Administrator, and the FAA established the Office of Commercial Space Transportation (AST). The FAA, through AST, licenses and permits the launch of launch vehicles, the reentry of reentry vehicles, and the operation of launch and reentry sites consistent with public health and safety, safety of property, and the national security and foreign policy interests of the United States. AST's mission is unique within the FAA because it also includes the responsibility to encourage, facilitate, and promote commercial space launches and reentries by the private sector, including those involving space flight participants. Since 1989, the FAA (or its predecessor office in the Office of the Secretary of Transportation) has licensed over 500 launches and reentries, and there have been no fatalities, serious injuries, or significant property damage to the public or space flight participants.

The FAA's responsibilities are not limited to protecting the public. In 2004, Congress granted the Secretary of Transportation authority to oversee the safety of the emerging commercial human space flight industry. Under 51 U.S.C. § 50905(b)(4), no holder of a license or permit may launch or reenter crew unless the crew has received training and satisfied medical or other standards specified in a license or permit, all in accordance with FAA regulations. In addition, section 50905(b)(5) states that a holder of a license or permit may launch or reenter a space flight participant only if the holder of the license or permit has informed each space flight participant in writing about the risks of launch and reentry.

[3] Available at: https://www.faa.gov/space/human_spaceflight

The FAA established requirements for human space flight under Title 14 of the Code of Federal Regulation (14 CFR) part 460, as required by the Commercial Space Launch Amendments Act of 2004. Part 401.7 defines requirements for crew and flight crew and imposes notification, medical, qualification, and training requirements. While these requirements are focused on public safety, part 460 also establishes informed consent requirements for space flight participants. Part 460 became effective on February 13, 2007, and applies to anyone applying for or having a license or permit under 14 CFR Chapter III who conducts a launch or reentry with flight crew or space flight participants on board a vehicle or employs a remote operator of a launch or reentry vehicle with a human on board.

Other than requiring informed consent, the FAA's authority to regulate for the health and safety of crew, space flight participants, and government astronauts is limited. To ensure that the industry has an ample "learning period" to develop, Congress prohibited the Secretary from promulgating any regulations governing the design or operation of a launch vehicle intended to protect the health and safety of crew, government astronauts, and space flight participants until 2012, absent serious or fatal injury, or an unplanned event during a launch or reentry that posed a high risk of causing a serious or fatal injury. Congress has extended this prohibition twice—the FAA Modernization and Reform Act of 2012 extended it to October 1, 2015, and the U.S. Commercial Space Launch Competitiveness Act of 2015 (CSLCA) extended it to October 1, 2023. However, Congress did encourage the FAA to continue to work with industry on ways to improve human space flight safety. The FAA has accomplished this through working with industry in general, NASA, and COMSTAC to develop recommended practices, share information, and develop voluntary consensus standards.

U.S. companies offering HSF opportunities to paying customers are projected to grow as space tourism and other applications increase in popularity. Commercial space travel will include not only suborbital and orbital trips, but also travel to cis-lunar and beyond destinations, travel to space habitats (commercial space stations and other tourist destinations), and, perhaps, point-to-point earth destinations through space. From February 2019, through March 2023, three commercial HSF operators successfully flew humans on suborbital trajectories or in Earth orbit. There have been 18 FAA-licensed commercial HSF launches with no fatalities or serious injury to government astronauts or space flight participants.

The CSLCA requires the Secretary of Transportation to submit a report identifying activities most appropriate for a new safety framework that may include regulatory action, if any, and a proposed transition plan for such a safety framework. Specifically, Section 111(7) of the CSLCA revised 51 U.S.C. § 50905(c) by inserting, among other things, a new paragraph (7), which states:

> *(7) REPORTS.-Not later than March 31 of each of 2018 and 2022, the Secretary, in consultation and coordination with the commercial space sector, including the Commercial Space Transportation Advisory Committee, or its successor organization, shall submit to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Science, Space, and Technology of the House of Representatives a report that identifies the activities, described in this subsection and subsection (d) most*

appropriate for a new safety framework that may include regulatory action, if any, and a proposed transition plan for such safety framework.

III. Review of Readiness Indicators

In the October 20, 2017, CSLCA Section 111(6) report to Congress[4], the FAA produced a list of proposed indicators with the intent to determine if the agency and the commercial space transportation industry were ready to develop and transition to a new safety framework for the safety of human space flight. These indicators did not have specific and measurable metrics associated, but were developed as guides to indicate when a framework should be established. The detailed list of indicators is in the Appendix, and a general discussion is below.

The first set of indicators includes industry's readiness to enter into a safety framework, focusing on three areas:

1. Purpose of people flying in space
2. Size and complexity of the industry
3. Safety of the industry

Commercial human space flight activity has grown and is increasing year over year since the Department submitted its initial report in February 2019. Four operators have launched under an FAA license or experimental permit carrying humans onboard. As of June 1, 2023, SpaceX successfully operated three commercial and six NASA human space flight orbital missions; Scaled Composites flew five suborbital human spaceflight missions of the SpaceShipOne and four SpaceShipTwo flights, the last of which resulted in one injury and one fatality. Virgin Galactic flew nine suborbital missions successfully; and Blue Origin carried out six suborbital missions successfully. Boeing is seeking NASA certification in 2023 to fly government astronauts and seeks a license to fly space flight participants for tourism and other purposes. Sierra Space also is developing a crewed version of its Dream Chaser spaceplane.

The public perception of space flight safety has increased as people are flying for adventure by either a sponsored seat or a purchased ticket to fly. There has been an increase in celebrities and members of the public flying for adventure. Employees of space flight companies also have flown. Government astronauts, through NASA's commercial crew program, fly on FAA-licensed flights to the International Space Station as part of their occupation. At this time, there are no vehicle manufacturers supplying launch or reentry vehicles for other operators; all companies manufacture their own launch and reentry vehicles. In addition, all HSF launches have been from the United States, as opposed to international spaceports.

With the exception of a Virgin Galactic SpaceShipTwo mishap in 2014, all licensed or permitted HSF missions have been completed safely.

The second set of indicators pertains to the industry's progress in developing a safety

[4] https://www.faa.gov/about/plans_reports/congress/media/Sec.-111-Report-to-Congress-Evaluation-of-Commercial-Human-Space-Flight-Safety-Frameworks-and-Key-Industry-Indicators.pdf

framework and focuses on three areas:

1. Voluntary safety reporting
2. Voluntary consensus standards
3. Compliance with standards

This set of indicators points to the extent of industry self-regulation and establishing an industry-led safety regime. There has not been an appetite from industry to establish a voluntary safety reporting system yet. There are several reasons for this reluctance on the part of industry. First, no statutory data protection safeguards are in place for the commercial space transportation industry, in contrast with the aviation transportation industry (49 U.S.C. § 40123). Another reason often cited by industry is that safety issues, if reported, could affect the income or potential venture capital investments for the company reporting an issue. A third reason given is that those safety issues are proprietary knowledge in a nascent industry that is "failing forward" and considers failures as learning opportunities. An expensive lesson learned by one company may give a capital advantage to another company.

The development of robust voluntary consensus standards is another indicator that is not as advanced as expected. The industry has not established a robust set of voluntary industry consensus standards for high-priority areas and therefore, companies do not self-identify adherence to voluntary consensus standards. There are several reasons for this delay in the development and use of standards. First, it is expensive for a company to devote subject matter expert time to discussions about, and to build consensus around, a standard for a mode of transportation that is so divergent. The subject matter expert's time is spent designing, building, or modifying their employer's vehicle; this is a critical issue with the known shortage of engineers and scientists with the background to work in this booming industry. Another reason for the less-than-robust number of published standards is there are no regulatory performance requirements to establish boundaries and direction for the development of standards. Additionally, there is no third-party verification of adherence or compliance with standards.

The final set of indicators pertains to the FAA's readiness to enter into a safety framework and focuses on two areas:

1. U.S. DOT authority to transition to a safety framework
2. U.S. DOT expertise in Human Space Flight Safety

The expiration of the learning period or moratorium will facilitate the first indicator. Other than public safety-focused requirements, the FAA's part 460 is limited to the informed consent of crew and space flight participants.

The FAA engages with the ASTM F47 Committee on Commercial Spaceflight in developing standards and has increased participation with the working groups establishing standards for human space flight. Additionally, the FAA is working to update and publish a new version of the 2014 *Recommended Practices for Human Spaceflight Occupant Safety.* The agency will provide the updated document to COMSTAC for its review, observations, and recommendations before it is published later this year. The FAA originally developed this document to provide a compilation of practices that the agency believes are important and recommends for

commercial human space flight occupant safety. Now the document requires substantial updates, and the update effort includes incorporating lessons learned, adding new recommended practices, and incorporating additional information on how operators can verify the implementation of the recommended practices in the design, manufacture, and operation of launch and reentry vehicles.

Since 2014, when the FAA published the original *Recommended Practices for Human Space Flight Occupant Safety* document, there has been a significant increase in the frequency of commercial human space flight missions, as well as differences in the scope and type of missions compared to those envisioned in 2014. The FAA considered a broad range of human space flight activity in orbital and suborbital flights, from when occupants are exposed to vehicle hazards prior to flight through when they are no longer exposed to vehicle hazards after landing. In the 2014 document, the FAA did not explicitly cover orbital rendezvous and docking, long-duration flights (longer than two weeks), extravehicular activity, and any flights beyond Earth orbit. More specifically, the FAA assumed that any orbital vehicle would stay in orbit for a maximum of two weeks and could return to Earth in under 24 hours if necessary. The FAA also assumed that each member of the flight crew would be safety-critical, and space flight participants may perform limited safety-critical tasks. The updated *Recommended Practices for Human Space Flight Occupant Safety* will address gaps the FAA has identified and will provide a good foundation for the upcoming safety framework discussions with industry.

Based on the review of these readiness indicators, the FAA believes both the industry and the FAA are ready to work together and begin developing a safety framework. As discussed below, the FAA is beginning a formal gathering of industry recommendations by establishing a SpARC this year. The large time gap between the sunsetting of the learning period and the effective date of any new safety framework that includes regulation will allow for the implementation of a safety framework in an appropriate timeframe to meet industry needs.

IV. Activities Most Appropriate for New Safety Framework

The FAA's October 20, 2017, report to Congress[5] outlined several safety elements that a comprehensive set of safety standards for human space flight should address, including:

Design

- Human Needs and Accommodations – the steps necessary to accommodate specific human needs, such as consumables, human waste disposal, etc.
- Human Protection – the steps necessary to keep an occupant's physical and psychological stress at levels that can be considered safe for space flight participants and sufficient for flight crew and government astronauts to execute the flight.
- Flightworthiness – the minimum system capabilities necessary to maintain occupant safety.
- Human/Vehicle Integration – operational and design constraints necessary to integrate humans with a human space flight system.

[5] https://www.faa.gov/about/plans_reports/congress/media/Sec.-111-Report-to-Congress-Evaluation-of-Commercial-Human-Space-Flight-Safety-Frameworks-and-Key-Industry-Indicators.pdf

- System Safety – engineering and management principles, criteria, and techniques to achieve acceptable risk, within the constraints of operational effectiveness and suitability, time, and cost, throughout all phases of the system life cycle.

Manufacturing

- Steps necessary to ensure the system manufactured matches its design, including quality assurance, acceptance testing, and configuration management.

Operations

- Management – program controls necessary to ensure proper implementation of safety requirements.
- System Safety – system safety management and engineering principles, criteria, and techniques applicable during the operational phase of a system's life cycle.
- Planning, Procedures, and Rules – plans and procedures necessary to safely operate a human space flight system.
- Medical Considerations – medical needs and constraints for flight crew and space flight participants.
- Training – training needs of the flight crew, government astronauts, space flight participants, ground controllers, and safety-critical ground operations personnel.

These activities are reflected in the 2014 *Recommended Practices for Human Space Flight Occupant Safety* document. The activities most appropriate for a new safety framework early on most likely will include a number of these activities.

To further investigate activities most appropriate for a new safety framework, the FAA contracted with the Aerospace Corporation (Aerospace), a Federally Funded Research and Development Center, to research the safety frameworks of multiple transportation and leisure sectors and analyze case studies to show any emerging common themes that might be applicable to commercial HSF safety. These case studies came from conventional cars, autonomous vehicles, cruise ships, commercial aviation, and submarines. Aerospace Corporation identified three common components in their research:

i. People
ii. Safety Culture
iii. Data Collection and Analytics

Aerospace Corporation emphasized how human beings, with their potential to make mistakes, are the most fundamental element of any safety framework. Regardless of the exacting nature of risk mitigation strategies, the involvement of people throughout the design, development, and operation of systems will introduce risks. Those risks can be mitigated, but unanticipated hazards can be spotted by humans, who must be empowered to speak up and identify those hazards. This leads to the second element identified—safety culture. A positive safety culture will allow people to "see something and say something" without fear of punishment or retribution. The final key element is data collection and analytics. Aerospace noted, "[w]ithout collecting data on hazards, risks materials, processes, and the subsequent analyses, any reaction

to mishaps or accidents will be retroactive."[6]

Aerospace Corporation found that elements of a sound safety framework include, but are not limited to, industry consensus standards, best practices, regulations, oversight and enforcement, inspections, audits, verifications, certifications or licensing, international agreements and treaties, and accident and mishap investigations. As noted in the Aerospace report,[7] the safety framework for commercial HSF should exhibit the following five characteristics:

1. **Adaptive and evolutionary.** Technologies and safety aspects change through continuous innovation. As such, a framework should be able to evolve and adapt to various transportation and launch methods. It also should be able to adapt to individual operators and companies in all stages of development and maturity.
2. **Innovation permissible.** A safety framework should encourage innovation and be open to new approaches to accomplish safety goals.
3. **Comprehensive.** A framework should consider all system risks and not ignore risks absent of regulatory authorities. Hazards exist along all phases of flight. However, a framework should be flexible enough to address the range of risk factors appropriately.
4. **Quantifiable and technically informed.** Identified hazards and associated risks should be assessed in a quantifiable manner which calls for consistent data collection and analysis. Similarly, best practices, voluntary consensus standards, and regulations need to be technically informed and based on quantifiable data.
5. **Collaborative and transparent.** Safety is a shared interest of all stakeholders. Approaches and solutions to safety issues should be shared as broadly as possible.

These five characteristics will enable the successful and future-proof development of the safety framework.

Aerospace noted that the industry's proactive participation in creating consensus standards, systems for data collection and sharing, and maturing a sustainable industry safety culture will influence the timing and extent of government regulatory involvement significantly. Successful implementation of an industry participatory framework will minimize any regulatory burden on the industry while encouraging the development of increased safety protocols.

In summary, the FAA plans to use the SpARC (discussed below) as a collaboration platform to produce a list of activities most appropriate for a new safety framework. The FAA will use the updated Recommended Practices document, the Aerospace study, and any other relevant input to inform this process.

V. Transitioning from Today to New Safety Framework Tomorrow

As noted earlier, since 2004, Congress has maintained a "learning period" prohibiting DOT from promulgating any regulations governing the design or operation of a launch vehicle intended to protect the health and safety of crew, government astronauts, and space flight participants, absent a serious or fatal injury, or an unplanned event during a launch or reentry

[6] Aerospace Report, p. 1.
[7] Aerospace Report, p. 5.

that posed a high risk of causing a serious or fatal injury to crew, government astronauts, or space flight participants.

The current safety framework is based on an informed consent regime. The FAA requires the operator to inform space flight participants of the risks of a launch or reentry and that the U.S. Government does not certify the safety of the vehicle on which they have purchased or been given a seat to fly into space. The FAA and the commercial operator must provide information on the risks, so the occupants can make the informed decision to fly or not to fly.

The transition from informed consent to a new safety framework will need to occur in phases and must evolve as the industry develops. As Congress noted in 51 U.S.C. § 5090l(a)(l5):

> *The regulatory standards governing human space flight must evolve as the industry matures so that regulations neither stifle technology development nor expose crew, government astronauts, or space flight participants to avoidable risks as the public comes to expect greater safety for crew, government astronauts, and space flight participants from the industry.*

The future of the commercial human space flight industry depends on continual improvement of its safety performance, and the FAA is dedicated to performing its part. Performance-based regulatory regimes can be positive guardrails allowing innovation and development within established bounds for safety. These requirements also allow voluntary consensus standards to be developed to provide a means of compliance and can be the basis for updating or establishing new performance requirements for the industry to increase the safety of participants.

Any new regime will require the development of new performance-based rules, not simply prescriptive rules, giving the industry flexibility to develop new safety approaches at the speed of innovation and the ability to use voluntary consensus standards to meet the performance requirements. At this point in the commercial human space flight industry's evolution, transitioning from the current informed consent regime to a new safety framework should not stifle technological developments; rather, it will help the industry grow safely.

The first phase of a new regulatory framework regime will involve updating and publishing the *Recommended Practices for Human Space Flight Occupant Safety* document. This updated document will be the basis for SDOs, such as ASTM, to create consensus standards for the industry to utilize, and the government to use in establishing performance-based regulations. The FAA is updating this document and additional regulatory or legislative action is not needed.

Also, under 49 U.S.C. § 106(p)(5), the Secretary chartered the SpARC for HSF Occupant Safety (HSFOS).[8] SpARCs are similar to Aviation Rulemaking Committees (ARC), which have been used for many years by the FAA's Aviation Safety organization to gather industry data and feedback on potential aviation regulations. The HSFOS SpARC will assist the FAA in

[8] 49 U.S.C. § 106(p)(5) authorizes the Secretary of Transportation to establish Aerospace Rulemaking Committees that are not subject to the requirements of the Federal Advisory Committee Act.

formulating the first set of rules after the learning period sunsets. Eighteen months after its establishment, the SpARC will submit a report of recommendations to the FAA Administrator. After the Administrator receives the SpARC report, the FAA will draft a Notice of Proposed Rulemaking (NPRM) for public comment, during which time industry, the general public, and other government agencies will have the opportunity to review and comment on the proposed rule. Following the public comment period, the FAA will decide if a final rule can be published or if significant changes need to be made prior to publishing a final rule. This process will follow the Administrative Procedure Act (APA) as codified in 5 U.S.C. §§ 551–559. A final rule is projected to take approximately five years from the start of a SpARC through the publication of the final rule, with an effective date sometime after the rule is published.

The FAA will diligently seek recommendations from industry and other government departments and agencies to develop the final list of activities to include in the initial new safety framework. The FAA is working with industry and others through COMSTAC, SpARCs, and international space agencies, to garner the best ideas for developing the safety framework.

VI. Aerospace Rulemaking Committee

The HSFOS SpARC is comprised of approximately 24 representatives from current and prospective license and permit holders, training providers, industry groups, and academia. The discussions within the HSFOS SpARC meetings will be closed sessions to encourage full participation and open discussion. The FAA will task the HSFOS SpARC to provide consensus comments on two major items.

The first item is to determine the scope of future human space flight occupant safety regulations. The SpARC should also consider the level of safety for the occupants—e.g., how safe should flights be for crew, government astronauts, and space flight participants? A higher level of safety would require a more rigorous and extensive pre-flight evaluation and licensing process.

The second item will be to provide recommendations on how to create a human space flight occupant safety regime. This will be the framework for potential regulations—i.e., how the FAA should monitor and oversee occupant safety on commercial launch and reentry vehicles. The SpARC should consider the extent of the oversight. Regulations for the aviation industry cover the exact design specifications, parts, and materials used on passenger aircraft, and the SpARC will investigate and make recommendations on an approach between the current regime based on informed consent and the regime used for aviation. The SpARC will provide input for the FAA to determine that approach.

The FAA will develop the full plan for transitioning from the current regime based on informed consent to a new regulatory framework after receiving recommendations from the HSFOS SpARC. The plan will be informed by case studies from other transportation modes and likely will be incremental in nature.

VII. Other Actions Being Taken Now

In addition to the actions discussed above, the FAA also has been supporting industry's efforts to develop voluntary consensus standards for HSF, primarily with ASTM. Formed in 2016, the ASTM Committee F47 on Commercial Spaceflight has five technical subcommittees that develop and maintain standards. The scope of the committee is the development and maintenance of voluntary consensus standards and recommended practices for the commercial space flight industry. Among other standards, the committee is developing human space flight safety standards. The FAA supports ASTM through involvement with the subcommittees and working groups. FAA subject matter experts provide input and apply their expertise to assist with the development of ASTM standards.

The FAA is continuing its research and development effort to identify risks and risk mitigations for HSF participants to include equipment safety as well as environmental risks (e.g., space medicine). These projects will identify risks, as well as research tools and methodologies to mitigate the risks identified, informing the regulatory regime as well as standards development and best practices. The FAA has developed a significant body of research through the Center of Excellence for Commercial Space Transportation and is transitioning to an even greater collaborative body of research across the United States Government as well as academia. This body of growing work is informing the update of the *Recommended Practices for Human Space Flight Occupant Safety* document and will support safety framework discussions with industry.

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VIII. Conclusion

The United States is the world leader in the exploration of the next frontier: space. The HSF industry is moving at the pace of innovation, and the FAA believes both the FAA and industry are ready to work together to establish a new safety framework built on case studies, industry and government experience, research, and public input. The FAA continues to support industry fully in the development of substantial voluntary industry consensus standards as an integral part of any safety framework. The safety framework will not stifle industry's technological development. Rather the safety framework will encourage innovation while guarding the safety of the crew, government astronauts, and space flight participants.

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• Safety of the Industry	• The extent to which there is evidence of unsafe operations. • The extent to which the industry is having difficulty attracting new customers. • The extent to which insurance companies are willing to insure human space flight operations.

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Industry's Progress in Developing a Safety Framework Indicators

Readiness Area	Indicators
• Voluntary Safety Reporting	• The extent to which individual companies have an internal voluntary reporting system to identify and address potential precursors to accidents. • The extent to which industry members share safety data with each other, with a common data format and taxonomy.
• Voluntary Consensus Standards	• The extent to which industry has formed a consensus on top-level performance standards. • The extent to which industry has developed and maintains voluntary consensus standards in high-priority areas. • The extent to which industry has developed and maintains a robust set of voluntary consensus standards.
• Compliance with Standards	• The extent to which individual companies self-verify compliance with voluntary consensus standards. • The extent to which a third party verifies compliance with voluntary consensus standards.

Table 3

U.S. Department of Transportation Readiness Indicators

Readiness Area	Indicators
• USDOT Authority to Transition to a Safety Framework • USDOT Expertise in Human Space Flight Safety	• Status of the "learning period." • The extent to which the FAA has helped create elements of a space safety framework. • The extent to which the FAA has engaged with industry regarding standards development. • The extent to which the FAA has published safety practices related to commercial human space flight. • The extent to which the FAA has experience participating in a space safety framework.