

Human Space Flight Occupant Safety
Aerospace Rulemaking Committee

Recommendation Report
April 4, 2025

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I. Executive Summary

On April 21, 2023, the Secretary of Transportation established a Charter for the Human Space Flight Occupant Safety Aerospace Rulemaking Committee (Part 460 SpARC¹ or SpARC).² The Charter tasked the SpARC to:

Provide specific consensus comments on the following issues:

- i. Determining the scope of future human space flight occupant safety regulations;
- ii. Estimating the cost of future occupant safety regulations to the industry; and
- iii. Creating a human space flight occupant safety regime.³

Accordingly, this report offers consensus comments and recommendations on the status of the commercial human space flight industry, the Federal Aviation Administration's (FAA) current regulatory management of this industry, a qualitative assessment of the economic impact of certain recommendations herein, and the potential scope of any future human space flight occupant safety framework. The Office of Commercial Space Transportation (AST) within the FAA shares common goals with industry: To protect public safety; ensure occupant safety requirements are commensurate with the scale and scope of the industry, technological maturity of vehicle systems, and national policy priorities; and avoid premature regulatory burden that could otherwise inhibit this vital national capability.

Congress established that “the United States should ...only to the extent necessary, regulate those launches, reentries, and services to ensure compliance with international obligations of the United States and to protect the public health and safety, safety of property, and national security and foreign policy interests of the United States.”⁴ Congress designated the Secretary of Transportation to manage this authority.⁵ This authority was subsequently delegated to the FAA in 1995.⁶ Congress further established that the provision of launch services by the private sector “would be facilitated by stable, minimal, and appropriate regulatory guidelines that are fairly and expeditiously applied.”⁷ The FAA presently manages a comprehensive regulatory framework intended to protect public safety during launches and reentries under its legacy rules (in parts 415, 417, 431, and 435 of Title 14 of the Code of Federal Regulations (CFR)) and revised rules (in part 450 of the CFR).

In 2004, Congress granted regulatory authority over human space flight to the Secretary of Transportation (subsequently delegated to the FAA), subject to a learning period prohibiting such regulations.⁸ Congress has extended this learning period multiple times in recognition that regulations governing human space flight are not yet appropriate. This learning period currently extends through December 31, 2027. Congress has further established that any:

[R]egulatory standards governing human space flight must evolve as the industry matures so that regulations neither stifle technology development nor expose crew or space flight

¹ Part 460 refers to Part 460 of Title 14 of the Code of Federal Regulations, which contains the Federal Aviation Administration's human space flight requirements.

² [Human Space Flight Occupant Safety Rulemaking Committee Charter, April 21, 2023.](#)

³ *Id.* at 1.

⁴ Commercial Space Launch Act, Public Law 98-575, Sec. 2(7) (30 Oct. 1984).

⁵ *Id.* at Sec. (5)(a).

⁶ Department of Transportation and Related Agencies Appropriations Act, Public Law 104-50 (15 Nov. 1995).

⁷ Commercial Space Launch Act, Public Law 98-575 Sec. 2(6) (30 Oct. 1984).

⁸ Commercial Space Launch Amendments Act of 2004, Public Law 108-492 Sec. 2(c)(1), (2) (23 Dec. 2004).

participants to avoidable risks as the public comes to expect greater safety for crew and space flight participants from the industry.⁹

Under this learning period, Congress established that commercial human space flight providers shall operate within an informed consent regime, in which participants are provided specific details on the risk of the activity, consistent with adventure sports. Further, the FAA may promulgate rules (and has promulgated rules in 14 CFR part 460) intended to protect the health and safety of occupants in furtherance of public safety. The FAA may also promulgate occupant safety rules “limited to restricting or prohibiting design features or operating practices that...have resulted in a serious or fatal injury to crew or space flight participants” or that “contributed to an unplanned event or series of events during a licensed or permitted commercial human space flight that posed a high risk of causing a serious or fatal injury.”¹⁰

To appropriately inform the SpARC’s review, the SpARC membership includes subject matter experts from the launch and reentry industry, academia, independent human space flight safety experts, trade groups, legal professionals, new entrants to the industry, and other stakeholders. Additionally, the SpARC called independent witnesses from the U.S. government and other industries, including the insurance industry, to provide additional expertise.

The SpARC established four working groups (Regulatory Innovation, Safety, Medical, and Economic Impact) to determine the scope of human space flight occupant safety regulations and create a human space flight occupant safety regime. The Regulatory Innovation and Safety Working Groups merged as the SpARC recommendations were developed. Thus, the recommendations from these two working groups are combined rather than presented separately. The groups worked collaboratively to evaluate:

- The efficacy of the current human space flight occupant safety framework.
- Potential future safety frameworks and regulations that can be implemented.
- The technological and operational maturity and scope of the commercial human space flight industry.
- The technological and operational capability of the federal government to manage a human space flight occupant safety framework.
- Safety frameworks, both regulatory and standards-based, from other activities that could be applied to human space flight occupant safety.
- Issues pertaining to health and medical screening or risk assessment.
- The economic impact of future potential regulations.
- The comparative value of industry standards and regulations in the context of human space flight.

The SpARC evaluated the technical and operational maturity of both industry and AST, the readiness of both entities to operate within an expanded regulatory framework, and the timelines under which the regulatory framework of these activities might evolve. Over approximately 20 months, the SpARC interviewed subject matter experts, reviewed the full scope of human space flight activity, and reached consensus on the following findings:

1. **The commercial human space flight industry remains in an early development phase and has not reached levels of operational capacity, design stability, or frequency of flight anticipated when Congress granted regulatory authority to the Secretary of Transportation in 2004.** Technical approaches to human space flight remain diverse and without conformity of design seen in modes of common carriage transportation (e.g., aviation), to include suborbital and orbital

⁹ *Id.* at Sec. 2(a)(5).

¹⁰ *Id.* at Sec. 2(c)(14).

autonomous spacecraft, suborbital and orbital semi-autonomous spacecraft with varying degrees of crew control, suborbital aircraft launched vehicles, and balloons. Each vehicle architecture represents vastly different technical complexity and maturity, with significant differences in operation, use cases, and safety systems. The market for commercial human space flight is highly limited and growth has not occurred per earlier projections.

2. **The industry will continue to evolve, and scientific advances and technological improvements will enhance safety and reduce system risk over time.**
3. **The FAA and industry agree that commercial human space flight operators are highly focused on safety and incentivized to continuously improve; however, this activity remains risky because of unique and unavoidable challenges in space flight (i.e., operation in a challenging environment and high potential consequence of failure).** This risk will remain high until operators and the government refine safety approaches over thousands of flights. The industry's status stands in contrast to traditional modes of transport like common carriage aviation, which serves billions of people globally at all income levels and for all purposes, professional and leisure alike.
4. **The FAA's current public safety and informed consent framework governing occupants are appropriate given the state of the industry today.**
5. **Occupant and public expectations of safety evolve as a mode of transportation matures.**
6. **The FAA's current list of indicators presented to Congress in 2023 is inadequate to capture industry and regulator readiness for a new safety framework.¹¹**
7. **The ongoing feedback loops between the FAA and industry representatives are inadequate, leading to significant disconnects.** The FAA has indicated that it believes now is the time to develop and transition to a new safety framework.¹² However, no operators represented in the SpARC believe there is an urgent need for a new safety framework governing occupant safety, with additional perspectives and recognition of the need for evolving standards as the industry matures, as outlined throughout this document.
8. **The FAA does not apply a safety continuum today to its human space flight safety framework.** The Part 460 safety framework is "one size fits all," hypothetically meaning that, without change, the 5000th flight of an orbital vehicle would be subject to the same rules as the second flight of a suborbital vehicle. This stands in contrast to commercial aviation where experimental/light sport aircraft frameworks coexist with more rigorous type certification categories.
9. **The FAA has opportunities for improvement with the implementation of current regulations.** The well-meaning, but sub-optimal, implementation of the newest public safety framework governing launch and reentry (Part 450 regulations) offers many lessons to improve future occupant safety frameworks, especially as related to utilizing performance-based requirements.
10. **Vehicles determined by NASA as appropriate for crewed launch for government astronauts meet or exceed any occupant safety requirements that the FAA currently enforces in Part 460 to protect members of the crew.**

¹¹ [DOT Report to Congress: U.S. Department of Transportation Evaluation of Commercial Human Space Flight Activities Most Appropriate for New Safety Framework](#), September 29, 2023.

¹² *Id.*

- 11. The FAA would need to acquire (or gain access to) new technical capabilities to appropriately regulate human space flight beyond the framework that exists today.**

Recommendations

With these findings, the SpARC developed the following consensus recommendations for a future human space flight occupant safety framework:

REC 1	The FAA should utilize an oversight continuum to evaluate the degree of rigor strictly necessary, consistent with Congressional direction, for future occupant safety regulations that would coexist with the current rules (which are tailored to the adventure/experimental phase of the industry) and comport with AST’s statutory direction to establish “...stable, minimal, and appropriate regulatory guidelines that are fairly and expeditiously applied.”
REC 2	The FAA should continue to implement the current human space flight occupant safety framework, which includes informed consent, as the primary basis for managing risk under Part 460 while the industry remains in a nascent phase.
REC 3	The FAA should adopt a new list of indicators that better captures the state of the industry and the regulator. Indicators should be used to judge whether there is a need to introduce new occupant-safety frameworks.
REC 4	The FAA should use a “phased” or “incremental” approach to regulation for occupant safety.
REC 5	The FAA should ensure any new occupant safety regulations do not overlap or redundantly cause review under both Parts 450 and 460. Future occupant safety rulemaking processes should focus on identifying only additional regulations needed to protect occupants.
REC 6	The FAA should leverage any available industry standards and accept them as means of compliance to current and future rules where practical.
REC 7	The FAA should carefully consider the appropriate types of requirements for each phase of new regulations by considering the regulator’s ability to evaluate compliance and the impact requirement types can have on innovation.
REC 8	The FAA should accept NASA procurement of human space flight services as an equivalent level of safety to current and future elements of Part 460 pertaining to occupant safety.
REC 9	The FAA should partner with NASA and commercial vehicle operators to maximize its growth of technical resources to close the gaps in expertise that current and future phases of the regulatory framework demand. An emphasis should be placed on recruiting individuals with highly relevant professional experience as well as maximizing hands-on professional development opportunities within the existing workforce.
REC 10	The FAA should contribute to an effort to strengthen the existing informed consent process.

REC 11	The FAA should maintain an industry safety record database to inform space flight participants about the general risk of space flight as well as vehicle and operator specific safety records as required under § 460.45(c) (“An operator must inform each space flight participant of the safety record of all launch or reentry vehicles that have carried one or more persons on board, including both U.S. government and private sector vehicles.”)
REC 12	The FAA should improve its implementation and harmonization of existing processes under Part 450 and Part 460, which will have beneficial effects for both public and occupant safety.
REC 13	The FAA should initiate a rulemaking to modify Part 460 to enable space flight participants to perform public safety-critical roles when given the appropriate training.
REC 14	The FAA should initiate a rulemaking to provide relief for prescriptive rules in 14 CFR part 460 that do not universally apply to the architectures that emerged over the last 20 years.
REC 15	The FAA should develop and allocate subject matter experts to collaborate with industry in voluntary consensus standards forums.
REC 16	The FAA should establish an ongoing advisory committee to capture industry feedback, demand, and readiness for new occupant safety frameworks.
REC 17	The FAA should expand technical resources to manage the growing scope within the FAA’s current authority and more effectively learn from the advancements occurring in the industry.
REC 18	The FAA should facilitate voluntary data sharing between operators.
REC 19	The FAA should recommend a matrixed assessment approach that utilizes safety-related roles and responsibilities of the space flight participant for risk assessment to determine the participant’s ability to perform safety-related functions.
REC 20	The FAA should support improvements of legal clarity for the practice of aerospace medicine.
REC 21	The FAA should recommend a baseline expectation of documentation internal to each industry provider that establishes and details risk assessment and acceptance as well as corresponding rationale, with an expectation that such documentation will be provided if required by the FAA or other regulatory body at a future time.
REC 22	The FAA should include the estimated cost of all proposed and modified rules in future rulemaking.

For additional details on each of these recommendations, see Section VI. Recommendations and Conclusions. The public and spacecraft occupants need to recognize that the industry is in the high-risk adventure/exploration stage and not be fooled by thinking that regulations are adding a safety layer and preventing risks. It is the consensus of the SpARC that occupants are well served by the current regulatory framework that openly discloses the risks that they will be exposed to by choosing to fly in space. The vehicle occupants are in the best position to judge the benefits and weigh the risks appropriately, as long as risks have been communicated appropriately.

II. Chair's Comments

This SpARC Part 460 consensus report is the result of over 20 months of meetings, reviews, analysis, listening sessions, and vigorous discussion and debate conducted on behalf of the commercial human space flight industry by representatives from industry-leading companies, subject matter experts, aerospace medicine professionals, legal experts in space law, new industry entrants, operators, users, and the FAA itself, which provided its expertise to answer questions and provide information whenever requested. Drawing on decades of experience as well as “breaking news” information and the diverse experience of all representatives, the report constitutes a major contribution not only to the FAA as it considers a future regulatory framework for commercial human space flight occupant safety, but more broadly to the national and international dialogue regarding commercial human space flight across a range of interrelated topics such as factors impacting market growth; broad implications for data sharing between government and industry as well as across industry; difficulties in developing a robust knowledge base and capturing complex changes in technology across a growing, diverse but still emerging sector; and of course thoughtful consideration of the rationale and implementation of future regulation regarding commercial human space flight occupant safety.

To that end, the most significant aim of any regulatory practice and business model in the commercial space industry should be safety. This includes, in order of priority, ensuring public safety, crew safety, and mission safety; these goals are achieved through a deliberate and interdisciplinary approach to risk assessment and risk mitigation encompassing all aspects of the commercial space flight mission, starting with the pre-launch training activities and concluding post-landing following crew recovery operations and any medical reconditioning or post-flight care. The vehicles, missions, crewmembers, and many other aspects of commercial space flight represent the next steps in our history of human exploration of the unknown and expanding our capabilities in science, technology, medicine, and curiosity. An intentional delay in mandating government regulation fosters rapid and innovative growth in knowledge and capabilities and allows commercial space flight companies to be agile in the development and iteration of novel solutions to challenges associated with human space flight. This model is dependent upon individual providers and the industry as a whole recognizing and honoring their obligation to prioritize safety in the hierarchy; in turn, this focus on safety further enables the growth of the industry and ever-growing access to space.

Of particular note in this report is the integrative approach taken to a number of the topics discussed here. Rather than presenting industry recommendations in a stove-piped manner, the members of the SpARC have approached their tasks both specifically and holistically, addressing the interplay between various parts of the CFR (notably Parts 450 and 460, but also implications from Part 440), recommendations aimed at improving the relationship and interactions between government and industry, and considerations regarding potential economic impacts of a future regulatory framework in light of experience from other industries, as well as the implications of specific recommendations found herein. In keeping with this approach, some of the recommendations here go beyond the purview of the FAA, with calls to increase resourcing and expertise at the agency that may require Congressional action as well as collaboration across federal agencies. At the same time, many of the recommendations herein are highly specific and nuanced with extensive rationales. The reader is advised to take some time with the report, as it represents a “deep dive” from some of the best and most experienced thinkers and operators in the industry.

Taken together, the recommendations in this report are intended to create a future where the FAA and industry can cooperate proactively and implement flexible occupant safety frameworks. The human space flight market faces a complex future where many architectures and varying degrees of flight heritage will coexist. The regulatory safety framework must be correspondingly flexible and innovative to encourage the industry's growth while maintaining its excellent public and occupant safety record. The FAA is

encouraged to engage thoughtfully with these recommendations, provide feedback, and request clarifications as needed, and to continue its efforts to strengthen cooperation and collaboration with industry whenever possible toward these shared goals.

III. Background and Purpose of the Part 460 SpARC

A. Creation of the Part 460 Aerospace Rulemaking Committee (SpARC)

The U.S. Department of Transportation (DOT) chartered the Human Space Flight Occupant Safety Aerospace Rulemaking Committee (Part 460 SpARC or SpARC) on April 21, 2023, “to provide consensus information, concerns, opinions, and recommendations” on the current and future human space flight occupant safety framework presently managed by the Federal Aviation Administration (FAA).¹³ The charter directs the SpARC to provide specific consensus comments on the following issues:

- i. Determining the scope of future human space flight occupant safety regulations;
- ii. Estimating the cost of future occupant safety regulations to the industry; and
- iii. Creating a human space flight occupant safety regime.¹⁴

All evaluations, findings, and recommendations in this report represent the consensus of the SpARC.

B. Policy Background

The Commercial Space Launch Act of 1984, as amended, authorizes the Secretary of Transportation to “only to the extent necessary, regulate those launches, reentries, and services to ensure compliance with international obligations of the United States and to protect the public health and safety, safety of property, and national security and foreign policy interests of the United States.”¹⁵ The DOT is further guided by Congress’s stated purpose “...to promote economic growth and entrepreneurial activity through use of the space environment for peaceful purposes[.]”¹⁶ Congress found that “space transportation is inherently risky, and the future of the commercial human space flight industry will depend on its ability to continually improve its safety performance.”¹⁷ In 1994, following limited activity in the commercial space sector, DOT delegated regulatory responsibility to the FAA, while retaining the statutory authorization imparted by Congress.¹⁸ The FAA subsequently established the Office of Commercial Space Transportation (AST) to manage this responsibility.

In June 2004, a two-person private crew flew the experimental Spaceship One to an altitude over 100 kilometers (km), marking the first non-governmental flight to suborbital space.¹⁹ Following this milestone, Congress passed the Commercial Space Launch Amendments Act (CSLAA) in 2004.²⁰ The CSLAA established the regulatory guidance for human space flight occupant safety. Specifically, the CSLAA provided the Secretary of Transportation (the FAA, by delegation) the authority to regulate occupant safety, but established a “learning period” through 2012 for both industry and DOT to develop technical expertise,

¹³ [Human Space Flight Occupant Safety Rulemaking Committee Charter, April 21, 2023.](#)

Part 460 refers to regulations concerning “Human Space flight Requirements” within 14 CFR Part 460.

¹⁴ *Id.* at page 1.

¹⁵ 51 U.S.C. § 50904.

¹⁶ 51 U.S.C. § 50901.

¹⁷ 51 U.S.C. § 50904.

¹⁸ [Origins of the Commercial Space Industry](#) (page 3).

¹⁹ George Nield, D. Brooke Owens, and John Sloan. “[The Origin and Practice of Commercial Human Space Flight Regulations](#),” Federal Aviation Administration (2008).

²⁰ Commercial Space Launch Amendments Act of 2004, Public Law 108-492 (23 Dec. 2004).

operational experience, and policy guidance prior to promulgating any regulations (under Part 460) in this area.

The Congressional intent behind the CSLAA was made clear during debate on the House floor when Representative Boehlert, a co-sponsor of the bill, stated:

[H]ere is what the bill does not do. It does not allow the FAA right now to guess whether some new untested rocket technology will do harm to the people on board. Why? Because this industry is at the stage when it is the preserve of visionaries and daredevils and adventurers. These are people who will fly at their own risk to try out new technologies. These are people who do not expect and should not expect to be protected by the government. Such protection would only stifle innovation.²¹

At the time of the CSLAA's passage, both industry and government anticipated and required significant, near-term industry activity to inform the learning period. In the Human Space Flight Requirements for Crew and Space Participants final rule regulatory evaluation section, published in 2006, the FAA predicted between 5,081 and 10,142 launches with private individuals—known as Space Flight Participants (SFPs)—through 2016, with many or most occurring during the pendency of the learning period.²² However, the rapid technical progress did not materialize, and there were zero human space flight missions with SFPs during this timeframe. The first mission with SFPs occurred in 2021, and there have been over two dozen suborbital and orbital space flight missions with SFPs since then. Given this limited level of activity compared to the expected minimum experience projected by the FAA in 2006, Congress successively extended the learning period from 2012 to 2015, 2023, 2024, and 2028 to provide additional time for this operational activity to materialize. Each time, Congress has reaffirmed that the policy framework for commercial space launch and reentry accepts that there will continue to be this “inherent risk” of space flight and that the industry remains in a nascent state, with significant technological development required.²³

IV. SpARC Charter – Tasks and Objectives

Task 1. – Determining the scope of future human space flight occupant safety regulations.

The scope of future human space flight occupant safety regulations in this SpARC are generalized within space flight human safety in launch, re-entry, and times before flight and after landing where humans are exposed to flight hazards. The tradeoffs between space flight human safety and public safety also are within scope. Additionally, the discussions in this SpARC included what the appropriate roles of government and industry are in creating a safety framework, and how the two parties can work together.

Task 2. – Estimating the cost of future occupant safety regulations to the industry.

The Economic Impact Working Group was developed within the SpARC to address this objective. The working group's comments and recommendation follow the FAA's duty to implement “stable, minimal, and appropriate regulatory guidelines that are fairly and expeditiously applied” while ensuring that any regulations neither stifle technology development nor expose crew, astronauts, or space flight participants to avoidable risks as the public comes to expect greater space flight safety...from industry.”²⁴ Reviewing independent sources on the human space flight market, including expected global government investment,

²¹ 150 CONG. REC. H10048-49 (daily ed. Nov. 19, 2004).

²² [Human Space Flight Requirements for Crew and Space Participants Final Rule](#), 71 FR 75616 (December 5, 2006), (See Regulatory Evaluation Section, page 75629).

²³ 51 U.S.C. § 50905(a)(12).

²⁴ 51 U.S.C. § 5090.

as well as outside assessments from the Congressional Research Service and the Government Accountability Office helped to inform consideration of potential economic impacts of future occupant safety regulations. Observations made by the group are to inform the SpARC, rather than replacing the FAA’s own economic impact report required as part of the regulatory process.

Task 3. – Creating a human space flight occupant safety regime.

The SpARC developed recommendations intended to create a future where the FAA and industry can cooperate proactively and implement flexible occupant safety frameworks. The human space flight market faces a complex future in which many architectures and varying degrees of flight heritage will coexist. The regulatory safety framework must be flexible and innovative to encourage industry growth while maintaining its public and occupant safety record.

V. Regulatory & Industry Overview

A. Regulatory Innovation & Safety

1. Status of Commercial Human Space Flight

a. Current Safety Framework

Any U.S. commercial operator seeking to fly SFPs today must receive FAA licensing to ensure public safety. The FAA launch and reentry public safety framework is complex and comprehensive. Importantly, the learning period does not prohibit all regulations on commercial space flight (see Figure 1).

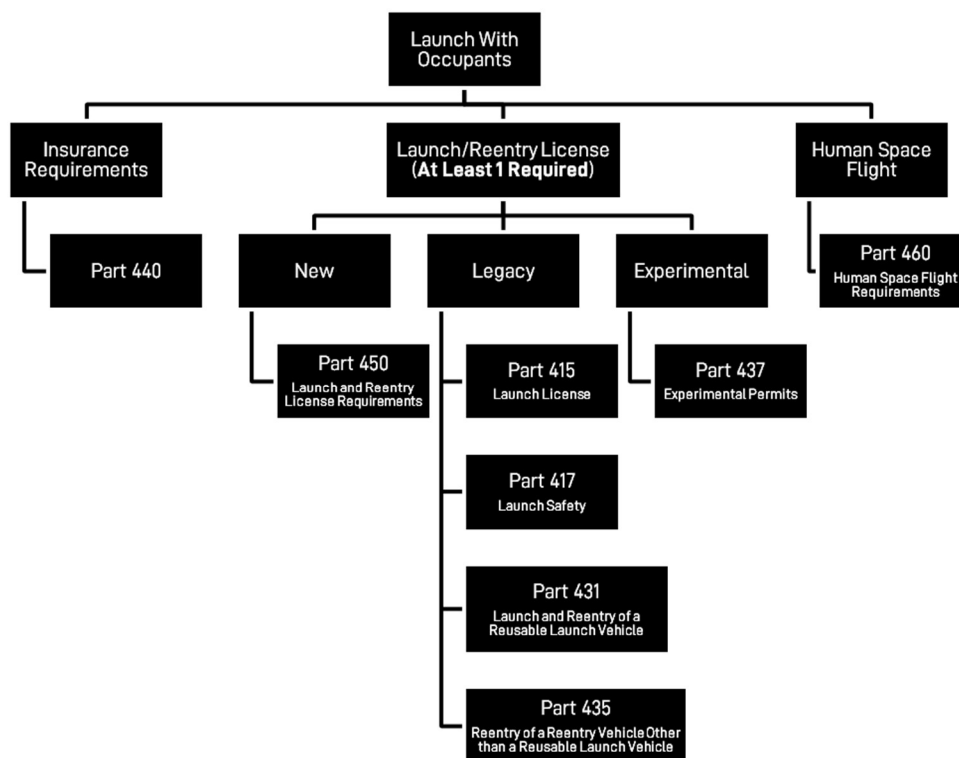


Figure 1: FAA-imposed regulatory requirements for human space flight today

i. Launch and Reentry Regulations Under Part 450

Regulations on commercial launches and reentries are intended to protect public safety, property, national security, and foreign policy interests.²⁵ To achieve this outcome, the FAA imposes significant requirements for operators under its legacy regulations (located in 14 CFR parts 415, 417, 431, and 435) and revised regulations (located in 14 CFR part 450). Importantly, the FAA does not and cannot—by law—regulate for mission success, due to the “inherent risk” in space flight identified by Congress, and because the FAA’s authority does not extend to orbital operations. Missions may result in failure to achieve their intended outcomes—including loss of vehicle—as long as the public is protected. Under this regime, the FAA and industry representatives have a perfect health and safety record for licensed launches—with zero injuries or fatalities. It remains the launch provider’s responsibility to ensure the appropriate controls are in place for “mission success,” which could mean placing a payload in its intended orbit, or in human space flight, safely landing back on the ground with healthy occupants.

The FAA’s regulations for launch and reentry require comprehensive reviews by the government of launch and/or reentry vehicle system safety, flight safety, and ground operations safety—all with the goal of protecting public safety. The existing regulatory review areas encompass the full range of potential public safety risk—and mitigations to reduce that risk—from company quality processes and planned trajectories to detailed safety critical designs and schematics of the launch vehicle.

The launch/reentry licensing process can take years between the mandatory pre-application period, where means of compliance are approved, and the formal application review period, where the FAA analyzes all necessary material supplied by the provider. A vehicle operating license under Part 450 is divided into two categories of documentation: 1) means of compliance and 2) license material. Means of compliance (MOC) are documented plans for how an operator will demonstrate compliance to a particular requirement or set of requirements. MOC may be generic or specific to an operator or vehicle. FAA concurrence to certain MOCs is the first step in obtaining a Part 450 license.²⁶ The evidence that an operator followed its planned MOCs for a given launch is contained in license material.

Part 450 departs from legacy regulations in structure and regulatory compliance strategy. The new regulation is built around performance-based requirements that allow operators to propose novel means of compliance. This structure contrasts with the legacy regulations and their prescriptive requirements, which were outdated and required waivers to allow for modern-day launch and reentry operations. Part 450 also consolidated regulations for various space operations under one part.

The FAA mandated operators must switch to licensed operations under Part 450 by March 2026. However, to date, of the 24 active launch licenses, only six are operated under Part 450. Of the three active reentry licenses, two are new operators under Part 450.

The FAA has licensed launches and reentries with space flight participants under its legacy regulations but has not licensed any commercial human space flight missions under Part 450 regulations. Industry, the FAA, and Congress have acknowledged numerous, significant operational concerns with Part 450. As a result, DOT chartered a new SpARC on November 7, 2024, to evaluate these issues and provide recommendations for improvement.²⁷

The interactions between Part 450 and Part 460 remain untested, an important data point for the industry as it seeks to understand the degree of overlap that exists in practice. Given the open-ended nature of

²⁵ 51 USC § 50905.

²⁶ 14 CFR 450.35.

²⁷ [Launch and Reentry License Requirements Improvement Aerospace Rulemaking Committee Charter, November 14, 2024.](#)

performance-based requirements, where what is needed to be done is specified, but not how to do it, the FAA publishes Advisory Circulars (AC) to help operators understand the intent of a given rule and reference one way, but not the only way, to comply with a rule.²⁸ Inevitably, the first time an operator leverages a Part 450 license in conjunction with a Part 460 human space flight license, unforeseen challenges will arise, and opportunities for improvement will be identified. The lessons learned can then be incorporated into updated Advisory Circulars and future rulemakings.

The Part 450 safety framework is summarized in visual form in the Streamlined Launch and Reentry License Requirements final rule:

Figure 2: Safety Framework

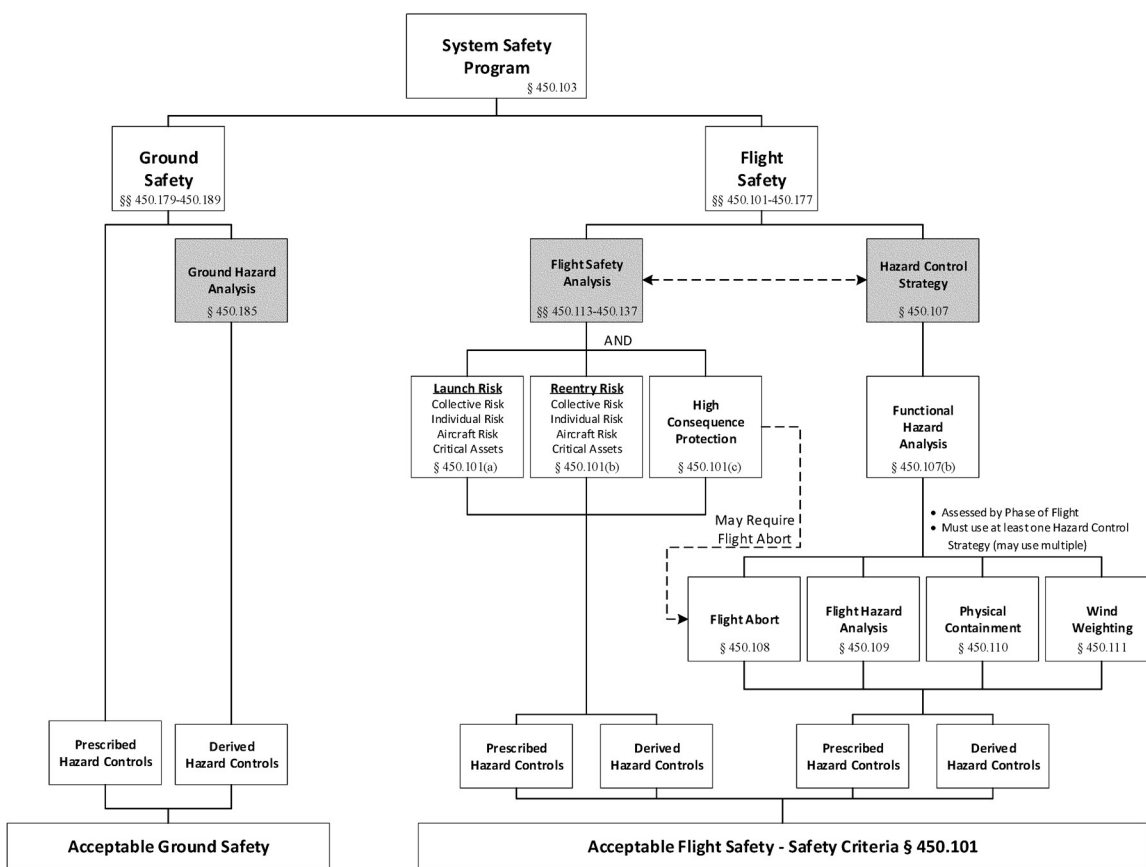


Figure 2: Visual representation of the Part 450 safety framework as presented in the Streamlined Launch and Reentry License Requirements final rule²⁹

ii. Financial Responsibility Requirements (Part 440)

The FAA issued the Financial Responsibility for Licensed Launch Activities final rule (Part 440) on August 26, 1998.³⁰ The rule was promulgated in response to a Congressional mandate to establish financial responsibility requirements for risks arising from licensed launch and reentry activities, and to allocate risk

²⁸ [Aeronautical Information Manual \(AIM\) Code of Federal Regulations and Advisory Circulars.](#)

²⁹ [Streamlined Launch and Reentry License Requirements](#), 85 FR 79566 (December 10, 2020) (*See* Section III, p. 79574).

³⁰ [Financial Responsibility Requirements for Licensed Launch Activities](#), 63 FR 45592 (August 26, 1998).

among various parties involved in licensed operations, including the United States government. While consideration of Part 440 is outside the scope of this SpARC, background is included here due to its implications for occupant safety and economic impacts discussed later in the report.

The Part 440 regulations outline the financial responsibilities for licensed reentry activities, launches, and permits and consider the following:

- **Maximum Probable Loss (MPL)** - A probabilistic assessment of the amount of insurance or escrow needed to cover property and life damage in the event of a mishap during launch or reentry. The are two different coverages required:
 - a. Losses to third parties, excluding Government personnel and other launch or reentry participants' employees involved in licensed or permitted activities and neighboring operations personnel, that are reasonably expected to result from a licensed or permitted activity are those that have a probability of occurrence of no less than one in ten million.
 - b. Losses to Government property (range) and Government personnel involved in licensed or permitted activities and neighboring operations personnel that are reasonably expected to result from licensed or permitted activities are those that have a probability of occurrence of no less than one in one hundred thousand.
- **Reciprocal waiver of claims** - A requirement that licensees, permittees, and customers extend to their contractors, subcontractors, and customers.

Overall, the purpose of the Part 440 rule is for the licensee to provide its evidence of financial responsibility as determined by the FAA MPL. The MPL limit of financial responsibility is intended to cover claims brought by third parties and damage to U.S. government property from the risk of loss by the licensed activity. The requirement to provide evidence of financial responsibility does not extend to potential claims of occupants of the launch or reentry vehicle. Crew and SFPs are excluded from the definition of "third party." Further, Part 440 is intended to limit the U.S. Government's liability exposure while facilitating the development of the robust U.S. commercial launch/reentry industry.

The FAA convened a SpARC to review and provide recommendations on Part 440. The Part 440 Financial Responsibility Aerospace Rulemaking Committee (440 SpARC) provided a forum for industry stakeholders to provide recommendations for updating Part 440, which governs administration of the financial responsibility regime for licensed launch and reentry activities in commercial space. The 440 SpARC was tasked with providing consensus comments on improving MPL determinations, modernizing financial responsibility requirements, and creating a responsive reciprocal waiver of claims regime. As noted in the final 440 SpARC report, the 440 SpARC explored approaches to updating current FAA practices and assumptions, as well as new methodologies to demonstrate financial responsibility. The 440 SpARC conducted analyses to confirm its proposals were reasonably achievable and responsive to industry needs and the requirements of the financial assurance and insurance underwriting markets that are critical to allowing licensees to demonstrate compliance with the financial responsibility requirements. The final report of the Part 440 SpARC was submitted to the FAA on March 1, 2024.³¹

iii. Human Space Flight Occupant Safety (Part 460)

In 2006, the FAA published the Human Space Flight Requirements for Crew and Space Flight Participants final rule.³² These regulations were promulgated at a time when commercial space flight operators were expanding or planning to expand into the human space flight business. Because the FAA's statutory authority is to protect public safety, the new human space flight requirements were structured to include

³¹ [Part 440 Financial Responsibility Aerospace Rulemaking Committee](#) (March 1, 2024).

³² [Human Space Flight Requirements for Crew and Space Flight Participants](#), 71 FR 75616 (December 15, 2006).

“rules on crew qualifications and training, and informed consent for crew and space flight participants” to protect the public from space flight operations involving humans.³³ The occupant safety requirements account for hazards to the public from human space flight operations and provide a foundation upon which future human space flight requirements may be added if the learning period expires, and Congress and the FAA determine new regulations are needed as the industry evolves.

The categories of “crew” and “space flight participant” recognized that certain people aboard a space flight may be employed by the operator, whereas others would be passengers. While this structure mimics the airline industry, it did not adequately predict the direction of operator space flight models where crew or pilots, separate from passengers onboard, are necessary. The U.S. Commercial Space Launch Competitiveness Act (CSLCA) Incorporation final rule was published on September 19, 2024, with an effective date of November 18, 2024.³⁴ The rule addressed applicants seeking licenses for space flight operations involving government astronauts by adding two new subparts to the human space flight regulations containing requirements for operators with government astronauts with and without safety-critical roles on board vehicles. This third category of passenger bridged a gap in Part 460’s original structure that did not foresee the commercial space flight operations of today where NASA astronauts are transported via commercial spacecraft to and from the International Space Station.

The regulations are divided by operations with crew versus operations with space flight participants based on their role onboard the spacecraft. Crew is defined as:

[A]ny employee or independent contractor of a licensee, transferee, or permittee, or of a contractor or subcontractor of a licensee, transferee, or permittee, who performs activities in the course of that employment or contract directly relating to the launch, reentry, or other operation of or in a launch vehicle or reentry vehicle that carries human beings. A crew consists of flight crew and any remote operator.³⁵

A crew assumes responsibility for some input to operate the spacecraft in a safe manner to protect the public. Current crew requirements under Part 460 include specific crew qualifications and training, including of an FAA pilot certificate, including instrument rating, and knowledge necessary to control the spacecraft within the National Airspace System (NAS).³⁶ Further, any crew with safety-critical roles must also “possess and carry an FAA second-class airman medical certificate issued in accordance with 14 CFR part 67.”³⁷ Under Part 460, a crew is also subject to operator training for their duties as crew.

For launches or reentry operations with crew, operators must meet specific requirements for crew training, environmental control and life support systems (ECLSS), smoke detection and fire suppression, and human factor requirements. This exists to protect the health of the crew such that the space vehicle can be operated in a safe manner that does not pose a risk to the public. Space flight participants do not incur the same level of protection because their roles do not impact public safety. Space flight participants are defined as “an individual, who is not crew, carried aboard a launch vehicle or reentry vehicle.”³⁸ FAA regulations require that operators inform both space flight participants, as well as crew, of the risk incurred by participating in the launch or reentry operation.

³³ *Id.* at 75632.

³⁴ [U.S. Commercial Space Launch Competitiveness Act Incorporation](#), 89 FR 76714 (September 19, 2024).

³⁵ 14 CFR 401.5.

³⁶ 14 CFR 460.5(c)(2).

³⁷ 14 CFR 460.5(e).

³⁸ 14 CFR 401.5.

The model of informed consent allows space flight participants, who do not incur the same protection as crew, to appropriately understand the hazards of the operation. This requirement places the responsibility of educating the space flight participant on the operators to communicate all hazards of the space flight operation among other launch and reentry safety statistics. Space flight participants are then left with the choice to acknowledge these hazards and fly or not. This model is akin to other high-intensity or adventure sports like skydiving or mountain climbing.

A key element of the implementation of Part 460 is the learning period that limits the FAA from promulgating rules specifically governing occupant safety beyond those necessary for protecting the public. The FAA may not publish rules to specifically protect occupant safety until the learning period expires, or a specific design feature causes, or almost causes, a serious injury or death. While the current crew requirements under Part 460 protect crew health via life support systems and other training or spacecraft requirements, they are in the service of ensuring safe operations of the vehicle to ultimately protect the public. This stands in stark contrast to commercial air travel, where the FAA's type certification process applies highly prescriptive rules intended to protect passengers and the public based on a history of incremental improvements and proven designs, with over a century of development with a consistently increasing flight rate. The FAA currently supports over 16 million scheduled flights per year and the public has a very high expectation of safety on common carriage modes of transportation.³⁹ Congress recognized that the commercial space flight industry is too dynamic and too early in its development cycle for the kind of full-scale regulation that characterizes air travel. The FAA acknowledges this by stating:

"The aviation industry is regulated down to the exact design specifications, parts, and materials used on passenger aircraft. Congress has not directed such 'certification' of commercial human space flight vehicles but has instead directed an informed consent requirement to be in place."⁴⁰

The reality of human space flight operations and their regulation by the FAA is that operators must meet the requirements in parts 450 and 460. Part 450 regulates safe operations of space vehicles, and any systems identified as safety critical undergo rigorous reviews by the FAA for their implications to public safety. While not all mitigated hazards protect occupants, any space flight passenger ultimately receives a certain amount of protection from the safe function of the space vehicle per its Part 450 evaluation. *However, as of this writing no operator currently holds both a Part 450 launch or reentry license and a Part 460 approval.* The connection between these two regulatory regimes has not yet been tested in tandem.

Critically, with humans onboard, the FAA has the authority to promulgate rules governing the design and operation of a vehicle as a result of learning from a serious injury, near miss, or death.⁴¹ This authority exists outside of the moratorium on other regulation imposed by the learning period. The FAA has indicated that under current authority, a rulemaking would be limited to addressing the specific cause of the accident or near miss. The FAA may also decide to use guidance instead of issuing a rule to mitigate risk based on the lessons learned. The current authority enables AST to take proactive steps in response to a near miss to prevent future accidents.⁴²

b. Evaluation of Industry and Government Readiness

The 2015 U.S. Commercial Space Launch Competitiveness Act (CSLCA) mandated that DOT must report to Congress "key industry metrics that might indicate readiness of the commercial space sector and the Department of Transportation to transition to a safety framework... that considers space flight participant, government astronaut, and crew safety."⁴³ At the time, there was mounting excitement surrounding

³⁹ [Air Traffic By The Numbers, September 9, 2024.](#)

⁴⁰ [Regulatory Preparation for U.S. Commercial Human Space Flight](#), IAC-22-B3-2-71847, September 2022, (p. 4).

⁴¹ [51 U.S. Code § 50905\(c\).](#)

⁴² *Id.*

⁴³ [U.S. Commercial Space Launch Competitiveness Act, Public Law 114-90](#), Sec. 111(6) (November 25, 2015).

NASA's Commercial Crew Program (CCP), as well as suborbital vehicles in development offering rides to adventure travelers. The reports mandated by the CSLCA ensured that Congress would stay informed about industry developments. In a Senate report accompanying the CSLCA, the context behind the heightened sensitivity to industry progress is provided:

As activity in the commercial launch industry has increased in recent years, the FAA has started to consider the potential for an expansion of its licensing and regulatory activities regarding commercial space flights. Under current law, however, the FAA is constrained from proposing or implementing new regulations governing commercial space flight that would affect the operations of the crew transportation capabilities currently under development. The moratorium on such regulations during the industry's "learning period" was first enacted under section 2(c) of the CSLA Amendments of 2004 (118 Stat. 3977), and in 2012 was extended through September 30, 2015 (51 U.S.C. 50905(c)), with the rationale that FAA regulatory burdens on the relatively new and rapidly evolving commercial space launch industry could slow innovation, particularly when it remains to be clear which areas the FAA should regulate. Congress has indicated it wants the FAA to be in discussions with industry regarding safety, and excepted from this regulatory moratorium are potential new regulations on vehicle design or operation that stem from design issues that have contributed to a serious or fatal accident. Additionally, space flight participants participate under an informed consent risk regime. Current restrictions on FAA regulation authority apply only to those regulations intended to protect the safety of crew and spaceflight participants, and this legislation would add government astronauts. There are no such restrictions on regulations protecting the safety of the uninvolved public.⁴⁴

In 2017, the FAA submitted its first report to Congress detailing three sets of indicators that "might indicate readiness to transition to a safety framework that may include regulations."⁴⁵ The report goes on to cite the core underlying premises behind the indicators, which are rooted in statute:

A number of core premises underlie the indicators that might indicate readiness to transition to a safety framework that may include regulations. The first is that the human space flight industry must continually improve its safety performance. This is because industry growth depends on attracting new customers beyond early adopters, many of whom will expect higher levels of safety. This is in accordance with 51 USC § 50901(a)(12), which states that "[s]pace transportation is inherently risky, and the future of the commercial human space flight industry will depend on its ability to continually improve its safety performance."

The second premise is that as industry grows and matures, the depth and breadth of a safety framework should evolve. An industry-wide safety framework can codify and disseminate lessons learned from 64 years of human space flight, as well as new lessons learned from the growing industry. Industry conformity with a safety framework will also become necessary to support continuous improvement of the industry's safety performance.

The third premise is that the public's expectation of safety will increase as the purpose of flying to space evolves from adventure, to occupation, to transportation. If flying for adventure, people who are willing to take the risk will fly, and those who are not willing to,

⁴⁴ [U.S. Commercial Space Launch Competitiveness Act Report of the Committee on Commerce, Science, and Transportation on S. 1297](#) (July 22, 2015).

⁴⁵ [FAA Evaluation of Commercial Human Space Flight Safety Frameworks and Key Industry Indicators](#) (October 20, 2017) p. 15.

will not. People who must fly in space as part of their occupation will have a higher expectation of safety. The flying public will have an even higher expectation of safety when space travel becomes a means to get from point A to point B.⁴⁶

The FAA created three categories of indicators based on the premises above tracking industry readiness, industry's progress in creating standards-based safety framework, and FAA readiness, detailed in Table 1-3 below.⁴⁷

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.	- 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.

⁴⁶ *Id.*

⁴⁷ *Id.* at 18-19, 21, 24.

Table 3: FAA Readiness Indicators

Readiness Area	Indicators
• FAA Authority to Transition to a Safety Framework.	• Status of the “learning period.”
• FAA Expertise in Human Space Flight Safety.	• 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.

In 2019, the FAA provided an updated report to Congress on the industry’s status in relation to the list of indicators and concluded:

At this point in the commercial human space flight industry’s evolution, transition to a new safety framework might stifle technology development. As the industry continues to evolve, FAA remains committed to aiding the development of voluntary industry consensus standards and is actively engaged with industry in that effort. Industry’s proactive participation in creating a safety framework can influence the timing and extent of government regulatory involvement, and successful implementation of an industry-led framework could minimize the need for government involvement.⁴⁸

In September 2022, the FAA published a paper at the 73rd International Astronautical Congress (IAC) in Paris called *Regulatory Preparation for U.S. Commercial Human Spaceflight*. In this paper, the FAA evolves its view of the industry by stating:

The FAA has seen an increase in commercial human spaceflight activity that may indicate readiness of the commercial space sector to collaborate on a safety framework including regulations for human spaceflight. The FAA is entering a regulatory preparation period... The FAA’s regulatory preparation includes three major aspects – an Aerospace Rulemaking Committee (SpARC), updating the *Recommended Practices for Human Space Flight Occupant Safety*, and participating in voluntary consensus standards development.⁴⁹

At the time the FAA published the paper at the IAC, seven suborbital flights (under two providers) and two orbital flights (under one provider) with space flight participants had taken place, accounting for the “increase in commercial human spaceflight activity.” Although the FAA provided the list of indicators in 2017, it did not provide thresholds for any indicators to provide clear guidance on what specific changes or thresholds the FAA was looking for to indicate readiness for a new safety framework.

In September 2023, the FAA again updated Congress in a required report. At that time, the industry had accumulated 10 suborbital launches and three orbital commercial human space flight launches. This time, a more definitive stance was taken about the readiness to introduce a new safety framework:

In 2019, 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

⁴⁸ [U.S. Department of Transportation Evaluation of Commercial Human Space Flight Activities Most Appropriate for New Safety Framework](#), February 26, 2019, (p. 5).

⁴⁹ Coleman, K., Biley, J., Halt, T., Puri, R., Sloan, J. (2022), *Regulatory Preparation for U.S. Commercial Human Spaceflight*, (p. 2).

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.⁵⁰

The reports to Congress and the paper presented at the IAC help explain the evolution of the FAA's perspective and its interpretations of Congressional mandates. If the industry has "evolved substantially," it is unclear which FAA indicators reflect that claim, especially when compared to the initial FAA projections in the Human Space Flight Requirements for Crew and Space Participants final rule that, on the low side, would have resulted in thousands of commercial human space flight launches under the learning period.⁵¹ The FAA did not cite which indicators specifically reflect the change in readiness to transition to a new safety framework. For example, between 2017 and 2023, the number of operators actively working on commercial human space remained constant, the purpose of travel was overwhelmingly for adventure purposes, all missions were safely executed, the development of consensus standards was minimal, and no provider reported adoption of human space flight specific industry standards.

c. Current Commercial Human Space flight Operations

Two critical features of the current space flight operations market are its divergent architectures and slow, inconsistent launch cadence. No two operators are conducting the same mission or offering the same services, but to date, there are only three operators actively operating private flights. The intervals between flights for each operator carrying SFPs are highly variable, and delays or schedule changes are common. The market can be divided by suborbital and orbital operations. The experience for occupants can be very different depending on the provider and planned trajectory – time in space can vary from several minutes on a suborbital trajectory to several days on an orbital flight.

i. Suborbital Operations

Currently, industry supports a small number of human space flight missions per year. Blue Origin launches customers on an 11-minute suborbital arc onboard the New Shepard launch system; thus far, nine crewed flights of New Shepard have been conducted. These operations use a single-engine booster capable of a soft landing and reuse with a capsule that deploys parachutes for a soft landing. The capsule can carry up to six occupants who experience several minutes of weightlessness while the capsule is in free flight.

Virgin Galactic has also flown 12 crewed flights of their suborbital missions aboard the VSS Unity spaceship. The aircraft, a specialized carrier vehicle, and spacecraft are attached to each other during a horizontal takeoff. Once a certain altitude is reached, the spacecraft separates, ignites its engine, and ascends into space before returning to Earth and landing like a glider on a runway.

ii. Orbital Operations

SpaceX offers commercial flights aboard its Crew Dragon spacecraft, which carries four people to low Earth orbit via the Falcon 9 launch vehicle. As of this writing, the FAA has licensed six commercial flights and ten missions under NASA's Commercial Crew Program. Crew Dragon is capable of docking with the International Space Station and is qualified to remain on station for several months.

⁵⁰ [U.S. Department of Transportation Evaluation of Commercial Human Space Flight Activities Most Appropriate for New Safety Framework](#) (September 29, 2023), p. 3.

⁵¹ [Human Space Flight Requirements for Crew and Space Participants](#), 71 FR 75616 (December 15, 2006) at p. 75629.

iii. Future Operations

The human space flight market continues to diversify rather than coalesce. No vehicle has accumulated enough experience to objectively prove itself as the optimal architecture. Anything from high-altitude balloons to winged orbital spacecraft like NASA's Space Shuttle could provide human space flight services within the commercial market in the future. For example, Sierra Space is developing the *Dream Chaser*TM spaceplane. Initially designed to ferry cargo to and from the International Space Station in an uncrewed configuration, the next iteration of the vehicle will be designed to carry occupants (crew, SFPs, and government astronauts). Dream Chaser is a lifting body design that launches vertically on a rocket as a payload and is deployed in Earth orbit and has the ability to free fly or rendezvous with a Space Station. Upon completion of a mission, the vehicle conducts a deorbit burn and returns to Earth, landing horizontally on a runway.

2. Evaluation of Alternative Occupant Safety Frameworks

The Regulatory Innovation and Safety Working Groups reviewed existing regulatory and self-governance frameworks and content. The objective was to understand how other industries implement regulatory frameworks to balance public safety, occupant safety, and industry innovation. The goal was to find either an existing framework that was a good fit for the commercial human space flight industry or elements of frameworks that fit the unique nature of the commercial human space flight industry.

Topics covered by the Regulatory Innovation Working Group or Safety Working Group via briefings from SpARC participants, FAA employees, and external subject matter experts as invited parties are listed in Table 4.⁵²

Table 4: Topics Reviewed by Regulatory and Safety Working Groups

Human Space Flight Industry	State of the industry, provider perspectives, Congressional direction, previous industry reviews (FAA reports to Congress), FAA Report on Indicators of Industry Readiness
Existing Regulatory Framework	Informed consent, 14 CFR Part 460, public safety regulations via Part 450, public risk criteria history, Role of Part 460 relative to Part 450
Human Space Flight (HSF) Industry Safety Standards	FAA Recommended Practices document, ASTM International Standards, NASA Standards (1130)
Aerospace Industry Standards	Reviewed AS9100 – Quality Management Systems, ISO 45001 & FAA Safety Management Systems
Potential Analogs - Aviation Regulations & Other Examples	Special airworthiness process, experimental aircraft, light sport aircraft, other informed consent based activities
Insurance Industry	Aviation and space insurance market concepts
Safety Requirement Types	Performance vs. prescriptive vs. process requirements

⁵² Additional topics covered by the Economic Impact Working Group are detailed in Section V. C. of the report.

a. NASA Human Space Flight Requirements

Although not a regulatory agency, NASA has significant expertise in human space flight safety and imposes strict requirements on vehicles it operates and those operated by its contractors to maximize government astronaut safety.

NASA's Commercial Crew Program has two orbital spacecraft flying today. NASA exercises significant oversight in developing and operating vehicles under the Commercial Crew Program, leveraging its wealth of experience. Commercial crew vehicles are subject to a rigorous volume of requirements⁵³ set by NASA and rooted in the agency's lessons learned. Many Commercial Crew Program requirements are prescriptive in nature but encourage novel solutions via waivers or variances to certain requirements to innovate on the final vehicle designs. The success of this arrangement is contingent on NASA providing timely and expert review of novel solutions. NASA has hundreds of highly experienced engineers supporting the effort and the capacity to participate in ongoing technical working groups with the providers as required. NASA consistently recruits engineers from leading universities while regularly being reported as one of the nation's most desirable places to work.⁵⁴

Even with the significant oversight and guidance offered by NASA as part of the Commercial Crew Program, significant anomalies, both on the ground and in flight, impacted both Commercial Crew Program providers, though none led to a serious injury or death. As NASA states in its human rating specification:

It is impossible to develop a set of Agency-level technical requirements that will definitively result in the development of safe systems for all human space missions. Compliance with directives and standards can provide the framework for safety; however, the Program Manager is responsible for providing safe and reliable systems for human missions.⁵⁵

The human space flight resources and experience available at NASA far exceed what is available within the FAA. This constraint fundamentally limits the types of safety frameworks that are feasible to implement by regulation. The FAA is working to address this by forming partnerships with NASA and other organizations to increase its experience and guide updates to its Recommended Practices for Human Space Flight Occupant Safety document:

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.⁵⁶

NASA's Commercial Crew Program Office also directs the Suborbital Crew program. Suborbital Crew (SubC) is intended to allow NASA to take advantage of commercial capabilities in suborbital flight to offer microgravity experience for astronauts, civil servants, and researchers. Under this program, NASA is pursuing qualification of existing commercial systems prior to procuring flights. The SubC program uses a "Safety Case" approach, acknowledging that its existing documentation is not appropriately flexible to suborbital system missions. Critical systems and operational processes are evaluated in partnership with

⁵³ [ISS Crew Transportation and Services Requirements Document](#) (October 12, 2016).

⁵⁴ Peachman, Rachel Rabkin (2025), *America's Best Large Employers*.

⁵⁵ [Human-Rating Requirements for Space Systems \(Updated w/Change 2\)](#), NPR 8705.2C (July 10, 2017) (See Section 1.1.3).

⁵⁶ [U.S. Department of Transportation Evaluation of Commercial Human Space Flight Activities Most Appropriate for New Safety Framework](#) (September 29, 2023), p. 5.

program entities to determine acceptability of risk for NASA sponsored occupants. Virgin Galactic and Blue Origin, two suborbital providers within the SpARC, are participating in this program.

Operators have access to requirements and associated standards from NASA regardless of having a contract with NASA; these standards and associated rationale are well documented. Operators can engage with NASA via funded and unfunded Space Act agreements, other contracts, etc. Though NASA is not a regulatory agency and does not have the responsibility or jurisdiction to provide oversight of non-NASA commercial human space flight activities, it will play an important role in guiding the FAA's future work through collaboration with the agency.

b. Aviation Regulations

The history and development of the commercial aviation industry offers many lessons and cautionary tales. The working groups evaluated promising regulatory options from the aviation industry that could be appropriate for the future of commercial human space flight.

The FAA utilizes the concept of a "safety continuum" in aviation. By contrast, there is a single licensing approach today in commercial human space flight. The FAA recognizes that the regulatory requirements governing aircraft can vary as a function of their risk to the public, whether a commercial service is being provided, and/or the commensurate public and passenger expectations of safety. Only a subset of the aircraft categories is "certified" by the FAA as safe for paying passengers. Likewise, with commercial human space flight, a "one size fits all" approach may not be appropriate in the future as vehicle architectures and operational cadences further diverge.

i. Experimental Aircraft

Experimental aircraft are not required to meet a design type and can be used for different purposes, such as research and development, crew training, or market surveys. The experimental safety framework enables operators to test different types of designs, which in turn accelerates innovation. However, the aircraft are more restricted by the FAA in their use, with conditions and limitations on the certificate, such as a prohibition on passengers for compensation. Experimental research and development aircraft are also limited in the areas in which they may operate. For example, the FAA will often require the operator to follow a specified route to and from the airport to avoid highly populated areas and restrict the operation of an experimental aircraft to a certain area. The operator must also display the word "experimental" in large, bold letters on the aircraft and demonstrate, via flight-testing, that the aircraft will perform as expected for the experiment. The time required to process an application for an experimental certificate varies based on the complexity of the aircraft and the type of experiment.⁵⁷ The FAA's objective is to balance public safety concerns against the operator's desire to explore innovative operations and emerging technology. FAA policies and procedures for issuing the certificates include an objective common baseline and a subjective evaluation.⁵⁸

The FAA does not have defined risk criteria that are quantitatively evaluated; rather, it employs a more subjective approach in terms of reviewing corridors and operating areas that avoid densely populated areas where possible. The occupant safety requirements for experimental aircraft are relatively less rigorous partly because there are limits on who can fly as well as minimal public risk. For example, family members can fly on the aircraft, but flying passengers for compensation or hire is prohibited.

Of the frameworks that exist today in the safety continuum, the experimental framework has the most in common with commercial human space flight. The current human space flight operations are in their early

⁵⁷ FAA Order 8130.2K, [*Airworthiness Certification of Aircraft*](#) (August 8, 2024).

⁵⁸ *Id.*

days of accumulating flight experience, and the people flying are extremely limited and informed of the elevated risk. Though in commercial human space flight, compensation can be accepted, it is only authorized *after* participants have been informed of the risk in a detailed briefing.⁵⁹

ii. Light Sport Aircraft

Light sport aircraft have a risk profile that falls between small type-certified aircraft and experimental aircraft. Accordingly, the certification process for light sport aircraft is less rigorous than that for a type-certificated aircraft but exceeds the requirements for experimental aircraft. Certification requirements for light sport aircraft include a high-level design and production requirement, a means of compliance with voluntary industry consensus standards, and an issuance of airworthiness certificates to individual aircraft based on operational audits of manufacturers, a statement of compliance from the manufacturer, and inspection of the individual aircraft. Due to the higher certification requirements, light sport aircraft operators enjoy greater operational privileges than experimental aircraft operators. Some examples of operating privileges provided are:

- small, simple aircraft with a maximum of two seats;
- operated primarily for recreational/personal use; and
- operations for compensation/hire limited to flight training or glider towing

The FAA participates in the development of consensus standards and has authority to reject any standards deemed inadequate. Collaboration between the FAA and industry is therefore critical to ensure changes remain in compliance. The FAA is participating in human space flight voluntary consensus standards development with industry, leaving the door open for a similar safety framework for human space flight in the future.

iii. Common Carriage

Typically, “common carriage” is defined as transporting passengers or cargo for compensation.⁶⁰ Given the millions of scheduled flights each year, it is not reasonable to expect the flying public to understand the risks of flight, and commercial aircraft regularly fly over densely populated urban environments, posing a significant public safety risk. The government, as implied by the safety continuum, steps in to implement detailed regulations that certify an aircraft as safe. Everything – from the types of materials used to levels of redundancy and production facilities – is governed by FAA imposed rules. Because the general public cannot meaningfully consent to the risk associated with being on an aircraft or flying over a populated area, the government fulfills the role of determining an aircraft is safe for public transport or for flying over populated areas.

Certifying an aircraft as “safe” requires the FAA to know what is and is not a safe design, process, or operational concept. This is possible due to the wealth of data available from billions of flights and over a century of accumulated experience, along with relatively homogenous designs of commercial aircraft. There are many aircraft manufacturers and aircraft models that have reached an operational level of maturity where the lifecycle and service life, down to the individual components, are fully understood. The uncertainty and lack of available data in the history of human space flight, where no vehicle has achieved “operational” status, marks a significant difference.

⁵⁹ 14 CFR 460.45(a).

⁶⁰ [FAA Advisory Circular 120-12A, Private Carriage Versus Common Carriage of Persons or Property](#) (April 24, 1986).

Compared to the aircraft industry, even the Space Shuttle never achieved full operational status. Instead, it remained an experimental development program all the way through its final flight. As Macauley (2005) stated:

The shuttle program at the time of the Columbia accident had accumulated 32 years of experience and 113 flights (including Columbia's 28th). Yet according to the [Columbia Accident Investigation Board], the shuttles were still developmental.⁶¹

The NASA specification for Human-Rating Requirements for Space Systems (NPR 8705.2C) states, "It is impossible to develop a set of Agency-level technical requirements that will definitively result in the development of safe systems for all human space missions." The industry has significant work remaining to develop standards and requirements that approach the confidence and statistical certainty the FAA has in type certification rules. The differences in flight heritage and data are important factors in evaluating the appropriateness of applying the aviation type certification approach to commercial human space flight.

iv. Informed Consent Frameworks

The United States government affords individuals the freedom to participate in many inherently risky activities, provided individuals are informed of the risk and their actions do not harm members of the public. The same structure currently applies to commercial human space flight whereby the requirements in Parts 450 and 460 jointly ensure there is negligible risk to the public, and Part 460 ensures the occupants are thoroughly informed of the risks. Part 460's informed consent process is rigorous compared to other high-risk activities.⁶² Operators must provide detailed written documentation to SFPs covering known hazards and provide the opportunity to ask questions about the risks in person. The FAA published a 22-page guidance document to ensure a degree of consistency in the briefing across all operators.⁶³

Adventure activities, such as sailing expeditions around the world, and popular adventure sports like climbing, spelunking, and skydiving are all permitted even though the risk far exceeds the risks taken in a "normal day." In a briefing to the SpARC, the FAA stated that "Voluntary risks have ranged from 10 to maybe 1,000 times higher than involuntarily imposed risks in terms of what people accept, not necessarily by regulation, but in practice."⁶⁴ As a point of reference, many high-risk activities are carried out in high volumes:

⁶¹ Macauley, Molly K. (2005) ["Flying in the Face of Uncertainty: Human Risk in Space Activities,"](#) Chicago Journal of International Law: Vol. 6: No. 1, Article 10.

⁶² [14 CFR 460.45.](#)

⁶³ [Federal Aviation Administration Guidance on Informing Crew and Space Flight Participants of Risk, Version 1.1](#) (April 4, 2017).

⁶⁴ FAA briefing to SpARC (April 5, 2024).

Table 5: Examples of regularly practiced high risk activities

Activity	Rate	Risk Management
Climbing Mt. Everest	Many thousands of summits through January 2024	Government permit to climb with some conditions
USA Sky Diving	3,650,000 jumps in 2023 ⁶⁵	Informed Consent and Third-Party Training
USA Scuba Diving	2,500,000 dives per year ⁶⁶	Informed Consent and Third-Party Training
Commercial Suborbital Space Flight	6 flights in 2023	Informed Consent and Operator Training
Commercial Orbital Space Flight	3 flights in 2023	Informed Consent and Operator Training

Adventure activities have historically been accessible to certain sectors of people who have both the means and desire to put themselves in these dangerous situations. Several of these activities and their risks to adventurers rely on a person’s physical capabilities as well as environmental factors. All these activities rely on equipment to protect the participant, whether it is parachutes for skydivers, ropes and carabiners for climbers, or the structure of a boat, submersible vessel, or spacecraft. If this equipment fails, some of which there can be no multi-redundant backups, injuries or fatalities may occur.

Very few requirements exist to prevent people, capable or otherwise, from attempting risky activities. For example, according to the United States Parachute Association, the “FAA and USPA rely on self-regulation from within the skydiving community for most training and operational requirements.”⁶⁷ While pilots, flight and ground instructors, parachute riggers, and air traffic control operators have requirements and guidelines for their flight operations, parachute operators’ regulations in 14 CFR Part 105 protect “air traffic [and the protection of] persons or property on the surface” but do not regulate for safety of the skydiver.⁶⁸ Rather, skydivers are self-regulated and sign waivers prior to jumps confirming that they choose to incur all risks associated with the activity. For adventurers, often the only requirements levied are regulations that protect others rather than themselves. The individual must decide if the risk is worth the reward they will get from engaging in the activity. In some cases, counterintuitively, the risk is part of the appeal to adventurers.⁶⁹

v. Insurance Industry Briefing

Space insurance coverage is a critical enabler of innovation and investment, and insurance providers currently work with clients to insure against first party or property losses, such as satellites and launch vehicles, or third-party liability claims, including providing insurance to satisfy ‘evidence of financial responsibility’ required under 14 CFR Part 440.

Human space flight is not included in typical commercial space flight liability insurance at the present time. However, the insurance industry has been working to determine what covering human space flight would look like. Some insurers work within their accident and health divisions for human space flight coverage, while other insurers may consider an extension for workers compensation insurance for those operators with employee crews.

⁶⁵ [United States Parachute Association 2023 Annual Survey Results.](#)

⁶⁶ [DEMA, Driving Equipment & Marketing Association 2024 Diving Fast Facts.](#)

⁶⁷ [United States Parachute Association, The FAA & USPA.](#)

⁶⁸ 14 CFR 105.5.

⁶⁹ [High Risk Voyager: The Growing Allure of Adventure Tourism](#), October 4, 2024.

Significant losses in recent years have led to some insurance companies pulling out of the space market altogether. Insurers appreciate predictability of losses, and the volatile and nascent nature of commercial space flight makes it difficult for insurers to estimate their risk.

For human space flight coverage, it is critical that insurers be able to identify which losses are covered, and which are not. The insurance industry understands and can operate within varying levels of regulatory oversight, provided insurers have a clear understanding of the operative liability regime and the risks that are covered.

Within the current regulatory framework, the informed consent and waiver of liability regime is critical for insurers to understand what party has assumed liability for what activities and when. The briefing noted that a greater degree of consistency and better understanding of how operators actually conduct informed consent briefings, including any training received by occupants, will make it easier for the industry to assess and insure risk. At this time, because of the small market size, there is not enough demand to trigger an insurance industry led framework analogous to maritime, where the insurance industry plays an important role in defining required safety standards and offers lower premium costs to operators that comply with standards.

vi. History of FAA Risk Criteria

The SpARC evaluated material from the FAA Office of Commercial Space Transportation on the history and rationale behind the FAA determination of risk tolerability for launch and re-entry licensing. An expert from AST provided some background to shed light on how the FAA defines the necessary level of safety incorporated into 14 CFR 450.101, which specifies maximum acceptable levels of risk on both an individual and collective basis. AST representatives noted that the maximum risk to any individual member of the public set forth in § 450.101 is in line with other U.S. and international risk tolerability regimes and is estimated to be approximately .5% of the annual risk accepted by each U.S. pedestrian.

AST presented six factors that experts have identified as correlating well with overall levels of public concern (“outrage factors”). Those include:

1. Familiarity with the risk (the public is more concerned about risks that are new and unfamiliar);
2. Understanding of cause-effect mechanisms (there is greater concern if the connection between cause and effect is uncertain or complicated);
3. Equity of the consequences/benefits associated with the risk (there is greater concern if adverse safety effects are perceived to fall unfairly on specific groups);
4. Fear of risk consequences (there is more concern if the hazard is perceived as horrific, or involves widespread or irreversible impact);
5. Control of the risk (there is more concern if the people exposed to risk have no control over the risks involved); and
6. Trust in risk management (people are more concerned if they do not trust those responsible for managing the risk on their behalf).

AST evaluates these outrage factors to determine the level of risk acceptable to the general public associated with launch and re-entry, to balance the risky nature of space transportation against the U.S. government’s understanding that space transportation is vital to the nation’s economic well-being and national security.

AST determines an acceptable level of risk to the general public, which has no control over the risks of space transportation. In follow-up discussions, AST representatives noted that when dealing with occupants who have voluntarily accepted certain risks, the calculation of risk in relation to the “outrage factors” would be significantly different. AST noted that regulators do not typically focus on capping the amount of risk that individuals can accept voluntarily. However, in practice, researchers estimate that the public is willing

to accept risk levels for voluntary exposure to risk up to 1,000 times higher than levels for involuntarily imposed risks.

AST representatives echoed the theme that across different modes of transportation, as any activity becomes more broadly adopted, and the number of operations goes up, the level of risk tolerability decreases as evidenced either by direct regulation, or simply as a factor of what the public accepts.

vii. Delegated Authority at the FAA

In commercial aviation, Congress authorized the FAA to designate individuals and organizations in many specialties to perform aircraft certification functions. This leverages industry expertise and reduces the FAA's resource burden, giving companies more control over cost and schedule. The concept was originally introduced in the 1930s with medical examiners, with delegation codified in the 1950s and additional areas of delegation identified in subsequent decades.

Designated authorities have roles in design and data approvals, repairs, modifications, certification, personnel testing, medical certification, etc. They do not perform functions, such as rulemaking, surveillance/oversight, policy interpretations, certificate issuance, safety-critical operations, and medical appeals approval, which are reserved for the FAA.

There are two types of delegated authorities:

- Individual designees – These can be organization employees or external consultants, typically having previously established working relationships with the company and the FAA.
- Organization Delegation Authority (ODA) – This is a company organization delegated authority by the FAA. This is extremely intensive in administrative activities by both ODA and the FAA. An organization must have an independent ODA unit with an ODA administrator and an annual self-audit. The FAA has an organizational management team (OMT) with oversight authority and a lead assigned to the ODA. An OMT may serve multiple ODAs and has a core of technical experts that mirror functions in the organization.

Commercial space flight, human or otherwise, does not follow a certification regime nor does the FAA currently have legal authority to authorize space flight designees. The appropriateness of a delegated authority safety framework for human space flight is highly dependent on how the market evolves.

c. Discussion of Industry Standards

Industry standards are published documents containing requirements forged by consensus across experts in a given field or industry. Many non-government organizations, such as ASTM International (ASTM), International Organization for Standardization (ISO), the American Institute for Aeronautics and Astronautics (AIAA), and the Society of Automotive Engineers (SAE), publish standards addressing an extremely diverse set of topics, such as material testing procedures or quality management systems. Many government-published standards are also publicly available, even for topics like test requirements for launch vehicles.⁷⁰ Standards enable businesses to maximize efficiency and quality – instead of all companies designing custom bolts suitable for their application, standards offer ready-made solutions with proven quality that enable industry to solve higher level problems without “reinventing the bolt.”

⁷⁰ Air Force Space Command, *Space and Missile Systems Center Standard Test Requirements for Launch, Upper-Stage and Space Vehicles* (September 5, 2014).

The National Technology Transfer and Advancement Act directs federal agencies to use voluntary industry consensus standards “whenever possible”:

Standards are technical specifications that pertain to products and processes, such as the size, strength, or technical performance of a product, process, or material. Voluntary consensus standards are standards developed by standards-setting entities such as the American Society for Testing and Materials (a non-profit organization formed to develop standards); these organizations derive consensus through the principles of due process, openness, and balance of interests. Government standards are developed by individual federal agencies for their own use. Although unique government standards sometimes are appropriate, such as standards for certain specialized military equipment, in other cases, a voluntary standard would suffice. This creates duplication for industry, which may have to provide two lines of production to meet both government and private needs and can put U.S. companies at a disadvantage in international trade.

...The [National Technology Transfer and Advancement Act] also directs federal agencies to consult with and participate when appropriate in standards-setting organizations and provide explanations when they do not use voluntary consensus standards in their procurement or regulatory activities.⁷¹

Congress recognized the importance of consensus standards in the commercial human space flight industry given the specific direction in 51 U.S.C. § 50905 to devote DOT resources to their development:

The Secretary shall continue to work with the commercial space sector, including the Commercial Space Transportation Advisory Committee, or its successor organization, to facilitate the development of voluntary industry consensus standards based on recommended best practices to improve the safety of crew, government astronauts, and space flight participants as the commercial space sector continues to mature.⁷²

The FAA confirmed its commitment to comply with the statute by developing standards in the human space flight industry in its 2023 report to Congress:

[T]he FAA also has been supporting industry’s efforts to develop voluntary consensus standards for [human space flight], 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.⁷³

The Government Accountability Office (GAO) reviewed the FAA’s role in developing human space flight specific consensus standards. In its report, the GAO notes how the FAA is struggling to support consensus standards development:

⁷¹ U.S. General Accounting Office, *Voluntary Consensus Standards Agencies’ Compliance with the National Technology Transfer and Advancement Act* (March 15, 2000), p. 3.

⁷² 51 U.S.C. § 50905.

⁷³ [U.S. Department of Transportation Evaluation of Commercial Human Space Flight Activities Most Appropriate for New Safety Framework](#) (September 29, 2023), p. 13.

FAA officials and operators said the [ASTM F47] 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 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.⁷⁴

In another section of the report, the GAO documented how “...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.”⁷⁵ Making meaningful contributions to consensus standards generally requires highly experienced subject matter experts with applicable experience.⁷⁶ Other industries employ models where independent, highly experienced experts develop technical standards and also audit other entities to the relevant standard.

In the marine and offshore industry, there is an extensive use of standards or “classification rules.” Classification societies develop standards and offer services to audit conformance with classification rules. With a third-party audit verifying compliance, certain insurance policies become available or are discounted, creating a financial incentive to comply with the rules. Bureau Veritas is one example of a classification society that publishes extremely detailed rules for many different types of vessels. Their website states: “We use the vast experience of our engineers, gained through years of service in the marine industry, combined with advanced research into structure and hydrodynamics, to ensure the development of the most relevant and up-to-date Rules.”⁷⁷

In contrast to an organization like Bureau Veritas, no independent standards setting body has a meaningful amount of resources or experience that qualifies it to publish detailed rules governing commercial human space flight. The human space flight industry is experiencing a shortage of talent, and that makes it unlikely for any standards body to be able to recruit a high volume of qualified individuals. The only remaining option, then, is for industry to voluntarily contribute resources to collaboratively generate standards. AST is struggling to recruit personnel and places its support of voluntary consensus standards at risk. The FAA’s Aviation Safety (AVS) technical staff workforce, which, among other duties, evaluates standards, has over 1,000 people compared to the small number of people currently supporting space flight standards within FAA AST.⁷⁸ A recent GAO report detailed the challenges:

FAA has ongoing hiring challenges and workforce constraints... 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.⁷⁹

⁷⁴ United States Government Accountability Office Report to Congressional Requesters, [Commercial Space Transportation FAA’s Oversight of Human Spaceflight](#) (February 2024), p. 25.

⁷⁵ *Id.*

⁷⁶ [American National Standards Institute, ANS Introduction.](#)

⁷⁷ [Bureau Veritas – Rules & Guidelines \(2025\).](#)

⁷⁸ [FAA Aviation Safety Workforce Plan FY 2024-FY2033](#) (May 8, 2024).

⁷⁹ U.S. Government Accountability Office, [Commercial Space Transportation FAA’s Oversight of Human Spaceflight](#), February 2024.

In the FAA’s report to Congress on the status of industry voluntary consensus standards, it states:

Industry-led standards efforts have yielded progress, yet the pace of these efforts has been insufficient. In their report, COMSTAC determined that FAA leadership is needed to facilitate rapid progress on the safety framework to serve as a foundation for a safe and competitive industry.

...DOT is encouraged by the increasing availability of commercial space transportation standards and expects that the pace of standards development in the commercial space industry will continue to increase. With its performance-based approach, 14 CFR Part 450 creates a programmatic framework to accept standards as means of compliance. DOT will explore other opportunities to review, evaluate, and accept standards developed by the commercial space industry.⁸⁰

The DOT’s statement that the pace of standards generation is insufficient may not be the correct interpretation. Given the context of minimal launches and radically varying vehicle architectures, a more nuanced interpretation could be that the pace of standards generation matches the minimal growth of the industry and significant learning still taking place. All operators reported considerable learning flight to flight and continued design changes. It follows that human space flight specific industry consensus standards will lag as individual operators continue to significantly refine their requirements and designs.

Standards based on limited data or no data are unlikely to be adopted by operators in the industry. Given the minimal number of private commercial human space flights, the industry currently has limited experience and resources available to devote to human space flight specific consensus standards development. Additionally, the commercial HSF operators were licensed prior to the publication of most of these standards; therefore, there were no means for them to evaluate compliance. It is therefore unsurprising that operators represented on the SpARC were not able to confirm adoption of the few existing human space flight specific published standards. ASTM Committee F47 has four published standards specific to occupant safety as of this writing, with three proposed new standards in work. Beyond the occupant safety specific standards, there are 11 total published standards by the ASTM F47 committee that also address other aspects of commercial launch.

Table 6: Status of ASTM International Committee F47 Occupant Safety Standards⁸¹

ASTM F47 Occupant Safety Standards	Status
F3479-20 Standard Specification for Failure Tolerance for Occupant Safety of Suborbital Vehicles	Published
F3568-23 Standard Guide for Medical Qualifications for Suborbital Vehicle Passengers	Published
F3658-23 Standard Guide for Crewed Suborbital Space Vehicle Design	Published
F3668/F3668M-23 Standard Guide for Occupant Survivability in Orbital Vehicles	Published
WK73835 Spaceflight Participant Safety and Emergency Training	In Work
WK76298 Software Safety Standard	In Work
WK88055 Medical Qualifications for Orbital Vehicle Passengers	In Work
F3520-21 Standard Guide for Training and Qualification of Safety-Critical Space Operations Personnel	Published

⁸⁰ Federal Aviation Administration, [*Final Report on Voluntary Industry Consensus Standards Development*](#) (December 2021), p. 10.

In general, industry standards can play an important role in spurring innovation and domestic competitiveness. There is objective evidence supporting the case for consensus standards as a catalyst for innovation, especially in a market facing high levels of uncertainty:

Highly uncertain markets are often characterized by an unstable and fast changing technical environment, in which different technological paths compete with each other. In such markets, information asymmetries that increase the probability of a potential misfit between regulations or formal standards and the underlying market technologies increase drastically. This effect is more distinct in relation to regulations as they stem from a top down legislative process, contrary to formal standards which are derived from a process driven mainly by the market (i.e. firms) and are therefore more closely connected to the requirements of the underlying technology established in the markets. As a result, regulation has a negative impact on a firm's innovation efficiency in highly uncertain markets. Notably, formal standards have a positive effect on firms' innovation efficiency. One possible explanation might be that formal standards decrease technological uncertainty as they give direction for further technological developments. Furthermore, in markets characterized by a high level of uncertainty, there are not yet established links between standards and regulations. Consequently, the principle of regulatory relief does not function yet and the efforts to comply with the emerging regulatory framework might increase significantly, whereas standards have a more positive guiding effect than a negative cost creating effect on companies' innovation efforts.⁸²

Given the nascency of human space flight, diverging technical solutions, and unclear demand beyond early adventure travelers, the market faces significant uncertainty in the future. With minimal experience to forge industry consensus on commercial human space flight specific technical topics, the minimal published standards today simply serve a "positive guiding effect" on the industry. As experience accumulates, more standards will be published, adopted, verified by third parties, and eventually accepted as means of compliance to regulatory requirements.

i. FAA AST "Recommended Best Practices"

In September 2023, the FAA released its second version of *Recommended Practices for Human Space Flight Occupant Safety*. The purpose, regulatory context, and sources used are described within the document:

The purpose of this document is to provide a compilation of practices that the Federal Aviation Administration (FAA) Office of Commercial Space Transportation (AST) recommends for commercial human space flight occupant safety. The document is intended to create a dialogue among, and perhaps consensus of, government, industry, and academia on practices that will support the continuous improvement of the safety of launch and reentry vehicles designed to carry humans.

The document can also be used to help identify subject areas that could benefit from industry consensus standards. There are several industry and government standards that address the subject areas covered in this document, but some subject areas may not have standards that are appropriate for the commercial human space flight industry. The development of industry consensus standards in these subject areas could have significant benefits for the safety of future commercial operations.

⁸² Knut Blind, Sören S. Petersen, Cesare A.F. Riillo, [The impact of standards and regulation on innovation in uncertain markets](#) (February 2017).

...

This document is not regulatory and does not have the force and effect of law. These recommended practices are not meant to bind the public in any way and the document is intended only to provide information to the public.

...

In the development of Version 1 of the Recommended Practices, AST reviewed existing government and private sector requirements and standards, including those from NASA, the European Space Agency, and the International Association for the Advancement of Space Safety. AST used NASA's requirements and guidance for its Commercial Crew Program as the primary guide for the development of this document. With some exceptions unique to the program, the Commercial Crew Program requirements and guidance provide comprehensive coverage of occupant safety. Our purpose was not to copy NASA's requirements, but to use them to capture safety practices and judge whether they are, at a general level, appropriate for the commercial human space flight industry.⁸³

The industry was not consulted before publishing the latest revision of the document, and prior industry recommendations were not incorporated. As the FAA disclosed above, the document is derivative and largely based on NASA's Commercial Crew Program, which itself is based on learning from the sum of government experience in human space flight. No government-operated human space flight program ever achieved an "operational" status analogous to a commercial aircraft with type certification. As noted above in the Space Shuttle Columbia Accident Investigation Board report: "The organizational causes of this accident are rooted in the Space Shuttle Program's history and culture, including the... mischaracterization of the Shuttle as operational rather than developmental[.]"⁸⁴ It follows that the requirements governing a developmental program are themselves developmental. Therefore, all FAA human space flight specific recommended practices in the document can also be considered developmental. The FAA provided a visual summary of components it deemed important to address within a safety framework:

⁸³ [FAA Recommended Practices for Human Space Flight Occupant Safety Version 2.0](#) (September 2023) (See Sections 1 and 3).

⁸⁴ [Columbia Accident Investigation Board Report Volume 1](#) (August 2003), p. 9.

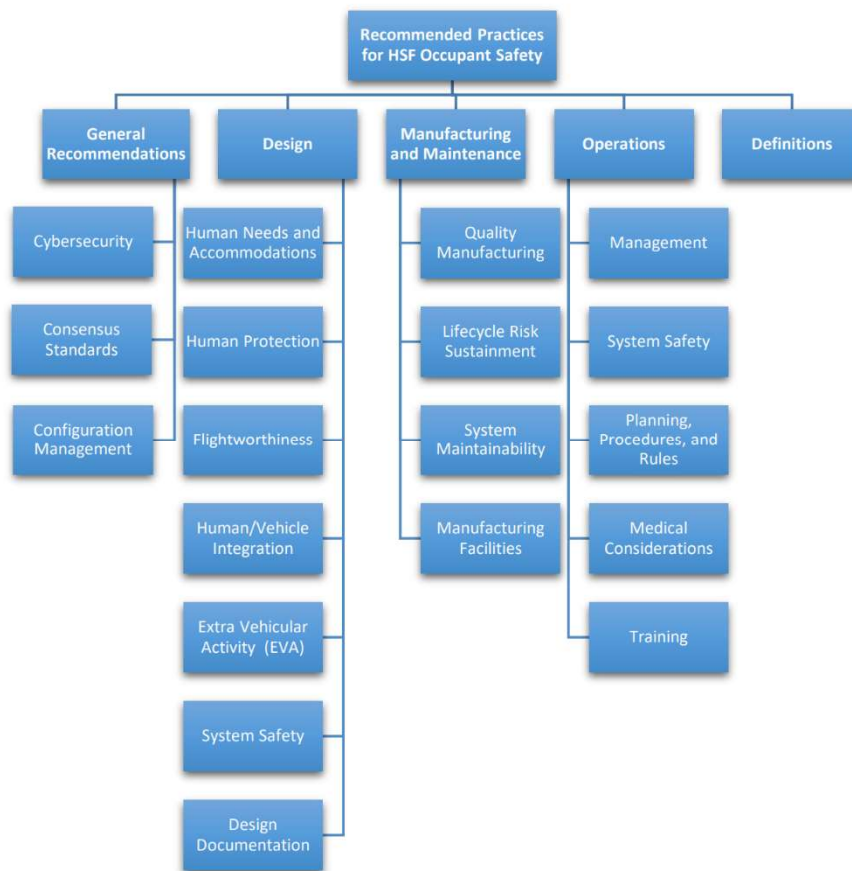


Figure 3: FAA’s Framework of Recommended Practices⁸⁵

During the course of the SpARC, the FAA explained that this document is not tied to any regulations; creation of the document falls under its authority to carry out pre-rulemaking activities. Indeed, a subset of the topics addressed in the document are not currently within the FAA’s regulatory authority granted by Congress. For example, the FAA does not currently have authority to regulate “on-orbit” activities; yet the document addresses Extra Vehicular Activity (EVA).

For each topic addressed in the document, the reference information comes predominantly from NASA, MIL, ISO, or other government sources, all of which are currently available to industry. As operators accumulate more experience, it is expected that many of the government references will be superseded by industry-led voluntary consensus standards.⁸⁶ The process of superseding government standards is predicated on the industry generated standards being “better” than the government standards. Theoretically, they would consist of requirements that yield safer outcomes with fewer resources and a degree of statistical certainty that can only be achieved with a large volume of flights. Again, using the Space Shuttle as an example, the Columbia Accident Investigation Board realized the vehicle was still considered developmental even after over 100 flights of service. It may be the case that “better” industry consensus standards compared to government standards will emerge only after hundreds, or even thousands, of flights are accumulated.

⁸⁵ [FAA Recommended Practices for Human Space Flight Occupant Safety](#) (2023), p. 32.

⁸⁶ *Id.* at Section 1.3, p. 15.

Industry continues to use numerous existing standards as guidance for its operations and designs. Some of the FAA’s recommended practices topics are not unique to human space flight – quality manufacturing principles, for example, have been well documented and addressed in other industries. Developing best practices for topics unique to human space flight will take the longest to develop and drive the timeline for a complete set of industry driven standards that addresses all components in the FAA’s framework of recommended practices, as well as some components that are missing. ASTM International Committee F47 is currently drafting specifications based largely on NASA CCP-REQ-1130, as did the FAA’s recommended practice document.

ii. Quality Management Systems (QMS)

The American Society for Quality defines a QMS as “...a formalized system that documents processes, procedures, and responsibilities for achieving quality policies and objectives. A QMS helps coordinate and direct an organization’s activities to meet customer and regulatory requirements and improve its effectiveness and efficiency on a continuous basis.”⁸⁷ While there are several Quality Management Systems available, AS9100 was reported by multiple operators as either already in use or being evaluated for adoption. As described by National Quality Assurance, “AS9100 works in conjunction with ISO 9001, an industry non-specific standard that sets the most basic quality management system requirements, adding additional requirements that apply specifically to the aerospace industry.”⁸⁸ Like other management systems, AS9100 leverages continuous improvement as a central operating principle, which can be summarized as “plan, do, check, act.”

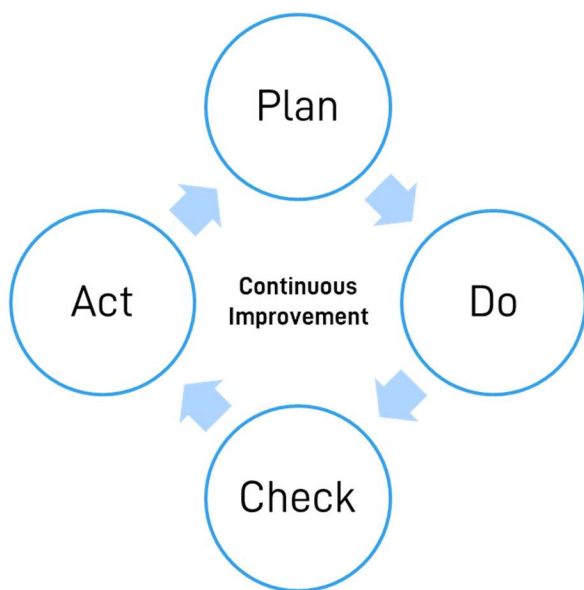


Figure 4: The continuous improvement cycle central to Quality Management Systems like AS9100

The concept of QMS has been adopted by many different industries independently. In manufacturing, configuration management, revision control, training, change management, and many other basic concepts are known to be critical in repeatably producing products with minimal variation and meets the product’s design intent. If a vehicle passes a flight test, in the absence of a third-party audited QMS, the uncertainty surrounding the next vehicle’s performance is greater. Although a QMS does not guarantee repeatable results, it is widely considered an essential element to reliably scaling up a production line and codify continuous improvement as a central operating principle within an organization.

⁸⁷ [American Society for Quality \(ASQ\) – Quality Management System.](#)

⁸⁸ [National Quality Assurance \(NQA\) – Guide to the AS9100 Standard](#) (September 6, 2022).

Quality Management Systems and Their Mapping to FAA Recommended Practices

In reviewing the FAA's recommended best practices document, the group noted how a significant percentage of its framework is addressed by implementing a QMS. As an example, the figure below shows how a QMS, such as AS9100, has potential to be leveraged as a means of compliance by the FAA. A QMS does not guarantee that operators' components of the framework are correct, but it does ensure that a procedure is documented, adhered to, and continuously improved related to the components highlighted in green.

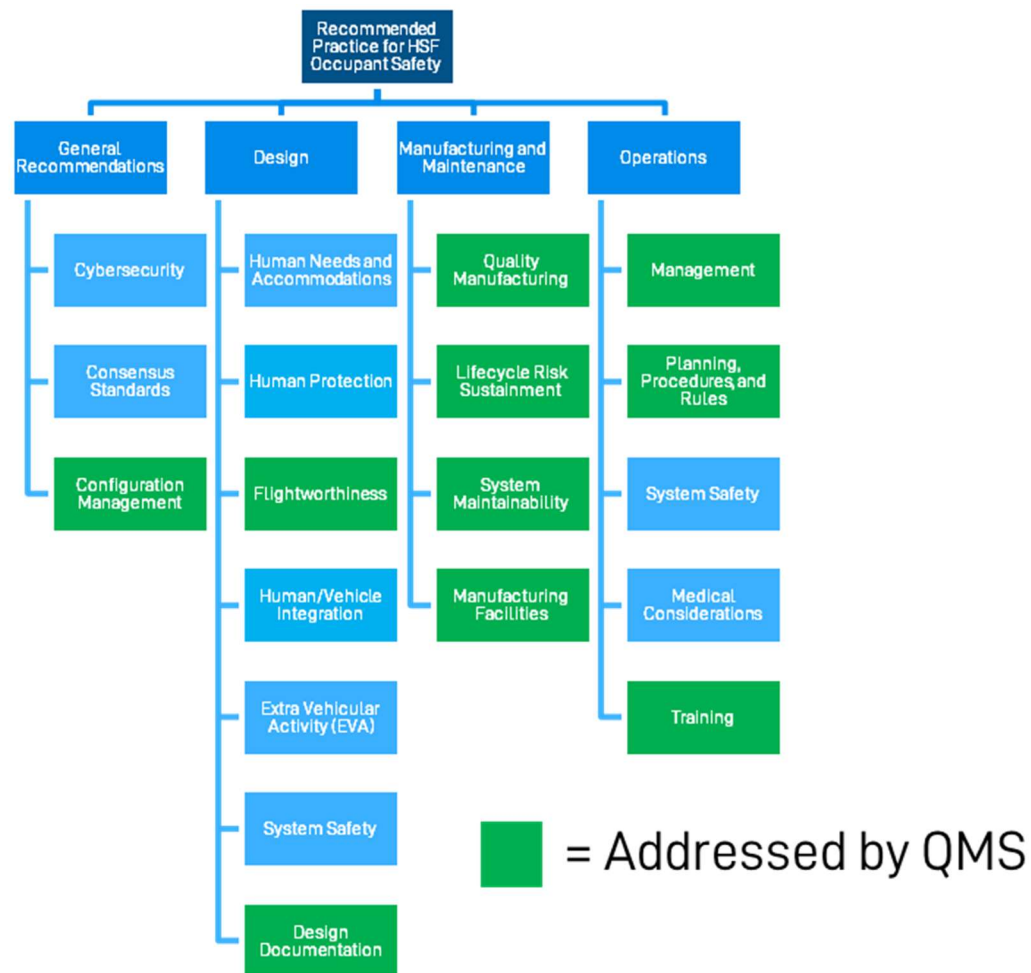


Figure 5: Notional depiction of how a QMS addresses components of the FAA's safety framework

iii. Safety Management Systems (SMS)

An SMS is a framework whereby an organization systematically identifies and mitigates hazards that present a health or safety risk to its employees or stakeholders. SMS has a broad range of applications from occupational safety to protect employees, to versions intended to protect airline passengers. ISO 45001 is

one example of an occupational health and safety management system that is also based on the plan-do-check-act cycle.⁸⁹

The FAA model of an SMS for commercial aviation consists of four key components: Safety Policy, Safety Risk Management, Safety Assurance, and Safety Promotion.⁹⁰ Emphasis is placed on the formalization of the interfaces on the four pillars, and how each interact and drive a company's safety culture. In commercial aviation, SMS implementation evolved and impacted different aspects of the industry over 25 years. The FAA requires an SMS for air carriers, though the use within this sector started with limited application and expanded through the course of development. The FAA also utilizes its own SMS.⁹¹ Focus is placed on collaboration and communication within an entity that has an SMS in place, as well as between regulator and this entity, if the SMS is a requirement for operation.

Overlap exists between Quality and Safety Management systems. The most recent version of the AS9100 QMS includes the concept of assuring "Product Safety":

An entirely new and separate clause has been added to AS9100 relating to product safety, and extra sections relating to product safety have been included where appropriate. These product safety requirements specifically address safety considerations throughout the product lifecycle, including through the manufacturing process.⁹²

Given the scope of the latest revision of AS9100 and existing launch/reentry procedures in Part 450 to systematically identify and mitigate hazards to public safety, the applicability and scope of an SMS governing occupant safety should be carefully controlled in the future. ASTM International Committee F47 has a new task group, Standard Practice for Safety Management System (SMS) for Human Spaceflight, where operators are attempting to forge consensus on an SMS scope that takes the potential for overlap with existing rules and standards into account.

B. Medical

1. Medical Industry Overview – Existing Sources of Commercial Space Flight Medical Guidance

Various professional organizations and subject matter experts have provided preliminary guidance for medical screening. Recent examples include the *FAA Recommended Practices for Human Space Flight Occupant Safety* v2.0 (2023) and *ASTM F3568-23 Standard Guide for Medical Qualifications for Suborbital Vehicle Passengers*, with a related document for orbital vehicle passengers in late-stage draft form at present.

The FAA Recommended Practices provide high-level guidance regarding screening considerations for flight crewmembers, including timing of medical assessments, psychological assessments, and pre-flight self-assessments prior to commercial space flight activities. While rationale is provided to describe physical demands of space flight, particularly high-risk medical history that could contribute to in-flight risk and the basic tenets of medical examination, prescriptive approaches to medical screening are not detailed in this

⁸⁹ [ISO 45001:2018, Occupational health and safety management systems – Requirements with guidance for use](#), 2018.

⁹⁰ 14 CFR 5.5.

⁹¹ [FAA Order 8000.369C – Safety Management System](#), June 24, 2020.

⁹² [National Quality Assurance \(NQA\) – Guide to the AS9100 Standard](#), September 6, 2022, (See 6. Begin Implementation).

document. For space flight participants (SFPs), the document highlights the need for evaluation and encourages commercial operators to pursue aerospace medical evaluation but provides no further detailing of specific examinations to consider.

Additional highlights of this document include a discussion of post-flight considerations for medical and psychological assessment and a discussion of health stabilization and medical planning approaches, though again, the document avoids prescriptive detailing. The intent is to allow providers to tailor these services to appropriately meet the specific needs of their SFPs in the context of their unique mission profile(s) and vehicle(s). Training is identified as an area of need, with the document noting that aerospace physiology and psychological instruction, as well as familiarization to onboard medical resources, have been topics identified as beneficial and desirable for all vehicle occupants. Finally, the Recommended Practices document specifies a need for emergency training to ensure that all vehicle occupants can take safety-critical actions appropriate to their position or role in the flight. The absence of prescriptive and detailed examination requirements is intentional, allowing for variability and novel approaches in the commercial space flight industry to drive specific approaches to screening and training techniques, and allowing for other subject matter expert associations to provide more detailed guidance when and where appropriate.

The ASTM International Standard Guide was produced as a consensus document by industry professionals, including those with significant experience in aerospace medicine or within the aerospace industry, intended to offer advice to commercial human space flight operators developing medical programs for suborbital space flight. This document provides more detailed areas of evaluation recommended by the contributors, including descriptive medical questionnaire subtopics and aspects of a pre-flight and post-flight physical examination. Even so, this document remains high-level and specific only to suborbital space flight profiles, noting the difference in operational concepts, profiles, risk considerations, and environmental stressors of suborbital space flight as different from those of orbital space flight. Further, the document specifically highlights an expectation that the guidelines provided may be tailored to fit a provider's specific space flight systems, operational procedures, safety standards, and risk profiles. Notably, the ASTM F47 Committee is currently working on a second standard to provide guidance for orbital vehicle occupants in a similar manner, and a task group has been formed to evaluate ethical human subject research practices within commercial space flight.

The high-level nature of the guidance provided by these and other documents speaks to the significant variation between commercial providers, vehicles, risk acceptance, and mission profiles. Variables that directly influence the health and medical safety of occupants, include, but are not limited to:

- Variability in vehicle type (for example, capsule or winged) and operational design (i.e. seat orientation relative to acceleration forces, use of pressure suits, etc.);
- Variability in prior vehicle flight experience / demonstrated capability;
- Mission duration;
- Launch profile and mission trajectory;
- Crew vs. SFP responsibilities;
- Mission-critical duties;
- Emergency actions;
- Impediments to critical actions;
- Factors contributing to space environment (e.g. suborbital profile, orbital profile, altitude, inclination, vehicle proximity operations, radiation, etc.);
- Variability in individual vehicle occupant medical risk factors, including novel medical conditions outside of the collective and preexisting human space flight experience;
- Re-entry and landing profile under nominal and contingency conditions (i.e. water vs land; parachute vs winged); and

- Location, details, and resources of support facilities (i.e. definitive medical care) at or in proximity to the launch and landing locations.

Alteration of any of these variables may greatly alter the risk profiling or risk factors for each individual occupant, driving variability in screening or mitigation approaches before and during flight. Thus, it is difficult to offer a single, all-encompassing and universally applicable set of medical screening and mitigation requirements that can account for the variability described above.

In addition, prescriptive medical screening or risk mitigation practices may not take into consideration any process improvements to the adaptive approach over time. Identification of novel risks, contributing factors, or effective mitigation techniques may alter the need for medical screening practices, and implementation of a required approach may not encourage adaptation of screening approaches to an evolving commercial space flight industry.

2. Medical Regulatory Overview

The primary objective of a regulatory medical model is to promote safe practices in the industry while enabling industry growth and innovation. The Medical Working Group has further identified the following detailed objectives that serve to advance this goal:

- Promoting industry providers' development of an internal framework of documented policies and procedures for risk assessment and mitigation, tailored to each industry provider's specific operations and scope.
- Ensuring medical providers who are evaluating SFPs, and otherwise supporting the industry, are appropriately qualified for their scope of practice based on education, knowledge, and experience.
- Permitting medical providers who satisfy the requirements above to practice medicine, within their scope of practice and operational duties, including across state lines.
- Enabling collaboration in development of industry safety practices and human research through data aggregation, tracking of lessons learned, and sharing of pertinent health and medical understanding among industry stakeholders.

These objectives are further explored below. They are formulated as follows:

1. Risks of Premature Regulation in a Developing Industry,
2. The Informed Consent Paradigm,
3. Analog Industry Approaches,
4. Alternative Interim Approach – Expectation of Internal Rationale.

a. Risks of Premature Regulation in a Developing Industry

The general intent of medical regulation in commercial space flight is presumed to be tailored towards the improvement of overall public safety and individual safety of the SFPs. The focus on SFP safety may result in additional public safety implications, as SFPs or crew with mission-critical activities may ultimately have a public safety role (for example, in the control of a vehicle). Further, regulation offers the potential for standardization of activity, allowing for a common expectation of minimal capability or actions. For example, regulating that a provider must train SFPs to take required actions in an emergency provides some expectation of commonality of response, in that a participant trained to a specific response is more likely to take required actions than one without such training. Similarly, regulation of medical screening approaches may provide a pathway to ensure that basic health and performance requirements are met, to ensure all vehicle occupants are capable of taking mission-critical actions to ensure the safety of themselves and those around them.

As the industry gains experience and the tempo of operations increases, it will become prudent to provide selective, evidence-based guidelines or even a binding set of baseline regulations to ensure the focus on safety remains the cornerstone of human space flight in the commercial era. At present, the specifics of the execution of these goals are left to the discretion of individual commercial providers, often with informed and shared decision making with the customer(s), with the expectation that best practices will be applied in good faith. These best practices are not formally established, and there is significant potential for what defines “best practices” to vary across providers. To address this gap, the industry has applied an informed consent paradigm to ensure potential customers are aware of the lack of standardization, the numerous unknowns, and the risks they are choosing to accept to participate in this nascent industry.

b. The Informed Consent Paradigm

In commercial space flight, a primary driver in recent industry growth has been the development of variability of practice, with encouragement of novel practices and consideration of vehicular parameters or inclusion of participant characteristics, including medical conditions, that have not been previously included in historical space flight or have historically been specifically disqualifying. Novel vehicle design represents the potential for unknowns, including novel hazards or risk mitigation approaches that have not yet been developed or considered. In this paradigm, risk mitigation has leaned heavily on an informed consent paradigm that strives to ensure that all SFPs have the requisite knowledge to understand the risks of a nascent industry. Providing the context for which SFPs can choose to accept such risk or decline further participation is necessary considering the austere environment in space, and the risks inherent to their vehicles.

Federal law requires an informed consent framework to provide SFPs a detailed understanding of the risks and hazards involved in human space flight, as well as those specific to the industry provider, vehicle(s), and flight profiles they are pursuing, and mission duration.⁹³ This informed consent must detail:

- Information about the risks of launch and reentry, including known hazards and the risks of unknowns;
- The safety record of human space flight to date; and
- The specific safety record of the operator’s vehicle.

Further, as previously discussed, each operator is responsible for ensuring that each SFP understands the risks presented and has the opportunity for all questions to be addressed. While not specifically stated, this informed consent paradigm is presumed to include an understanding of how each SFP’s personal medical status may contribute to the overall risk of the commercial spaceflight activity. For the current state of industry development, this approach has mitigated the need for detailed regulation of medical risk assessment and provided a means of educating SFPs on the substantial unknowns in this early industry, while avoiding unnecessary limitations on growth and innovative design or stymieing inclusivity.

When considering medical practice incorporated into commercial space flight endeavors, it is necessary to establish the context in which that medical practice is performed, and to what gains. High-level “best practice” guidance allows for innovation and tailoring of needs to an individual provider or vehicle, where more prescriptive practices applied to all commercial space flight providers may not allow for consideration of provider-specific pre-flight or in-flight management approaches (for example, onboard medical capability or the lack thereof) or limit novel development of new and innovative medical approaches. Given the enormous variety in commercial space flight vehicles, capabilities, customers, mission profiles, trajectories, and associated risks, it is difficult to provide a universal set of medical screening examinations

⁹³14 CFR 460.45.

necessary for all providers, SFPs, and flight paradigms. Prescriptive practice constraints not directly tied to a specific risk reduction goal, such as the requirement of specific laboratory or screening tests, are unlikely to improve safety. In short, medical providers within the commercial space flight industry must be allowed to practice both the art and science of medicine within their scope of practice and professional certification and in the context of their clinical scenario (i.e. mission, environment) and specific patient (i.e. SFP, employee crewmember).

Finally, in addition to informed consent, current regulations require that commercial space flight operators must provide adequate training for SFPs to ensure that they will appropriately respond to emergency situations, including fire, depressurization, and emergency egress of the vehicle.⁹⁴ Through the paradigm of requiring informed consent, ensuring SFPs understand the risks they are accepting, and ensuring adequate training to perform appropriately in emergency scenarios, the FAA has sought to maximize the safety of SFPs through self-education and emergency training while minimizing unnecessary or premature regulation of the still growing industry.

c. Analog Industry Approaches

Medical regulation in other industry environments may provide an analog in which the value and limitations of regulation of commercial space flight may be considered. Example regulations that might be used for comparison include NASA governmental space flight standards, the aviation industry, the maritime industry, the oil and gas industry, and commercial activities in austere or extreme environments. Each will be discussed below.

In brief, common themes seen across variable analog industries include tailoring of recommendations specific to the unique environment of exposure, specifying recommendations for employees (less so tourists or experiential visitors), and ensuring all persons can perform their own duties or safety-critical actions. Goals of regulation are minimizing risks to self, crew, and the public. Regulation generally becomes more detailed and specific for individuals, particularly employees of the industry, with increasing safety-critical actions and responsibility for increasing numbers of people. For example, commercial pilots are required to attain a more prescriptive screening examination than a private or recreational pilot.

Further, regulation is often aimed at the certification of the medical examiner rather than the individual participant or employee. The details of the medical examination to be performed may be stipulated (e.g., standardized FAA forms for medical certification of pilots) and the individual is evaluated against a clearly defined set of medical standards with waiver processes, where indicated. However, it is incumbent upon the provider to have the knowledge and expertise to understand the medical condition, the associated medical standards, and the operational scenario in rendering a decision related to medical certification, with or without a waiver. A focus on the subject matter expertise of the medical professional evaluating participants allows for variability and tailoring of practice to a specific environment, provider, or risk profile.

i. Governmental Space flight Standards: NASA

NASA utilizes a risk evaluation matrix to evaluate medical risk from a perspective of career longevity and long-term health.⁹⁵ This approach is similar to that of many international partner governmental space agencies such as the Canadian Space Agency (CSA), the European Space Agency (ESA), the Russian Space Agency (RSA), and the Japan Aerospace Exploration Agency (JAXA). While risk is inherent to human space flight, NASA pursues probabilistic risk assessment and management of identified risk in a trade-

⁹⁴ 14 CFR 460.51.

⁹⁵ [NASA Human System Risk Management Plan, Human Health and Performance Directorate, JSC Health and Medical Technical Authority, Revision A, October 2020.](#)

based system. The declared goal of such an approach is to minimize overall risk to astronauts while ensuring mission success, (i.e. “buying down risk.”) NASA’s Human Systems Risk Board (HSRB) evaluates human system risk with the following goals:

1. Minimization of risk to human occupants in any active mission,
2. Achievement of mission objectives and success of any given mission,
3. Longitudinal preservation of astronaut careers (effectively return on investment on any selected astronaut and training of astronaut candidates),
4. Minimization of long-term health consequences.⁹⁶

Further, while the HSRB manages human system risk content, it does not have a role in operational medical certification. Instead, the HSRB serves to identify risk areas requiring further research and apply resulting data to better inform acceptable vs. unacceptable risk posture for future reference missions.

Notably, the NASA Transition Authorization Act of 2017 authorized NASA to monitor and diagnose potential conditions and treat conditions associated with space flight.⁹⁷ This provided a means by which NASA could identify and manage long-term health impacts of space flight but additionally established some degree of responsibility for NASA to assume long-term risk mitigation for astronaut crew members. Thus, NASA’s approach to risk management is based upon extensive screening, detailed risk analysis, frequent iteration of risk review, and longitudinal surveillance of the astronauts.

These tenets do not necessarily translate to the commercial space transportation (CST) industry in which relationships between industry providers and SFPs are not as clearly defined as the relationship between a career astronaut employed by NASA. The SFP and their commercial space flight provider may have a relationship that is defined as an employee astronaut, a private citizen customer astronaut, a customer astronaut employed by a private company, a customer astronaut employed by a governmental agency (domestic or international), or another category not yet encountered. The specifics of the astronaut’s employment status will significantly influence the division of responsibility for long-term health surveillance and care for a commercial astronaut between the commercial provider, the SFP, and any third parties involved. There are multiple scenarios in which the space flight provider may have the smallest share of longitudinal responsibility with sizable portions assumed by the individual astronaut or third parties. When considered in conjunction with variable factors, such as mission frequency (one-time flier vs. career astronaut) and mission duration, the degree of monitoring, longitudinal support, and responsibility can vary greatly.

ii. Aviation Industry Standards

Standards for medical certification of aviation pilots are established in the Federal Aviation Regulations (FAR) 14 CFR Part 67. Medical standards are established based on type of aviation activity, including airline transport standards, commercial transport standards, private pilot standards, and additional classifications for other pilot standards, including gliders, rotorcraft, lighter-than-air, etc. The FAA provides additional medical standards for Air Traffic Control (ATC) specialists. Medical standards for pilots and ATC operators are designed to ensure personnel are capable of performing the duties of their position without unacceptable risk to themselves or others, including other employees, aircraft passengers, or the general public.

Notably, many of the regulations surrounding aeromedical certification are designed to address the medical practitioner’s own experience and certification. A pilot’s medical evaluation and subsequent certification

⁹⁶ *Id.*

⁹⁷ National Aeronautics and Space Administration Transition Authorization Act of 2017, Public Law 115-10 (21 March 2017).

can only be provided by an FAA-designated Aviation Medical Examiner (AME), a licensed physician who receives training and oversight directly from the FAA. A basic AME is certified to evaluate pilots for both private (third class) and commercial (second class) operations. AME designation can be further stratified to include Senior AMEs, the level of expertise required to provide first class medical examinations to pilots flying passengers for commercial airlines within the United States.

The FAA defines a medical certificate as “acceptable evidence of physical fitness on a form prescribed by the Administrator.”⁹⁸ The primary goal of the airman medical certification program is to protect not only those who would exercise the privileges of a pilot certificate but also air travelers and the general public. Medical requirements for pilots increase as the level of public risk increases. Pilots of light-sport aircraft and glider pilots, for example, are not required to have a medical exam given the limited public risk of an incapacitated pilot of a vehicle carrying very few occupants. In contrast, airline pilots that are responsible for both the public on the aircraft and public on the ground have the most stringent medical requirements. Similarly, air traffic control (ATC) tower operators have a safety-critical role to direct aircraft and protect the flying public, so they also have a requirement for a medical certificate. All classes require hearing and vision tests, including color vision, to ensure pilots can safely operate their vehicles and respond to communications and emergency alerts.

Additionally, conditions that could affect the pilot’s ability to safely operate an aircraft prompt further evaluation (for example, pilots are required to obtain an electrocardiogram to screen abnormal cardiac rhythms that could lead to sudden incapacitation). Special issuances of medical waivers are available on a case-by-case basis for a large range of medical conditions, including cardiovascular conditions, such as high blood pressure or coronary artery disease, central nervous system conditions that cause vertigo or equilibrium disturbances, endocrinological conditions such as diabetes mellitus, and many others as defined by medical standards documents. Further certification and training are required for AMEs offering specialty services and certification of pilots in unique circumstances, such as the Human Intervention Motivational Study (HIMS), which allows for treatment, monitoring, and return to flight for pilots suffering from mental health conditions, including depression and substance abuse. Title 14 CFR Part 67 prescribes the medical standards and certification procedures for first, second, and third-class medical certificates. A person who meets FAA airmen medical standards, based on a medical examination and an evaluation of medical history, is entitled to a medical certificate without restriction or limitation other than the prescribed limitation as to its duration.

In 14 CFR Part 68, the FAA established the BasicMed pathway, an alternative process to renew certification of a medical certificate for private piloting activities after examination by any licensed physician, without a requirement to visit a certified AME. However, this pathway includes specific limitations regarding size and performance of the aircraft, number of passengers, and specific medical events or conditions that require reversion to the standard AME process for certification. Further, this pathway is only available to pilots who have previously held an FAA medical certification, via the standard AME processes, with no interval change of their medical status, including deterioration of an existing condition or development of a novel condition that would violate the medical standards, since that time.

In general, the FAA requirements seek to limit the impact to public safety of subtle or sudden incapacitation of pilots or ATC operators, particularly those responsible for the safety of large portions of the general public, including those on commercial airline transport and those on the ground. As the aviation industry is fully matured with substantive aggregate health and medical data for evidence-based decision making, it is unsurprising to find both prescriptive requirements for AMEs and for the specific examinations performed for each class of pilot. However, as with the approach taken by NASA, these mature aeromedical practices do not easily translate to the developing commercial space flight industry.

⁹⁸ 14 CFR 1.1.

iii. Offshore Oil and Gas and Commercial Diving Industries

Offshore oil and gas industry workers frequently spend a prolonged time on an offshore oil drilling rig or drilling platform, a high-risk and austere industrial working environment frequently remote to medical care. The most common medical standard held for offshore workers is the standard set by the Oil & Gas UK (OGUK) physical, which includes requirements for vision, hearing, urinalysis, drug and alcohol screening, and a detailed review of medical history and pharmaceutical use. Screening examination is performed by a licensed medical specialist certified by the OGUK to perform medical evaluation of offshore workers, with examination required every two years. As with the aviation industry, much of the regulatory framework is designed to ensure the certification and expertise of the individual performing the medical evaluation rather than specific requirements and examination details aimed towards the individual undergoing evaluation.⁹⁹

There are no federal regulations regarding baseline medical standards of commercial diving industry employees responsible for frequent underwater diving activities and hyperbaric exposures, though some guidance documentation is available. For example, the Diving Medical Advisory Committee (DMAC)¹⁰⁰ is an independent consortium of diving medical specialists in Northern Europe that offers guidance and position statements regarding medical considerations for commercial and professional divers, including guidance to medical professionals performing occupational medical examinations on divers in this industry. However, guidance documents tend to focus primarily on the physiology of hyperbaric exposures and training requirements for diving medical examiners rather than prescriptive detailing of examinations required for an individual diver. This again highlights the necessity of qualified examiners while simultaneously allowing for variability and tailoring of practice to individual diver or industry provider needs.

As another example, the International Marine Contractor's Association (IMCA), a leading trade association in the offshore marine construction industry, offers an "international code of practice" regarding offshore diving.¹⁰¹ In this code of practice, the IMCA highlights the need for "each diving contractor to identify doctors with such qualifications and facilities to perform annual medical examinations on divers."¹⁰² Key factors highlighted include the need for a qualified medical practitioner who has a sound knowledge of diving medicine and hyperbaric physiology as well as a detailed knowledge of the scope, nature, and organization of commercial offshore diving work.

Non-regulatory, industry-driven guidance regarding specific medical examination considerations is additionally offered by some international groups, such as the Joint Australian/New Zealand Technical Committee, which published a manuscript detailing "Occupational Diving Operations: Standard Operational Practice." In this document, some detailed guidance is offered to medical practitioners regarding detailed exam considerations and further highlighting environmental considerations for commercial divers.¹⁰³ Again, as with the prior examples, guidance is aimed specifically at the medical practitioners, with a baseline assumption of qualification and expertise of such practitioners such that they can reasonably apply appropriate medical standards in their examinations specific to such austere environments.

⁹⁹ [Occupational Health Center, What is an OEUK Physical?](#) (December 27, 2023).

¹⁰⁰ [Diving Medical Advisory Committee, DMAC Guidance](#) (February 2025).

¹⁰¹ [IMCA, Medical Examiners of Divers](#) (July 2001).

¹⁰² *Id.*

¹⁰³ Guidance on medical examination NOT regulations; additional guidance can be found in 'Occupational Diving Operations Part 1: Standard Operational Practice' Australian/New Zealand Standard, AS/NZS 2299: 1999, Appendix K.

iv. Extreme Environment Tourism

There are no national or international regulations regarding participation in extreme environment tourism, such as high-altitude trekking. While specific industry providers (e.g. tourism companies) may have internal guidance, there is a lack of overarching guidance for the industry as a whole. Where medical concerns have become impactful to parts of the industry, it is often insurance underwriters, first responders, or the medical community that enact standards. As an example, in 2020, facing a growing demand for tourist participation and increasing need for medical evacuation, the high-altitude rescue industry supporting Mt. Everest high-altitude expeditions enacted a requirement for medical evaluation prior to final climbs to the summit. Austere rescue organizations servicing the Everest area developed requirements for medical evaluation to limit inexperienced or medically unfit participants from ill-advised climbs requiring evacuation and rescue.¹⁰⁴ However, this effort was notably not a government standard or applicable to other high-altitude environments, even including other peaks serviced by the same mountain rescue providers. In this case, requirements were developed specifically to a recognized need in a long-standing industry of high-altitude tourism at Mt. Everest. Additional guidance was directed at medical practitioners, highlighting the skills and fitness required for the taxing environment and the need for experience and expertise in high-altitude sports for practitioners evaluating participants.

These examples demonstrate that analog austere industries generally work without highly prescriptive medical regulatory frameworks, instead focusing on tailoring guidance to specific environments and ensuring the expertise of the medical practitioners authorized to evaluate a given individual for participation in that environment. Notable exceptions to this approach include NASA, where governmental astronauts serve as highly trained assets with a corresponding national interest to enable career longevity and limitations of long-term health risks, and the FAA, where the aviation industry represents a contrastingly mature industry servicing large numbers of the general public. However, with these contrasting industries as noted exceptions, the remaining analog paradigms tend to provide guidance and encourage medical expertise rather than pursuing or enacting national regulation or oversight of specific medical examination details. Medical expertise of the practitioner is in turn governed by the medical community itself through certification and educational standardization, with medicolegal precedent establishing an expectation of standard of care and expertise and a means by which a negligent or improperly acting practitioner can be held accountable for lapses in care. Thus, enacting detailed regulation of aerospace medical practice for the commercial space flight industry would be contrary to historical precedent.

d. Alternative Interim Approach – Expectation of Internal Rationale

In the absence of detailed regulations of medical examination or participant certification at this time, a reasonable alternative approach may be to pursue a stratified architecture of initially non-specific guidance developing into evidence-based specification of industry need. In this way, expectations can be communicated to industry providers without the need for detailed regulatory language. Similar to the informed consent paradigm, this allows for industry growth while maintaining an expectation of standard of care.

At the early stage of this nascent industry, it is reasonable to expect that industry providers will internally establish risk expectations and a risk management plan with a clear purpose. This establishes the baselines of internal standards and design requirements within a given company and helps to define the acceptable standards of internal risk. As a part of this process, it is expected that industry providers will internally establish:

¹⁰⁴ Agnew, Mark, [Everest climbers will need a medical evaluation before scaling peak, says extreme sports rescue specialist](#), February 12, 2020.

- Risk descriptive language and medical standards with, if applicable, a defined waiver process;
- Internal risk posture and acceptance level;
- Internal risk identification process;
- Risk disposition criteria and processes;
- Internal expectations of risk documentation;
- Internal policies regarding data privacy;
- Processes regarding internal auditing and quality assurance; and
- Identification of stakeholders and relative responsibilities.

Just as an industry provider would be expected to establish the above processes for vehicular design and iteration, there is a similar expectation that industry providers internally establish these processes for health and medical risks.

In lieu of prescriptive regulatory standards for medical risk evaluation and standardization, the establishment of an industry expectation for an internal process, risk assessment, rationale, and documentation of the above provides a means of interim monitoring of the developing industry. In the case of an adverse medical event, particularly one that occurred as an exacerbation or consequence from an existing medical condition, an involved industry provider should be able to provide participants or regulatory stakeholders documentation of their internal approach to risk mitigation and medical evaluation and the rationale behind that approach. This includes documentation addressing the expertise of health and medical subject matter experts used for evaluation of risks specific to vehicles, mission profiles, and individual participants, and the rationale behind their approach to ensuring the provision of such expertise where appropriate as a part of their risk assessment and mitigation paradigm. As the industry further develops, there may be reasonable standardization of some areas of medical risk mitigation; however, until further data are available to validate such standardization, an expectation that an industry provider can provide evidence and rationale behind their own approach is a reasonable baseline.

C. Economic Impact

Executive Order 12866, Regulatory Planning and Review (as amended by EO 14215, February 18, 2025) requires federal agencies to assess the economic impact of regulatory changes.¹⁰⁵ In keeping with this EO, the FAA included in the Charter for the Part 460 SpARC a requirement for assessing the economic impacts to industry of the recommendations in the report.

The Economic Impact Working Group reviewed all recommendations and rationale presented in the latter half of this report, and made an additional recommendation also presented there. However, to understand broader context, additional and independent sources on the human space flight market, including expected global government investment in HSF activities and outside assessments from the Congressional Research Service and the Government Accountability Office, were also reviewed. Other emerging markets for new technologies where regulation could have an enabling or damaging effect were considered, as were historical examples. In addition, separate interview sessions were conducted on the following topics:

- Status of HSF Market: (WEF, Citigroup, Analysys Mason, BryceTech)¹⁰⁶,
- Status of Industry Standards: ASTM International Committee F47,
- Insurance Industry Perspectives as of January 2025.

¹⁰⁵ [Executive Order 12866, Regulatory Planning and Review, September 30, 1993 \(as amended by EO 14215, February 18, 2025\).](#)

¹⁰⁶ BryceTech: Human Spaceflight Economic Activity, December 2024 brief to SpARC working group; CitiGPS: [Space: The Dawn of a New Age](#); WEF; Analysys Mason: SpARC telephone interview (October 2024).

Throughout much of the SpARC’s term, FAA authorities were operating under a “learning period” imposed by Congress, which prohibited the agency from promulgating new regulations to protect vehicle occupants and other aspects of human space flight. A three-year extension (to January 1, 2028) was passed into law near the end of the SpARC’s work.¹⁰⁷ This development reflects a continuing Congressional concern that the industry’s human space flight experience lacks sufficient activity to justify credible rulemaking or other regulatory activity by the FAA. However, as pointed out in the report, this extension of the learning period does not remove the need for continuing work by the FAA and the commercial human space flight industry to improve regulatory functions within the existing framework, especially in such a way that is cognizant of the economic impact on industry.

1. Regulating the Commercial Space Industry – Lessons from Other Cases

Crewed access to space, originally the exclusive prerogative of national governments, has become increasingly attainable by private sector actors over the past two decades. During this time, a number of companies have been founded that aim to open space to commercial endeavors including tourism, satellite deployment, and mining. Due to the highly visible nature of both its successes and failures, this emerging industry sector—loosely referred to as the commercial space industry—has attracted greater attention and scrutiny in recent years. The proliferation of different launch systems and risks to crew, government astronauts and space flight participants, and the public have incited calls for greater government oversight and regulation.

A sample of successful regulatory postures taken with newly developing industries has been described in a recent paper by Professor Susan Dudley of the George Washington University Regulatory Studies Center.¹⁰⁸ While the commercial space industry brings certain unique elements, some general guiding regulatory principles can be derived from her study of historical instances in which emerging industries were successfully regulated.¹⁰⁹ Three cases are particularly instructive: the deregulation of the airline industry in the 1970s, the regulation of biotechnology in the 1980s, and the regulation of the internet in the 1990s.

In the decades following its founding in 1938, the Civil Aeronautics Board (CAB) attempted to respond to concerns regarding the market power of the then burgeoning passenger airline industry by controlling private sector economic activity via price ceilings and floors, quantity restrictions, and service conditions. The original intent was to protect consumers from producers’ disproportionate market power in the sector. However, over the ensuing decades, a consensus gradually grew that the economic regulatory agencies had been “captured” by the industries they regulated.¹¹⁰ By the 1970s, it was apparent that regulation of the airline industry’s private sector economic activity through regulation of airfares, routes and services kept prices artificially high, benefitting the incumbent companies at the expense of consumers.¹¹¹ In response, a bipartisan effort was made to abolish CAB and to remove the unnecessary regulation of rates and services

¹⁰⁷ [Extension of Learning Period for Certain Safety Regulations Relating to Space Flight Participants](#), Public Law No. 118-159, Sec. 5702 (December 23, 2024).

¹⁰⁸ Dudley, Susan E. [Lessons from the Past for Regulating AI](#). GW Regulatory Studies Center Working Paper (November 2024).

¹⁰⁹ *Id.* Susan Dudley has identified four such cases and has drawn upon them to inform her proposed artificial intelligence regulatory paradigm. The cases and principles highlighted in this recommendation are originally from her work.

¹¹⁰ Green, M., & Nader, R. (1973). [Economic Regulation vs. Competition: Uncle Sam the Monopoly Man](#). The Yale Law Journal, 82(5), 871–889.

¹¹¹ Stigler, G. J. (1971). [The Theory of Economic Regulation](#). The Bell Journal of Economics and Management Science, 2(1), 3–21; Dudley, Susan E. “[Milestones in the Evolution of the Administrative State](#),” American Academy of Arts & Sciences, June 16, 2021; Simon, Donald (1977). [Senator Kennedy and the Civil Aeronautics Board: Phase I \(Case 157.0\)](#). Harvard Kennedy School of Government.

in the airline industry.¹¹² As a direct result of deregulation, both innovation and consumer welfare increased as airlines began to offer more frequent flights at lower prices.¹¹³ This in turn made air travel accessible to the American middle class for the first time.

This illustrates that “economic” types of regulation intended to constrain monopolies and achieve vaguely defined notions of the “public interest,” including price controls, rate-of-return regulations, exclusive licenses, line-of-business restrictions, and quality-of-service or access requirements, tend to restrict competition and benefit incumbents. Unleashing competition by removing those forms of regulation can lower prices, improve services, and enable innovation.

Another informative case is the government’s approach to biotechnology regulation in the 1980s. The development of recombinant DNA technologies—the ability to splice DNA from different species, edit the genetic code, and create genes with new functions—in the previous decade had opened an exciting, unknown, and potentially dangerous array of potential applications. In response, scientists, ethicists, and journalists convened in 1975 at the Asilomar Conference to declare a moratorium on recombinant DNA research until pressing public health and ethical concerns could be addressed. During this 16-month moratorium, the National Institutes of Health’s (NIH) Recombinant DNA Advisory Committee (RAC) converted the Asilomar Conference’s statement of principles into the first formal framework for biotechnology research and oversight. The RAC guidelines stipulated conditions under which institutions that receive NIH funds must conduct experiments.¹¹⁴

In the following years, these NIH guidelines were incrementally relaxed as scientists’ understanding of the applications of recombinant DNA grew. Research flourished under this approach and began to yield commercial applications of gene editing technology by the early 1980s. In response, regulatory agencies began to assert jurisdiction over these new products, and legislators contemplated whether new laws and new agencies might be needed. The White House formed a Working Group on Biotechnology, chaired by the Office of Science and Technology Policy, which included both the relevant research and regulatory agencies. This working group produced the *Coordinated Framework for Regulation of Biotechnology* in 1986. This framework advocated a risk-reward approach that sought to balance the need for adequate health and environmental regulations with the imperative of ensuring enough regulatory flexibility to avoid stifling the nascent industry.¹¹⁵

Crucially, the government decided not to establish a new statutory approach or a single biotechnology regulatory agency due to the broad spectrum of applications of the products created via genetic engineering techniques. These applications fell under the purview of numerous existing regulatory agencies. It was further determined that existing laws were sufficient to regulate the characteristics of the products created via genetic engineering techniques, *allowing the techniques themselves to remain relatively unregulated*. This approach stood in stark contrast to the more precautionary approaches adopted in Europe and other parts of the world. As a result, a disproportionate amount of downstream medical and agricultural innovation occurred in the United States.¹¹⁶

This sequence of events reveals several important principles. First, when regulating a novel technology or emerging industry about which there is still much uncertainty – including commercial human space flight

¹¹² Derthick, Martha and Paul J. Quirk, [The Politics of Deregulation](#). Brookings Institution. Washington D.C., 1985.

¹¹³ Crandall, R., Ellig, J. (1998). [Electric restructuring and consumer interests: lessons from other industries](#). The Electricity Journal, Volume 11, Issue 1, (pp. 12-16).

¹¹⁴ Office of Science and Technology Policy, [“Coordinated Framework for Regulation of Biotechnology,”](#) 51 FR 23302 (June 26, 1986).

¹¹⁵ *Id.*

¹¹⁶ [“The Rush to Regulate AI: We’ve Been Here Before,”](#) The Wall Street Journal, January 2, 2024.

– an agile iterative strategy is best able to respond to new developments and information in a timely manner. Second, single-mission agencies are susceptible to tunnel vision and potential regulatory capture which can be most effectively countered by encouraging dialogue and collaboration with other agencies that hold competing mandates. Third, focusing on the likely risks of a product, rather than on the technology or process used to produce it, makes applying existing regulatory practices manageable and avoids unduly precautionary policies. In many cases, ex-post remedies, rather than ex-ante approvals, are sufficient to protect public health and safety.

The final illustrative case is the Clinton administration’s regulatory response to the emergence of the internet. By the mid-1990s, the breakup of the AT&T monopoly and deregulation in the telecommunications sector had opened competition in high-speed information services. The Clinton administration embraced this development by issuing its 1997 *Framework for Global Electronic Commerce* in which it emphasized the internet’s potential to revolutionize commerce, reduce transaction costs, and create a global marketplace.¹¹⁷ This framework proposed that the internet’s potential as a global marketplace could only be fully realized if the government adopted a non-regulatory, market-oriented approach. It also emphasized the importance of creating a transparent and predictable legal environment to support global business and commerce. This approach is often credited for laying the groundwork that enabled American companies to become the dominant actors in the digital world.¹¹⁸

With rapidly evolving technology, the government should let the private sector lead and take a “minimalist” approach to intervention that encourages competition, protects property rights, ensures a “consistent and simple legal environment,” and targets tangible concerns (like protecting against privacy and preventing fraud).

As applied to commercial human space flight, these examples demonstrate that these and other regulatory mechanisms need to be carefully considered for their economic impact on industry and the desired growth of the commercial space flight market. As the space economy continues to shift from government driven to overwhelmingly commercially driven, including a very diverse commercial human space flight business model, a “light touch” regulatory environment will be essential for enabling the growth of this market and all other secondary markets that depend on it (e.g., tourism, research). In that context, as the industry matures, future regulatory activity should result in the improvement of safety.

2. Observations on the current commercial human space flight market

Historical projections of the commercial human space flight market by 2030 were overly enthusiastic, as reflected in this report. The reality is that less than 25 commercial human space flight missions have taken place as of this writing. Global macroeconomic conditions, geopolitical conditions, lengthy regulatory reviews, and technological limitations impeded market growth. More recent, independent studies vary wildly in their estimates of the human space flight market, both in terms of methodology – what’s included in the estimate – as well as the size of the market:

- Analysys Mason’s *Space Travel and Tourism Markets, 5th Edition* (March 2024) estimates that more than 100 commercial orbital space flights will take place between 2023 and 2033. These flights are estimated to carry more than 450 passengers and generate over \$19.5 billion in revenue. Analysys Mason’s estimate includes at least one commercial space station flying by 2030, largely

¹¹⁷ The White House, “[Framework for Global Electronic Commerce](#),” (1997).

¹¹⁸ Magaziner, Ira C., Cutter, Ann Grier, Costa, Len A. “The Framework for Global Electronic Commerce: A Policy Perspective,” *Vol. 51, No. 2, Technology and International Policy: Essays on the Information Age (Spring 1998)*, (pp. 527-538), [Journal of International Affairs Editorial Board](#).

supported by government demand.

- Citi GPS’s study *Space: The Dawn of a New Age* (2022) projected an approximately \$8 billion HSF market by 2040 also but included inter-city passenger travel in the estimate. Space orbital and suborbital flights were estimated to represent only \$1 billion of that figure, based on high ticket prices.
- The World Economic Forum’s *Space: The \$1.8 Trillion Dollar Opportunity for Economic Growth* (April 2024) combines space tourism and manufacturing as important new market segments, noting limited capacity to accommodate humans and limited launch capacity. Nonetheless, this is the most optimistic of the space tourism estimates at \$4 - \$6 billion *per year by 2035* including \$1 - \$2 billion in the more affordable suborbital flight capacity.

While these independent studies are helpful to understand the continuing “high bar” for *expectations*, the reader is cautioned once again that they include different methodologies and aspects of the commercial human space flight value chain, and therefore high levels of uncertainty. Although many of these reports are enthusiastic about the individual and collective value of the market, they are just as often focused on the limitations and uncertainties over the next decade.

3. Comments on Regulatory Structure and Investment

Prescriptive regulation— whereby the safety regulatory agency sets specific tasks, activities and standards that must occur, has its place as applied to mature technologies where there is little change and innovation is incremental. However, as noted earlier in the report, this type of regulation runs the risk of “locking in” existing practices and discouraging innovation, experimentation and the development of alternative methods of safety by creating an additive environment where any new innovations must be done *in addition to* and not *instead of* existing requirements. Such a regulatory structure can deter private actors with a profit motive from investing in innovation.

The goal of a strong, diverse, and vibrant commercial human space flight industry can be a cornerstone of U.S. leadership in the global space economy. It will not only reflect the growing human interest in space but also provide the opportunity for government and private research and development in a wide range of adjacent industries. Safety, and perceptions of safety, are essential to continuing investment, entrepreneurship, and willingness to participate in human space flight activities.

VI. Recommendations and Conclusions

A. Regulatory Innovation & Safety Recommendations

The Regulatory Innovation and Safety Working Groups used the information they obtained through SpARC activities and asked the following questions:

- 1) How should the FAA evaluate whether and when additional regulatory action is appropriate or necessary?
 - a) How does the safety continuum apply to human space flight?
 - b) Where does the industry sit within the safety continuum today?
- 2) When regulatory action is appropriate, what are the primary considerations for a successful framework for future human space flight occupant safety regulations?
- 3) Are there actions the FAA can take now to ensure the success of the industry and the quality of any future regulatory action?

The Regulatory Innovation and Safety Working Groups offer recommendations and conclusions based primarily on these questions. The discussion of the following Recommendations (1-18) is grouped into five primary sections, with subgroups in select sections. The purpose of these groupings is to illustrate how certain recommendations fall under similar topics.

1. Safety Continuum Application to Human Space Flight Regulations

a. The FAA's continuum model applied to space flight

No single regulatory model fits seamlessly for commercial human space flight. However, the SpARC analyzed how the FAA employs a “Safety Continuum” concept to right-size its oversight of the aviation sector. The FAA defines its “safety continuum” as follows: “The level of safety established by regulation, guidance and oversight that change based on risk and societal expectations of safety.”¹¹⁹ The safety continuum applies an appropriate level of safety from small Unmanned Aircraft Systems to large transport category aircraft. The differing level of safety balances the needs of the flying public, applicants and operators while facilitating both the advancement of safety and the encouragement of technological innovation.

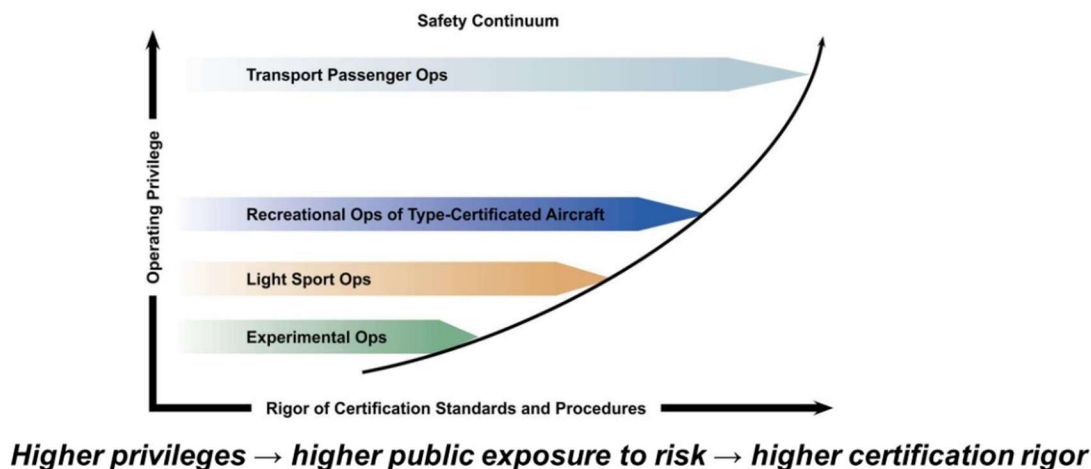


Figure 6: AVS Safety Continuum Concepts¹²⁰

The Safety Continuum varies freedoms afforded manufacturers, operators, and/or pilots based on their potential to impact public safety, which in aviation’s case includes occupants, or “the flying public.” Where limitations on this impact are reasonable and feasible without additional regulation, there is a lower rigor of the oversight provided. For lower rigor regimes, the threat to public safety is assessed qualitatively, not quantitatively. The concept provides substantial clarity and transparency both externally to the public and aviation community, as well as internally for the purposes of balancing workload and resource allocation for a budget-limited agency.

The regulatory mindset that led the FAA to create a substantially different framework for different types of activities is directly transferrable to the commercial space industry. In its space regulation, Congress and the FAA have already identified the need for differing approaches by, for example, setting up an experimental permit regime under 14 CFR Part 437, where risk need not be quantified, and non-paying occupants may travel on board.

¹¹⁹ FAA provided quote to the SpARC through briefing on May 10, 2024.

¹²⁰ FAA provided image to the SpARC through briefing on May 10, 2024.

Recommendation 1 – Utilize a safety continuum concept

REC 1	The FAA should utilize an oversight continuum to evaluate the degree of rigor strictly necessary, consistent with Congressional direction, for future occupant safety regulations that would coexist with the current rules (which are tailored to the adventure/experimental phase of the industry) and comport with AST’s statutory direction to establish “...stable, minimal, and appropriate regulatory guidelines that are fairly and expeditiously applied.”
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INTENT:

This recommendation is intended to provide the FAA with an anchoring concept for its role in human space flight. By considering that the optimal level of oversight can and will evolve over time, this model recognizes the need for balance between meeting/increasing safety oversight while imposing the least burden on industry and society, and enable market growth. Another way to view this continuum involves looking at societal tolerance for risk and demand for regulation to determine how much regulation is appropriate for a given vehicle or operator. For example, the FAA increases its aviation oversight to protect those who cannot control their exposure to risk where society’s expectation of safety has grown higher as a mode of transport becomes routine. The concept applies throughout the human space flight learning period and beyond—regardless of statute, it would not be appropriate for the FAA to regulate the human space flight industry today in the same manner as it regulates transport category aircraft. Instead, it should recognize that some operators developing their vehicle designs may operate under an experimental regime with more informed consent. When an operator approaches routine transportation, it would be more appropriate for the FAA to impose tailored safety requirements but require less informed consent.

Recommendations and ideas found later in the document can be linked to an oversight continuum like the concept illustrated in Figure 7 below, including indicators, near-term and future actions.

APPROACH:

Figure 7 demonstrates one possible continuum, capturing the general concept that the government applies more rigor to protect those who cannot control their exposure to risk. In this case, at opposite edges of this curve are two types of persons exposed to the possible hazards of a launch activity – the uninvolved public and space flight participants. The public has no ability to control the risks created by a launch and may not even be aware that one is taking place. The FAA’s current space regulations are accordingly more rigorous. A space flight participant, on the other hand, knows his or her risks and consents to them specifically. The FAA’s current regulations are correspondingly limited. The greater flexibility for human space flight reflects two points: first, that the industry offering human space flight is still developing and testing its technologies, and second, that Congress did not wish to deprive persons seeking to travel to space of the opportunity to do so as long as they are aware of the risks involved.

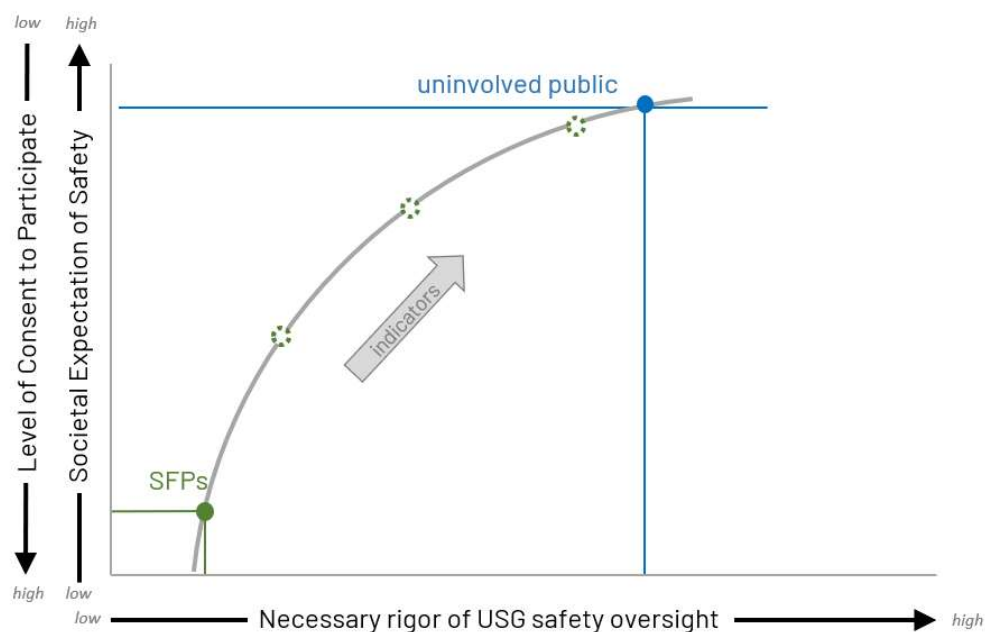


Figure 7: Notional Oversight Continuum

X-Axis, Necessary Rigor of Oversight: High level of rigor might include a full vehicle and operational certification program. Part 450 public safety regulations fall at the high end of this spectrum. Part 460’s requirements, including the informed consent regime, represent a relatively lower level of rigor. The rigor of a regulatory regime often reflects societal expectations. As a mode of transportation becomes ubiquitous and routine—as automobile and air travel have—the public expects higher and higher levels of safety. Where something is more obviously risky, such as sky diving or mountain climbing, the public has lower expectations of and demands for safety oversight as reflected in the notional graph.

Y-Axis – Level of Consent/Expectation of Safety: With more knowledge of the risks being undertaken, there may be more consent. The level of consent to participation can range from none and no awareness that a hazardous activity may affect them (i.e. the public), to formal consent after in-depth briefing and information sharing, resulting in a high awareness of hazards (i.e. SFPs under Part 460).

RATIONALE:

Necessary distinction between aviation and space launch

The safety continuum used in aviation relies heavily on setting and meeting the public’s safety expectations. The FAA comprehensively regulates passenger-carrying aircraft but provides much less oversight for experimental aircraft. With commercial air travel having become routine and demonstrating it can achieve a high level of safety; the public expects it and requires it. For experimental aviation flights, the law and the FAA take a different approach, forbidding compensation or hire, making sure the aircraft are properly marked, and overseeing the safety of those on the ground rather than those on board. At the upper end of the spectrum, transport passenger operations have a high level of rigor due to both risks to persons on the ground and risks to passengers. “The flying public” is therefore lumped in with those on ground in terms of the amount of regulatory oversight. The lack of distinction between occupant and non-occupant is understandable given the 2.9 million airline passengers traversing the domestic airspace each day.¹²¹

¹²¹ [FAA Air Traffic By The Numbers](#), September 9, 2024.

Rather than directly addressing a total level of risk to all parties, similar to the “operating privileges” axis found in the FAA AVS example, the proposed curve separates participant types and emphasizes key differences—the awareness and acceptance of risk and society’s expectations. The distinction was acknowledged by Congress when it passed the Commercial Space Launch Amendments Act (CSLAA) and established “space flight participant” as a separate category of persons whose participation may prompt separate regulatory action and mandated the use of informed consent.

Congress in the statute and the FAA in Part 440 further distinguish between space flight participants and airline passengers by requiring the former to agree to waive claims against commercial operators and the U.S. government. Airline passengers sign no such waivers.

Regulatory regime for public safety sets one end of the continuum

Because Part 450 is intended to cover public safety issues from launch and re-entry, the SpARC focused on the extent to which additional rigor (above/beyond the requirements of Part 450) may or may not be necessary for the protection of occupants. The uninvolved public is firmly located at one end of this continuum, and the FAA can consider, subject to Congressional direction, to what extent evolution in the industry pushes space flight participants towards a similarly high-rigor regime.

Commercial space launch operations, including human space flight operations, have a regulatory framework designed to protect public safety and address financial responsibility (Parts 450, 460, and 440). Operational limitations fall out of this rigorous review and include a quantitative assessment of risk to those on the ground. This robust public safety regime under 450 substitutes for operational privilege restrictions similar to those for experimental aircraft.

2. Commercial Human Space Flight Within the Safety Continuum Today

Recommendation 2 – AST’s current regulatory framework should remain in place

REC 2	The FAA should continue to implement the current human space flight occupant safety framework, which includes informed consent, as the primary basis for managing risk under Part 460 while the industry remains in a nascent phase.
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INTENT:

Representatives on the SpARC and AST share common goals: the safe and sustainable growth of commercial human space flight. Maintaining the current framework allows further development of both the industry and regulator. Commercial Human Space Flight remains in a period where occupants can make informed choices about their exposure to risky activities in lieu of increased oversight.

This approach is firmly rooted in enabling industry technology and consensus standards to develop while the industry remains in its infancy. Maintaining the current framework is also intended to enable the FAA to focus on learning, contributing to consensus standards development, and training its workforce to prepare for future phases of the regulatory framework.

APPROACH:

No specific action is required to carry out this recommendation – other recommendations in this report detail actions that can occur now to develop and prepare for future safety frameworks.

RATIONALE:

The current framework accurately addresses occupants on the oversight continuum.

Considering the proposed continuum in Recommendation 1, it is necessary to evaluate the state of the human space flight operations on this spectrum.

Space flight participants are individuals with control over their participation in a potentially risky activity. No one is forced to engage in space flight travel. This is enforced and reinforced by the statutorily required informed consent process. This existing oversight manages the flow of information, including a requirement for interactive discussion with the operator. The current regulatory framework also requires this be performed prior to accepting payment, removing any penalization of deciding not to participate. Additionally, the accessibility of these activities is low. Due to factors such as price and the “supply” of flight opportunities, the barriers are high.

The informed consent component of the current rules does not amount to safety oversight. It governs the risk information provided rather than specifying an allowable level of risk. The current regulatory framework provides a relatively high degree of rigor for this communication ensuring that participants can make this choice. Based on the notional proposed continuum curve, this is appropriate only so long as those at risk are able to consent to their participation. The level of rigor of safety oversight is a measure of the extent to which the government acts as proxy for an individual. As the level of agency for SFPs remains high, there is less necessity for the government to fill this role. Analogous regulatory behavior applies in aviation with experimental and light sport regimes. Within each of these regimes, the level of rigor provided by regulatory oversight is correlated to the level of awareness the occupants have of the risks being assumed on a respective vehicle and the risk to the public.

Until the industry evolves in such a way that clearly changes the balance along this continuum, informed consent remains the appropriate minimum threshold. By acknowledging this, AST, in line with its statutory obligation to regulate only to the extent necessary, can choose to step up the continuum slowly, ensuring regulatory action doesn’t outpace need or capabilities. Currently, it is feasible for all space flight providers to give informed consent briefings to each individual participant. Only marked increases in volume, cadence, condition of employment, and access to human space flight will push occupants up this curve towards a risk posture that looks like commercial aviation, something the recommended indicators are intended to show.

To ensure this remains appropriate during the initial growth of the industry, there are opportunities for the FAA to strengthen informed consent. (see Recommendation 10).

State of Industry vs. Congressional intent and FAA evaluations

In the Human Space Flight Requirements for Crew and Space Flight Participants notice of proposed rulemaking published on December 29, 2005, in response to the CSLAA, the FAA states:

In December 2004, Congress passed the Commercial Space Launch Amendments Act. The CSLAA requires that a phased approach be used in regulating commercial human space flight; that is, regulatory standards governing human space flight must evolve as the industry matures.¹²²

Because the regulatory standards must evolve as the industry matures, it is useful to understand the expectations for industry growth when the “learning period” was first established. In the Regulatory

¹²² [Human Space Flight Requirements for Crew and Space Flight Participants](#), 70 FR 77262 (December 29, 2005) at 77263.

Evaluation section of the same NPRM, the FAA made certain projections for the purposes of a cost benefit analysis. At the time, the FAA’s “low launch forecast” was 5,081 launches over 10 years.¹²³ In fact, no commercial human space flights occurred in the United States in the 10 years that followed the proposed rule. That is why, as recently as February 2019, DOT indicated in a report to Congress that based on the FAA’s indicators, “...there are no commercial human space flight activities that are ready for a new safety framework that may include regulatory action.”¹²⁴ The report goes on to state:

At this point in the commercial human space flight industry’s evolution, transition to a new safety framework might stifle technology development. As the industry continues to evolve, FAA remains committed to aiding the development of voluntary industry consensus standards and is actively engaged with industry in that effort. Industry’s proactive participation in creating a safety framework can influence the timing and extent of government regulatory involvement, and successful implementation of an industry-led framework could minimize the need for government involvement.¹²⁵

The statement in the report is internally consistent given the FAA’s expectation that *thousands* of human space launches would fly during the learning period versus the reality of less than 20 licensed private flights as of this writing, or roughly 0.3% of the “low” side of the FAA’s estimate. While industry works on innovative solutions to promote safety, the applicable regulatory safety framework must remain predictable and tailored to an emerging and complex ecosystem.

Public safety oversight also indirectly protects launch and reentry vehicle occupants

Any commercial launch or reentry operation, regardless of whether it carries occupants, is required to receive a launch license from the FAA under the public safety framework defined in Subchapter C of Title 14 of the Code of Federal Regulations. As noted in Section V.A.1, the licensing process is comprehensive, which aligns with the safety continuum concept. An important aspect of this regulatory regime is a robust system safety process. This is explicitly stated in the Streamlined Launch and Reentry Licensing Requirements notice of proposed rulemaking, which states:

All operators would be required to have a system safety program that would establish system safety management principles for both ground and flight safety throughout the operational lifecycle of a launch or reentry system. The system safety program would include a safety organization, procedures, configuration control, and post-flight data review.¹²⁶

During license evaluation, AST reviews an enormous number of an applicant’s processes through the lifecycle of a program/vehicle to determine sufficient protection of the public. In addition to a system safety program, this includes risk management cycles, hazard analysis methods, test and design variables for safety critical systems, and controls surrounding launch and reentry operations. Although the scope of detailed verification evidence examined by AST is focused on public safety, the process of approval often involves review of high-level company documents. These reviews are significant. AST approval of a program’s control documentation acts as a minimum bar for entry into the human space flight market. It ensures a certain level of maturity of the technical processes that an operator uses to ensure risks are minimized.

¹²³ *Id.* at 77273.

¹²⁴ [DOT Report to Congress: U.S. Department of Transportation Evaluation of Commercial Human Space Flight Activities Most Appropriate for New Safety Framework](#) (February 26, 2019), p. 5.

¹²⁵ *Id.*

¹²⁶ [FAA Streamlined Launch and Reentry Licensing Requirements](#), 84 FR 15296 (April 15, 2019), at 245.

Hazard analysis is the foundation for informed consent

Under the current regulatory structure, an operator is required to report to crew and space flight participants all hazards that an occupant may encounter (and the existence of unknown hazards). The FAA proposed in its preamble that “a hazard analysis focusing on keeping the space flight participants alive will be conducted by the operator to identify these hazards.”¹²⁷ The SpARC agrees with this assertion and notes that the process by which hazards are identified is available per current Part 450 regulations.

The SpARC acknowledges that the reviews involved in launch licensing, as well as hazard analysis, do not constitute safety oversight explicitly for occupants, but taken together they serve to demonstrate that the current framework provides confidence that the industry is building from strong foundations. These activities mandated by Part 450 support the following critical observation.

Critical Observation: Some commercial human space flight occupants benefit from a connection between public safety and occupant safety

OBSV	Depending on the presence of occupants who have roles that contribute to public safety, some aspects of occupant safety may already be governed by current regulations.
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INTENT:

The SpARC analyzed the existing overlap between public safety and occupant safety, and the functional implications both directly and indirectly in the current regulatory environment. Though the previous SpARC recommendation states that current regulations are the appropriate foundation for the industry today, the SpARC believes that many operations exceed this bar today, though to varying degrees.

It is imperative that AST understand this concept. As the need to add oversight becomes necessary, there must be a deep awareness of how current regulations already require the demonstration of certain safety features, processes, and analyses, all of which protect occupants, even if unintentionally.

RATIONALE:

Part 460 - Presence of Crew

The presence of humans on board, regardless of their roles, necessitates compliance with regulations for environmental controls and fire detection and suppression, as well as a requirement to perform an integrated flight test before allowing SFPs on board.¹²⁸ These bona fide occupant safety requirements protect the public by protecting the crew and are not strictly limited to demonstrating crew’s ability to complete safety critical tasks. To the extent that the same systems also protect SFPs during a launch, this represents an indirect form of oversight, and an opportunity for AST to gain insights.

Part 460 – Presence of Crew with Safety Critical Roles

The presence of crew with a safety critical role adds additional layers to safety. Operators are required to demonstrate to the FAA that human factors considerations cannot negatively affect the crew’s ability to perform their roles. The level of oversight necessary varies based on the types of public-safety critical roles and where these roles fall in the operational lifecycle. Again, a direct spillover effect can exist. For example, when a human space flight provider employs acceleration and noise protection features for crew, it is unlikely that those protections would not benefit a space flight participant as well. Additionally, if there were hazards that only affected space flight participants, their disclosure during informed consent could result in fewer persons interested in that flight.

¹²⁷ [Human Space Flight Requirements for Crew and Space Flight Participants](#) (December 15, 2006) at 75624.

¹²⁸ 14 CFR 460.11, 460.13, 460.17.

Part 450 - Presence of Crew with Safety Critical Roles

Recent launches represent a small increase in activity in commercial human space flight. However, as of this writing, no mission has been licensed under the latest safety regulatory framework, Part 450, in conjunction with Part 460. This is a critical note because Part 450 has requirements that protect occupants inherently, especially if the occupants have a role in protecting public safety.

In the current framework, if any human onboard has a safety-critical role that must be carried out to avoid negative impacts to public safety, Part 450 requires operators to demonstrate safety and receive FAA concurrence of system designs, implementation, and maintenance. For example, in § 450.143, an operator must submit documentation to the FAA for safety critical systems related to design, qualification testing, acceptance of hardware, and lifecycle (i.e. maintenance/refurbishment) and describe industry standards used in the development of these systems. This level of detail at times approaches oversight models used by NASA and national security entities tasked with mission assurance.

With the industry's current maturity level, the expertise available to both government and industry, and the individualized designs of different operators' vehicles, providing meaningful technical feedback to operators requires years of effort and extensive in-house and contracted engineering support. Three of the four current providers of human space flight have roles for the occupants that could impact public safety, which raises questions of how requirements like § 450.143 will be interpreted as applied to human space flight.

AST provided feedback to the committee on how it would interpret the current rules in Part 450 as applied to commercial human space flight. In its feedback, AST explained that a system could obtain a waiver from certain sections of Part 450, like § 450.143, in cases where it can be shown a foreseeable hazard arising from the system is "extremely remote." However, to demonstrate that the system has an extremely remote possibility of causing a public safety hazard, significant information that would be required under § 450.143 may be needed to obtain a waiver.

The rules could cause operators to undergo significant data reviews with AST to demonstrate either public safety protections or demonstrate the low likelihood of risks to the public for each subsystem that relies on occupant involvement.

Thus, by protecting the public, current regulations indirectly offer protection to vehicle occupants (in the case where launch providers also operate crew vehicles).

3. Indicators to evaluate need for future regulations

Recommendation 3 – Use better indicators to track industry evolution

REC 3	The FAA should adopt a new list of indicators that better captures the state of the industry and the regulator. Indicators should be used to judge whether there is a need to introduce new occupant-safety frameworks.
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INTENT:

This recommendation offers a set of indicators to assist AST in determining the appropriate timing for incremental rulemaking activity associated with occupant safety. Indicators are intended to be paired with the oversight continuum discussed in Recommendation 1 by tracking the evolution of an industry and the shift of occupants for certain activities along the curve. Indicators can suggest changing perspectives on consent or expectations of safety or external factors that may impact demand for action. All parties are encouraged to examine the industry in terms of how these metrics indicate a shift in public expectation toward a higher level of safety oversight, and what level and scope of oversight addresses these shifts. The SpARC notes that the human space flight industry is still in its early stages of development.

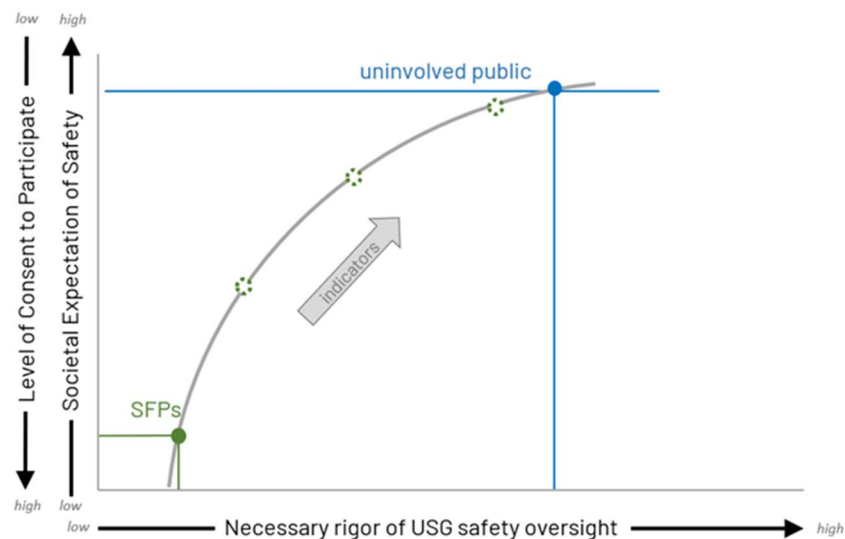


Figure 8: Notional safety continuum for commercial human space flight

APPROACH:

The FAA should update the list of indicators it tracks in its reports to Congress required by 51 U.S.C. § 50905(c)(6) to better capture both the need for regulations to protect occupant safety and the manner in which each indicator or metric contributes to this evaluation. Indicators should show either the need for regulation or should be useful information for assessing what needs to be done by regulation. Recommendation 16 in this document details an ongoing advisory committee that can help the FAA monitor the indicators described below.

The SpARC reviewed indicators that were defined by the FAA, as well as the reports intended to track these. Industry communicated a concern that these reports, while not unhelpful, did not critically examine how each indicator fit into the larger conversation of readiness. Indicators from the FAA, as well as

alternative recommendations from industry members, were compiled and voted on by the SpARC members to weigh our recommendations in this area. After further discussion and the development of near-term recommendations that speak to data collection for the purposes of influencing future rule content, this list was narrowed to only those indicators with a focus on timing. SpARC recommendations for alternative indicators are listed in the table below.

The SpARC is aligned on key observations as they pertain to metrics:

1. There is no single numerical inflection point at which there is an objective need to transition.
2. It is nonetheless critical to continue to measure and observe industry progress to understand the changing landscape and match future oversight to these changes in a logical manner.

Table 7: FAA Indicator Families and SpARC Proposed Indicators

FAA Indicator Family	SpARC Indicator(s)	Comparison / Gap Comments
Purpose of people flying in space	<i>Purpose of people flying in space*</i>	*While the committee discussed the purpose of flight as a relevant consideration associated with the oversight continuum, an objective standard of what constituted a shift in purpose was not isolated. At the center of this conversation was the concept of flying as a condition of employment, SFPs who have chosen to do research aboard a commercial flight, the requirement in the informed consent regime that participation be voluntary, and how the volume of participant types might measure a shift along the continuum.
Size and complexity of the industry	Number of Part 450/Part 460 Flights Per Year/Month Number of Humans Flying to Space Per Year Number of Vehicle Architectures and Mission Profiles	While the FAA notes number of operators overall and operators of similar space flight types as measures of size and complexity, the SpARC believes that measures of cadence and consistency of flight are better suited to indicating a need for additional safety oversight. This indicator was noted as the primary driver of shifts along the oversight continuum, as increased numbers of persons gain access to activities that put them at risk, regardless of their purpose. Both lists feature an evaluation of the diversity of space flight types
Safety of the industry	Proactive Observation of Unaddressed Safety Issues in Industry Industry Demand for Regulation	Similar indicators identified. The SpARC notes that “industry demand” encompasses the FAA’s concept of difficulty attracting new customers or procuring insurance.

FAA Indicator Family	SpARC Indicator(s)	Comparison / Gap Comments
Voluntary Safety Reporting		The SpARC does not believe that the existence of a reporting system was an indicator that regulatory action is necessary or not. Rather, this concept is addressed in recommendations for action and assume data collected from such a system could be used to determine focus areas for action.
Voluntary Consensus Standards		The SpARC does not believe that the existence and breadth of consensus standards was an indicator that regulatory action is necessary or not. Rather, this concept is addressed in recommendations for action and assume standards (or lack thereof) may factor in identifying focus areas or complexity of related regulations.
Compliance		See commentary above on Voluntary Consensus Standards. As the existence of standards is not considered an appropriate indicator for the need for regulatory action, it follows that compliance to these standards would be similarly categorized. Additionally, compliance data is difficult to successfully compile, especially where operators may partially comply due to bespoke applicability.
FAA Authority to Transition to a Safety Framework		The SpARC does not believe that the learning period is an indicator of the need to transition to a new regulatory framework. The learning period is an administrative gate.
FAA Expertise in Human Space Flight Safety	FAA On Time Performance with Current Scope of Work FAA Space Flight Technical Expertise	The SpARC recommends evaluating the FAA's performance and capabilities in addition to expertise. These indicators are not a commentary on the necessity (or lack thereof) for regulatory action. Instead, they can show a need for restraint while performance is improved and resources are grown commensurate to the quantity and complexity of licensing activity.

RATIONALE:

Beginning in 2015, Congress extended the learning period for human space flight and requested a report from the DOT that addressed “key industry metrics that might indicate readiness of the commercial space sector and the Department of Transportation to transition to a safety framework that may include regulations.”¹²⁹ Subsequently, they requested two follow-on reports that examined progress within these indicators. These reports have spurred many conversations in government and industry alike about what it

¹²⁹ Spurring Private Aerospace Competitiveness and Entrepreneurship, Public Law 114-90 (November 25, 2015).

means to be “ready” for new phases of a safety framework. One obvious interpretation is that the question is whether regulation is necessary. Necessity could be found in safety failures resulting in harm to space flight participants. Those safety failures have not happened. Or necessity could be found in human space flight becoming routine. Again, this has not yet occurred. Nor has it become a necessity for work-related travel.

Additionally, readiness—or need—to transition to new frameworks must be evaluated holistically and include the readiness of the regulator. The FAA has an enormous technical challenge in carrying out its mandate to promote the industry – it is tasked with encouraging innovation while achieving continuous improvement in safety performance. This requires skillsets that are already in high demand, with relatively few people in the job market having practical experience in human space flight. The nature of performance-based regulations requires the reviewers to evaluate how novel technical solutions may satisfy the intent of a requirement, which suggests that the expertise of the regulator should match that of industry.

Indicator: Number of Part 450/Part 460 Flights Per Year/Month

Motivation: The FAA should modify its current indicator to use flight cadence, preferably a trend of statistical significance, and to whether operations have become “routine.” That said, although the current “cumulative flights” number is not a good indicator, the data are still important in order to ensure all parties evaluating the safety continuum are working from the same information. Further information can be gleaned from the licensing regime applied to each flight. For public safety, launches continue to be licensed under Parts 431/435 or Part 450 (a bow wave of work is expected to transition the bulk of existing Part 431/435 licenses to Part 450). Part 460 applies when crew, SFPs, or government astronauts are onboard.

Consistent growth in the number of licensed human flights per year may indicate a shift in the bespoke space flight participant experience to routine public experience. The need for increased government oversight is only appropriate in a market that has expanded to the point that the informed consent process loses its potency or becomes impractical, and it becomes necessary for the government to step in between the individual and the operator. On the opposite end of the spectrum, noting stagnant growth or an obvious emphasis on payload launch might indicate that industry-led technology advancements are still not to the point of scaling beyond primarily adventure-based participation.

As noted in the Aerospace Corporation’s 2022 report, data collection is an extremely important component of a safety framework.¹³⁰ Obtaining statistically significant datasets that indicate the performance of a given safety framework is important to objectively demonstrate continuous improvement. The Aerospace Corporation’s 2008 report analyzing human space flight safety states “The formal transition... would occur when FAA/AST determines that it has collected a statistically significant data set for individual safety-related design, testing, and operations parameters.”¹³¹ The SpARC appreciates the challenge of collecting consistent data due to the many distinct designs and operations concepts that have emerged since this report.

Measurability: The FAA provides all licensed launch data to the public, which makes this metric easily traceable. Tracking numbers of flights provides the following insights:

- Cadence of all launch operations vs. cadence of human launch operations: The growth of the human flight market continues to lag behind payload and test flights.
- Consistency of human launch operation cadence: Since the first commercial human flight, there have been periods of incremental activity, and periods with long pauses. The industry has not experienced the exponential, consistent growth envisioned after the first vehicles were designed and operated.

¹³⁰ [Commercial Human Spaceflight Safety Regulatory Framework](#), Aerospace Report NO. ATR-2022-02101 (September 30, 2022).

¹³¹ [Analysis of Human Space Flight Safety](#), Report to Congress (November 11, 2008), p. 61.

The SpARC notes that some commercial launch operations are performed as a service for the U.S. government. These operations, though licensed by the FAA, often feature an increased level of oversight due to mission assurance requirements levied by the contracting agency. These flights should be reported, but the dataset may need to speak to that nuance.

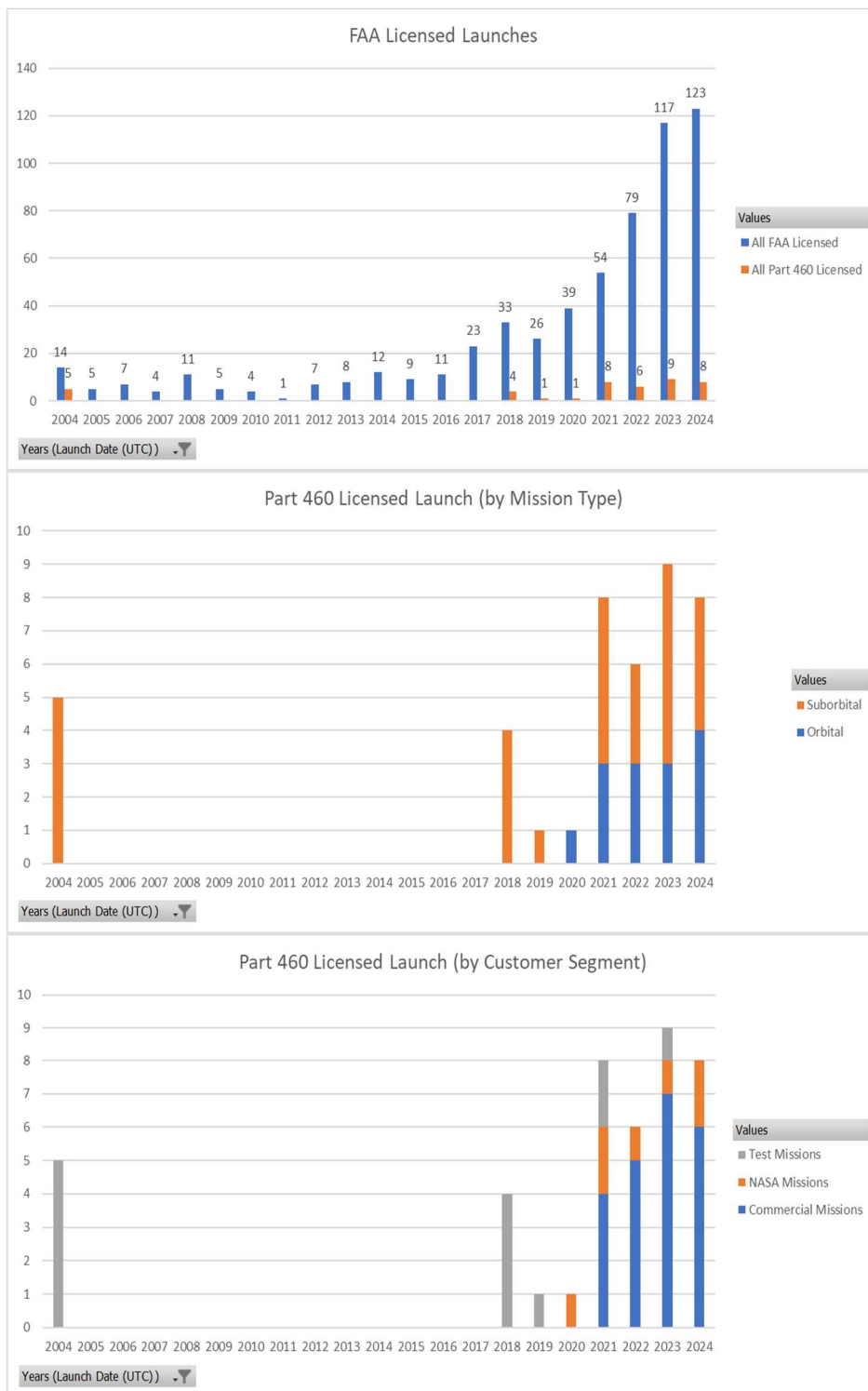


Figure 9: Status of FAA Licensed Launches as of November 4, 2024

Indicator: Number of Humans Flying to Space Per Year

Motivation: This metric combines the per-flight tracking with a volume per vehicle. Space vehicles currently operating or planned to operate carry no more than eight individuals at a time. Informed consent is only appropriate as long as it is feasible to rigorously brief individuals about the hazards associated with space flight and answer their questions. When the number of people flying per year grows beyond reasonable capacity to perform these briefings, it is an indicator that change is warranted.

The SpARC notes that the number of humans flying to space per year will likely be matched by a shift in the purpose of flying. The FAA proposes an indicator related to purpose, which the working group discussed. Diverging opinions emerged about what constitutes occupationally driven space flight, but the need for regulatory action because of this shift was generally agreed to be linked to an increase in volume.

Measurability: The FAA currently tracks individual-level data through the informed consent and waiver of claims process mandated by Part 460.

Status: 2023 had 49 individuals launch to space in the USA.¹³²

Indicator: Number of Vehicle Architectures & Mission Profiles

Motivation: The space industry stands apart from other DOT-regulated operations in its breadth and variety. The extreme nature of launching into space necessitates unique solutions based on an individual company's target mission and constraints. Orbital (and within this Low Earth Orbit, Medium Earth Orbit, Geosynchronous Orbit, Lunar, Beyond), suborbital, vertical takeoff, horizontal takeoff, and reuse are all potentially in scope for the future of human occupied launch.

At the extreme end of the regulatory spectrum lies aircraft, which are predictably tube and wing, and designed to a very broad envelope of possible flight variables. By contrast, space flight has no reasonable expectation of commonality. Each operator continues to design for a single mission or range of missions that differ from its peer group to generate an efficient solution for its business. To this extent, there can be no expectation of reasonable, universal, prescriptive rules and regulations. Even performance-based concepts suffer from the level of abstraction required to be applicable to all parties. Future safety frameworks must contend with this reality. While this diversity continues to expand, the FAA should track activity and identify commonalities among operators but recognize that regulation may be premature. If it develops that all operators are using the same standards or abiding by similar principles, the FAA could then exercise a leadership role in the development of industry standards.

Measurability: The evolving world of space flight can be measured in this way, but nuance must be acknowledged beyond the numbers. Existing and future vehicles may straddle existing categories, create their own, or begin to demonstrate consolidation of operational constraints.

Status: All current and planned operators have significantly different combinations of design and operation concepts with unique characteristics, and known future vehicles are adding more complexity rather than consolidating to one architecture. This diversity of concepts, both current and future, is illustrated in Figure 10.

¹³² McDowell, J., "[Spaceflight Statistics: Human Spaceflight Annual Statistics](#)" (2025).



Figure 10: Notional diversity of architecture and operations concepts

Indicator: Proactive Observations of Unaddressed Safety Issues in Industry

Motivation: Although the FAA maintains a similar indicator, the SpARC stresses that safety observations may be leading indicators for new rules rather than helping the FAA react to an anomaly. In many cases, there are opportunities to learn from activities before an anomaly occurs. The FAA should proactively engage with industry if, for example, a concerning practice goes unaddressed by an operator.

Measurability: Findings during the licensing or post-flight data review that did not cause an anomaly, but could in the future, if left unaddressed.

Status: The FAA uniquely has access to data from all operators.

Indicator: Industry Demand for Regulation

Motivation: Commercial human space flight activities are nascent, but operators share a common desire to see a thriving, safe industry continue long term. For continued growth, the industry will need to attract more and more willing customers. The FAA highlighted that regulations may be appropriate if the industry is having trouble attracting customers. The “voice of the customer” will be heard first by the operators. Routine flight will require accessing those individuals who are less inclined to take risks rather than only those with the early adopter, adventure-based mindset.

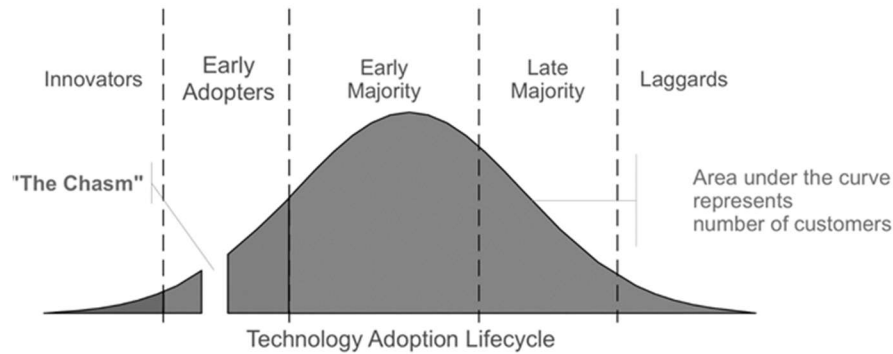


Figure 11: The Technology Adoption Curve¹³³

For this demographic of occupants, increased oversight may help drive demand for human space flight. The FAA should proactively seek feedback from human space flight operators to understand how their accessible customer base may be growing or shrinking and how this customer base maps to the flight cadence indicator. Industry demand for regulation may also grow from the need for additional insurance coverage and its relative inaccessibility. To the extent additional regulations may help standardize an insurance industry’s approach to risk characterization and therefore cost, these may be desirable if it increases access or demand for human space flight.

Measurability: Industry demand is not a quantitative measure but may be evaluated by the FAA through close communication with industry operators through an advisory committee or other means.

Status: No demand noted by SpARC participants.

Indicator: FAA Space flight Technical Expertise

Motivation: Currently, NASA has the most experience with human space flight by virtually any measure compared to other organizations. NASA’s human rating requirements are comprehensive; however, they recognize that no list of requirements results in definitively safe human space operations. As exercised by NASA, the requirements become a reference set to guide the development of designs and operations concept. The adequacy of these is judged by expert peer review together with the results of a comprehensive verification program based on “test-like-you-fly” principles.

Performance-based requirements allow for greater flexibility in designing and developing a system but, as is the case for NASA, require significant expertise and level of effort to tailor requirements and verify outcomes. If future safety frameworks contain performance-based requirements, successful implementation will require the FAA to access and deploy significant technical resources.

Measurability:

- Percentage of licensing workforce with hands-on experience designing, building, or operating space flight hardware.
- Advisory circular completeness and continuous improvement timelines.

Status: Operators on the committee have reported longer than desired evaluations of applications (including during the “pre-application” phase where novel means of compliance are accepted). The FAA has internal visibility to its own performance in hiring and retaining individuals with previous hands-on experience designing, operating, and maintaining space flight and ground system hardware/software. There are several

¹³³ Moore, Geoffrey A. and Regis McKenna, “Crossing the Chasm” (1991).

critical advisory circulars that have not yet been published for occupant and public safety. Operators on the SpARC have further reported inadequate incorporation of feedback on existing advisory circular documents.

Indicator: FAA On-Time Performance with Current Scope of Work

Motivation: The FAA should demonstrate excellent on-time performance licensing under its current authority before adding more requirements that would add complexity to applications.

Measurability: Consider the cycle time and engineering hours required for license review. One challenge in measuring on-time performance is that timelines during the “pre-application” phase for licenses is not measured even though that is the phase where novel means of compliance are evaluated and approved or denied. In a future where more performance-based rules exist, measuring this phase will become more and more important.

Status: Industry has reported delays caused by procedures in both the pre-license consultation process as well as the license processing phase. This is projected to get worse given the current deadline for operators to transition to launch and reentry under Part 450. These delays have direct implications for business operations and potential impacts to market growth over time.

Indicator: Purpose of Flight

Motivation: In an FAA report to Congress required by the U.S. Commercial Space Launch Competitiveness Act (CLSCA), it stated “...the FAA expects the public’s expectation of safety to increase as the purpose of flying to space evolves from adventure, to occupation, to transportation. These indicators reflect the flying public’s decrease in risk tolerance.”¹³⁴ The SpARC broadly agrees that the purpose of flight is a good indicator of industry maturity, but it should not be the primary driver in implementing a new safety framework.

Measurability: Though not explicitly measured, it will be obvious, either through public job requisitions, press releases, or social media, to determine when individual occupants are flying as part of their job responsibilities or as a mode of transportation versus for adventure purposes.

Status: A vast majority of private trips to space so far have been motivated by adventure purposes. Some crew and space flight participants have performed science experiments or demonstrations in partnership with their employers or other entities. Others have utilized former NASA astronauts to guide international professional astronauts on trips to the International Space Station.

4. Considerations for a successful framework for future human space flight occupant safety regulations

a. Approach to developing a future framework

Recommendation 4 –A phased approach to regulation

REC 4	The FAA should use a “phased” or “incremental” approach to regulation for occupant safety.
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¹³⁴ [Report to Congress: FAA Evaluation of Commercial Human Space Flight Safety Frameworks and Key Industry Indicators](#) (November 2021), p. 16.

INTENT:

A phased approach introduces requirements incrementally, allowing the FAA to continuously evolve their regulations while industry develops new solutions that simultaneously improve the safety and economics of space travel. As indicators signal shifts in the expectations of space flight participants, increased demand for regulation from industry, or a weakening of informed consent, the FAA should be empowered to enact non-comprehensive rules over a longer time horizon.

Additionally, a phased approach makes it simpler for the FAA to diversify the regulatory framework. As additional oversight is levied on activities that have seen a shift along the safety continuum, some activities may remain in an experimental posture. This will necessitate multiple regulatory options. As some operators' progress follows the leading edge of an incremental approach, others may remain in earlier phases.

To successfully move through a phased approach, the FAA's approach to the rulemaking process may need to change to support quicker, more incremental actions. By considering the approach modeled below, the FAA should also identify tools and process changes that may be necessary to support such actions.

APPROACH:

1. Determine appropriateness of additional rules

As discussed at length in previous recommendations, at present the industry uniformly sits at one end of the safety/oversight continuum where it remains appropriate to use the existing regulatory framework, including strong informed consent requirements. To define the phased approach, the FAA will need to monitor the indicators defined in Recommendation 3 for signs that the industry, or parts of it, demands further action. Under a phased approach, the incorporation of additional rules could be limited to only activities that meet a published set of criteria.

2. Determine content of an appropriate incremental rule

When the FAA determines an incremental rule is appropriate, after reviewing the safety continuum and indicators holistically (see Recommendation 3), it must carefully prioritize what requirements to implement first.

- **Does the rule offer meaningful protection to occupants?**

In the phased approach, rules would be introduced gradually – naturally, new requirements that have significant benefits to occupant safety should be prioritized over those that offer marginal or negligible benefits. To identify potential actions, the FAA should leverage its own observations of industry behavior, NASA's similar observations, and the collective insights of the industry (via committee feedback, standards documentation) as well. These recommendations are further defined in this report.

- **Does the rule have minimal implementation and enforcement complexity?**

Under a phased approach, the scope of incremental rulemaking must necessarily be limited. To down select a rule or set of rules, lower complexity requirements with high safety impacts should be prioritized. Many factors can contribute to a candidate rule's complexity, for example:

- The extent to which FAA technical resources will be needed to approve means of compliance.
- The extent to which third-party organizations may be able to judge compliance.
- The universal applicability of a rule to the diverse architectures that currently exist.
- The necessity of recurring or mission-specific analyses and verifications.
- The existence of conflicts with other relevant rules and regulations or industry standards.
- The presence or lack of consensus standards that govern the topic.

- **Has the rule been proven in another industry with objective benefits to safety?**

Some components of the comprehensive safety framework documented in the FAA’s *Recommended Best Practices for Human Space Flight Occupant Safety* document¹³⁵ are not unique to human space flight, or even the aerospace industry in general. Validated rules governing configuration management, for example, have proven their value in the automotive industry as much as in the aerospace industry. If two candidate rules have equal safety benefits and complexity, the one already proven in another industry should be prioritized.

Rules satisfying these criteria are good candidates for adoption in the early phases of the safety framework.

Example 1: The FAA could consider modifying rules that today are only enforceable in cases where the operator utilizes crew with safety-critical roles that can affect public safety. Extending the protections that exist today for crew to space flight participants is a logical step in branching into a new intermediate framework. The FAA already has experience administering the crew safety requirements – extending them to space flight participants is an opportunity to refine its approach to enforcing performance-based rules and inform the structure of future rules.

Example 2: The working groups identified the adoption of a Quality Management System as a candidate standard that meets the criteria above for inclusion in a safety framework. The potential impact on occupant (and public) safety is high. Third-party certifications have been widely utilized in aerospace, which could keep enforcement complexity low for the FAA if observed to be universally used in space flight.

3. Evaluate impact of rule on industry and regulator

A successful phasing in of rules will allow both industry and regulator to be proactive without harming progress. After each rulemaking, the FAA should evaluate how effective it has been at realizing the goal of incremental improvement without unnecessarily impacting industry progress. An industry advisory committee could provide an operator perspective directly, but the FAA can also evaluate the consistency of compliance. If the FAA was expecting a regulation to be met using similar means across industry but instead was met with highly varied and unique means, care should be taken to understand how to apply this finding in the development of future rules. If rule implementation requires significantly more resources to achieve than expected, then that, too, should be considered.

4. Determine if present state of regulation constitutes an “intermediate” phase

The FAA must also decide in evolving the safety framework, when to “branch” the requirements into a new type, analogous to the way the FAA applies progressively more rigor depending on the level of risk, consent, and privileges associated with each type of aircraft certification. As previously mentioned, as individual operators grow and refine their operations, they may require new frameworks that are tailored to their needs while new entrants still demand an experimental framework.

¹³⁵ [FAA Recommended Practices for Human Space Flight Occupant Safety Version 2.0](#), September 2023.

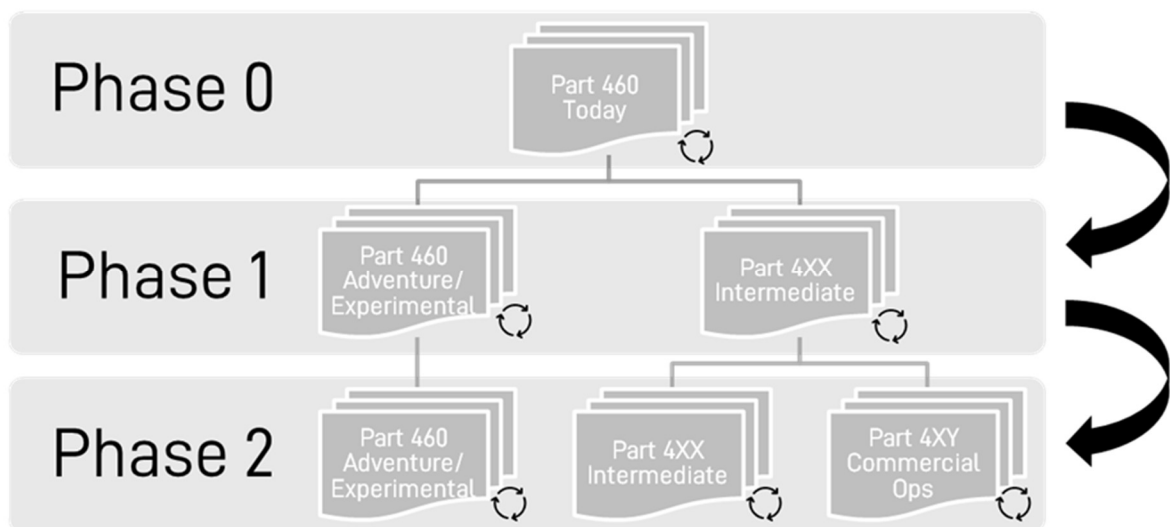


Figure 12: Notional representation of how the FAA could incrementally introduce new frameworks alongside current rules as the market develops

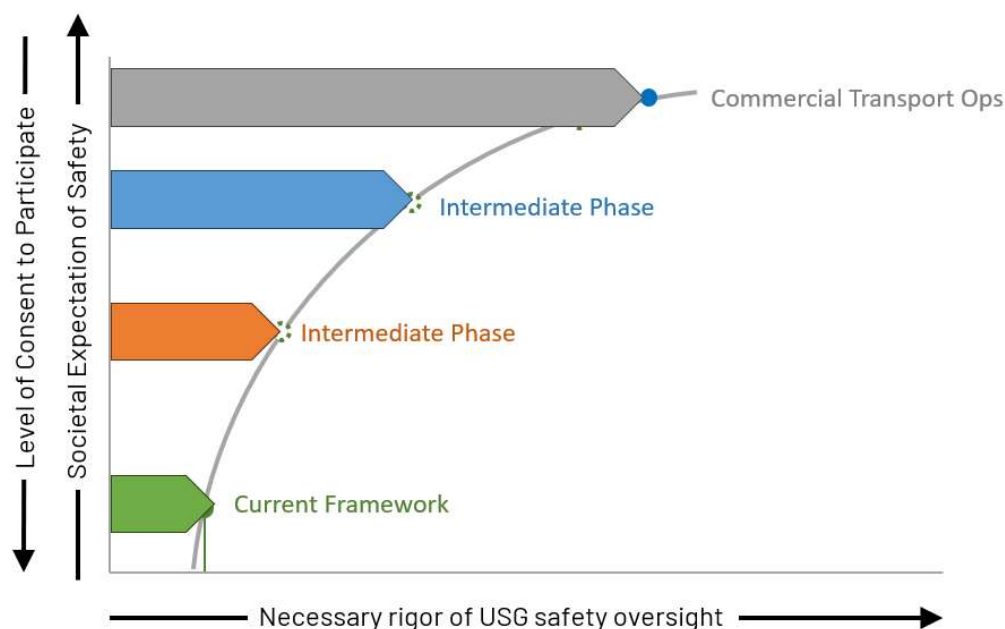


Figure 13: Phased Approach notionally mapped to safety continuum

RATIONALE:

There is broad consensus among the 460 SpARC members that there should be a “phased approach” to implement comprehensive occupant safety regulations that enable continued learning and innovation while promoting occupant safety. A phased approach refers to incremental steps towards a permanent regulatory environment, implementing certain mechanisms initially, creating feedback loops, and only gradually building to a comprehensive rule set, and only as necessary. A phased approach will help the United States retain its leadership in the commercial space industry and serve as a model for the world in responsibly

expanding the sector without stunting innovation. As noted in Recommendation 2, the FAA’s interpretation of the 2004 CSLAA is that a phased approach is required.

A successful, phased rollout of regulatory actions offers many advantages:

- Prioritizes safety while enabling industry flexibility during the nascent stage of commercial human space flight.
- Minimizes regulatory uncertainty, thereby encouraging new entrants and investment in the industry
- Enables operators and vehicles with varying levels of maturity to operate simultaneously with requirements and privileges tailored to the expectations of their customers and the public.
- Enables objective statistical evaluation of the statutory mandate that safety performance must continuously improve.
- Provides time for the industry to converge on optimal design and mission profile architectures and document best practices in consensus standards.
- Allows the FAA to take proactive action on certain safety concepts while continuing to develop a comprehensive safety framework using collected data.
- Enables the FAA to ramp up resources and technical expertise needed for future phases of the safety framework.

A phased approach has been cited and supported as a mechanism to achieve new safety frameworks in multiple recent reports. The FAA’s Report to Congress on the Evaluation of Commercial Human Space Flight Activities Most Appropriate for New Safety Framework, states that “The plan will be informed by case studies from other transportation modes and likely will be incremental in nature.”¹³⁶ In the most recent Aerospace Corporation review commissioned by the FAA, it concludes that “...accomplishing safety is an evolutionary and iterative process.”¹³⁷ The commercial space flight industry has introduced novel capabilities and has taken to continually adapting new and advanced technologies designed to promote safety.

A premature rulemaking may not improve safety, may stifle innovation, and may struggle to cope with several challenges:

- Extremely limited commercial flight experience and data.
- Shortage of engineering talent qualified to design, manufacture, operate, maintain, and regulate space flight and ground systems.
- Diversity of design and operations concepts by current and planned operators.
- Lack of mature space flight specific consensus standards.
- Risk of new rules unintentionally discouraging innovation.

There are important improvements the FAA needs to implement to make the phased approach successful:

To make a phased approach work, more frequent rulemakings with limited scope will be required. Recent rulemaking process durations do not lend themselves to a phased approach. The latest update to Part 460, published in September 2024,¹³⁸ incorporates various changes required by the CSLCA, which was passed in 2015. The FAA is working on promising improvements to streamline licensing, but the rulemaking process itself must also be streamlined to be responsive to changes in the industry as data become available.

The FAA has broad authority to participate in “pre-rulemaking activity” to shape the future of human space flight. The FAA exercised this authority in releasing the recommended best practices document for

¹³⁶ [DOT Report to Congress: U.S. Department of Transportation Evaluation of Commercial Human Space Flight Activities Most Appropriate for New Safety Framework](#) (February 26, 2019), p. 5.

¹³⁷ [Commercial Human Spaceflight Safety Regulatory Framework](#), Aerospace Report NO. ATR-2022-02101 (September 30, 2022).

¹³⁸ [U.S. Commercial Space Launch Competitiveness Act Incorporation](#), 89 FR 76714 (September 19, 2024).

occupant safety. The committee encourages the FAA to continue performing pre-rulemaking activities to evolve the best practices document, incorporating new technologies and approaches that industry is employing to improve safety and reliability. Many of the documents referenced in the recommended practices document were developed decades ago with approaches that are known to be obsolete and discourage innovation. If the FAA takes opportunities to be “hands on” with operators during development phases, it will start a cycle of learning that all will benefit from.

Comprehensive rules, including NASA’s approach, do not guarantee safety

As previously noted, NASA’s Human-Rating Requirements for Space Systems specification states:

It is impossible to develop a set of Agency-level technical requirements that will definitively result in the development of safe systems for all human space missions.¹³⁹

Similarly, no additional requirements in Part 460 will guarantee operation of safe systems for all human missions or result in zero risk. While it is not the right time to implement an entirely new and comprehensive human space flight safety framework, it should remain the long-term goal. Eventually, a safety framework will exist alongside the current framework that represents the incredible amount of learning still taking place in the industry and comprehensively address design and operational details. Gradually building up to that point will lead to safer and more economical outcomes.

Recommendation 5 –Prevent overlap or redundancy with existing regulations

REC 5	The FAA should ensure any new occupant safety regulations do not overlap or redundantly cause review under both Parts 450 and 460. Future occupant safety rulemaking process should focus on identifying only additional regulations needed to protect occupants.
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INTENT:

Avoid duplication between FAA reviews conducted under the existing Parts 450 and 460 and reviews conducted under any new regulations.

APPROACH:

The intent of the existing framework is to regulate launch and reentry for public safety. While it is not the intent of Parts 450 and 460 to protect occupants who do not have public-safety critical roles, the SpARC has observed in its discussions there are many beneficial impacts, nonetheless. SpARC members evaluated the processes and analyses conducted under Part 450 and determined they play a role in the safety of occupants, even if that is not the intent.

The FAA should not approach a new occupant-safety regime as if the proposed requirements exist in a vacuum, separate and independent from the existing public safety regime. A licensee seeking to license human space flight must seek a Part 450 authorization under the current regulations.

As the FAA considers any new regulation for the purpose of protecting occupants, the FAA should initially consider the analyses and reviews that already occur under Parts 450 and 460, to identify the ways in which those requirements may already identify and protect against hazards to occupants.

¹³⁹ [Human-Rating Requirements for Space Systems \(Updated w/Change 2\)](#), NPR 8705.2C (July 10, 2017) (See Section 1.1.3).

Regulations should be limited to those safety requirements that are necessary to protect occupants above and beyond the impacts of Parts 450 and 460 today.

RATIONALE:

As discussed in Recommendation 2, Part 450 requires all operators to receive a launch or reentry license from the FAA. The licensing process requires operators to conduct (and the FAA to review) detailed analyses that include identifying the likelihood of, and plans in the event of, hazards, malfunctions, or otherwise off-nominal performance of a launch or reentry vehicle. Examples of these requirements include:

- Section 450.107 – a requirement that operators conduct a flight hazard analysis;¹⁴⁰
- Section 450.119(b)- a requirement that a flight safety analysis account for each possible cause of a flight malfunction, including software and hardware failures, for every period of flight, including the relative probability of occurrence for each malfunction;¹⁴¹ and
- Section 450.131- a requirement that a flight safety analysis accounts for probability of vehicle failure.¹⁴²

Any future occupant safety framework that requires consideration of vehicle hazards will likely present a risk of overlapping with existing review content. In this scenario, it does not make sense to duplicate the work already performed, or to review the same processes that have already been reviewed under Part 450. It would not make sense for separate FAA personnel to evaluate hazards, with one team evaluating hazards from a public safety standpoint while another evaluates the same hazards from the perspective of occupant safety. In this instance, the FAA must account for an integrated compliance strategy. Where the FAA and operators have already performed the work to analyze and protect against hazards that could affect both the public and human occupants, it should be sufficient. These interactions should be proactively flagged during rulemaking so that the intended limitations on duplicate work can be thoroughly vetted by industry.

Recommendation 6 – Leverage industry standards

REC 6	The FAA should leverage any available industry standards and accept them as means of compliance to current and future rules where practical.
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INTENT:

This recommendation encourages AST to take advantage of consensus standards during all future rulemaking and development of regulatory guidance documentation.

APPROACH:

As AST identifies regulations that meet the goals of a phased approach, it should look to the evolving body of consensus standards and, if applicable, use the content to define a means of compliance. AST should create pre-rulemaking feedback loops with industry and standards bodies to ensure future standards are ready on time and automatically accepted as means of compliance to applicable performance-based rules.

Where applicable, AST should take advantage of existing highly qualified third-party auditing services to confirm compliance on an ongoing basis. As an example in the launch and reentry framework, Part 450 has requirements related to configuration management to track that the design intent hardware is installed

¹⁴⁰ 14 CFR 450.107.

¹⁴¹ 14 CFR 450.119.

¹⁴² 14 CFR 450.131.

during the manufacturing process.¹⁴³ AST could accept a valid QMS certification audited by a third party as a means of complying with the configuration management requirement.

RATIONALE:

Industry standards may be capable of iterating faster than the rulemaking process, which can serve as a catalyst for innovation. Incorporating the use of standards in commercial human space flight is in alignment with the National Technology Transfer and Advancement Act and the Office of Management and Budget Circular No. A-119, which states the goals of the government in using voluntary consensus standards:

- a. Eliminate the cost to the government of developing its own standards and decrease the cost of goods procured and the burden of complying with agency regulation.
- b. Provide incentives and opportunities to establish standards that serve national needs.
- c. Encourage long-term growth for U.S. enterprises and promote efficiency and economic competition through harmonization of standards.
- d. Further the policy of reliance upon the private sector to supply government needs for goods and services.¹⁴⁴

Using industry-led consensus standards also reduces the already high burden on AST to develop in-house space flight subject matter experts. The competition for scarce engineering talent in aerospace is well documented.¹⁴⁵ While AST must continue to aggressively recruit engineering talent, any approach that reduces its hiring burden has the potential to accelerate overall industry progress while reducing costs for the government.

Recommendation 7 – Match requirement types to needs

REC 7	The FAA should carefully consider the appropriate types of requirements for each phase of new regulations by considering the regulator’s ability to evaluate compliance and the impact requirement types can have on innovation.
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INTENT:

This recommendation encourages the FAA to continue its practice of considering the best types of requirements to meet its regulatory mandate and acknowledge the advantages and disadvantages of each major category. There is a need to balance ease of implementation with permissiveness to new ideas.

APPROACH:

The FAA should weigh the advantages and disadvantages of each requirement type against the intents of each phase of rulemaking. This context should be shared when a proposed rule is published to allow for improved commentary and recommendations.

RATIONALE:

In an ideal world, there would be a simple list of requirements that, if followed, guarantee mission success and occupant safety. As previously noted, the NASA specification for Human-Rating Requirements for Space Systems states: “It is impossible to develop a set of Agency-level technical requirements that will

¹⁴³ 14 CFR 450.103(c).

¹⁴⁴ [Revised OMB Circular A-119, Memorandum for Heads of Executive Departments and Agencies](#) (February 10, 1998).

¹⁴⁵ Weddle, Brooke. Poltronieri, Giulietta. Lavandier, Hugues. Voelker, Andy. [“The talent gap: The value at stake for global aerospace and defense”](#). July 17, 2024.

definitively result in the development of safe systems for all human space missions.”¹⁴⁶ From the organization that definitively possesses the most cumulative knowledge on human space flight, this is an accurate and humbling statement.

Prescriptive Requirements

Definition: Prescriptive requirements are requirements that are written specifically to address a known issue or concern and include specific methodologies for addressing the requirement. In other words, specific requirements provide the “what, why, and how.”

In general, the use of prescriptive requirements should be limited to those safety concerns or issues that are well understood through experience and past failures, with known solutions available to within a reasonable business case, and are fundamental to successful, safe operation

Advantages: The advantages of prescriptive requirements are the clear delineation of the problem and how the problem must be addressed for safety considerations. Assessment of compliance by the regulator is relatively straightforward compared to other forms of requirements. Compliance is determined as either “meets” or “does not meet” the requirement. As a result, prescriptive requirements are less subject to being “gamed.” The specificity of a prescriptive requirement should provide a higher level of confidence of proper implementation. In addition, prescriptive requirements can help translate best practices to operators with less experience than other operators, especially those operators that have better safety records.

Disadvantages: Prescriptive requirements can be perceived as being overly restrictive relative to potential innovative and different solutions than the prescribed solution. This is dependent on how the requirement and associated verification is written. There is a risk that operators could be disincentivized to develop innovative solutions. Yet an enormous benefit of the commercial, competitive environment is to spur potential new solutions that will provide a more competitive business case. If this occurs, the prescriptive requirement can be modified to include the new solution after completing the necessary rigorous assessment. To be operative in a development program, this requires a two-or more part “approval,” i.e. a “what if” pre-approval to allow design and testing to proceed and a follow-up at completion for final approval of the “re-written” requirement.

The need to maintain overall safety for space flight participants, operators, and the public places the burden of proof for innovation on the operator’s proposed design and operations. In this case, the operator’s technical judgement is necessary to demonstrate a better solution.

Performance-Based Requirements

Definition: Performance-based requirements define the required results to address safety concerns without specifically addressing how to accomplish the results.

Advantages: Performance-based requirements provide the operator the flexibility to address safety concerns in a manner consistent with the operator’s business model and the safety needs. This type of requirement can allow for more direct innovation relative to a known safety need.

Disadvantages: Performance-based requirements, if not monitored closely for compliance, have the risk of being “gamed.” Interpretation of the requirement, how the performance metrics are defined, measured, and tracked can be problematic without sufficient written detail.

¹⁴⁶ [Human-Rating Requirements for Space Systems \(Updated w/Change 2\)](#), NPR 8705.2C (July 10, 2017) (See Section 1.1.3).

Performance-based requirements require an interaction between the operator and regulator. This interaction can be time-consuming as both parties may have a different interpretation or method of satisfying the requirements. A shared urgency for review/approval or some mechanism to ensure timeliness (stated timeframes) will be needed. The balance, however, is found in that the burden of proof remains on the operator coupled with a higher level of sophistication required in the regulator’s assessment of compliance. Successful implementation of performance-based requirements is clearly dependent on the technical judgement of both the operator and the regulator (see discussion in Recommendation 9 on need to expand the FAA’s “bench” for technical review).

Process Requirements:

Definition: Process requirements define the needed methodologies and actions to be taken by the developers and operators to ensure the safety needs are met.

Advantages: Clear process requirements can help ensure a level of consistency across an industry and market to ensure safety for all involved. Process requirements should establish the “floor” of best practice for an industry to assure safe operations.

In the case of private enterprise human space flight, process requirements can help translate best practices to operators with less experience than other operators, especially those operators that have better safety records. This will help ensure “rogue” operators are unable to inadvertently penetrate a market and negatively affect consumer confidence with an accident due to bad practice.

Process requirements are more easily auditable than design requirements. However, care must be taken in specifying the context for their application if the full benefits are to be realized and be more easily auditable. For example, process standards, such as AS9100, require the organization seeking certification to define the scope and applicability of the desired certification.

Process standards can be written to apply at different levels depending on the need, e.g. AS9100 for a complete organization and its process used to design and develop hardware or very low-level standards, such as IPC-J-STD-001: Requirements for Soldered Electrical and Electronic Assemblies, which could be applied to a single part or area building parts.

Disadvantages: If the process requirements include an unknown flaw, the flaw can spread across an industry with detrimental effects. This type of requirement is dependent on developers, operators, and regulators critically assessing the defined the requirements for potential flaws and improvements. There also must be mechanisms to modify the process requirements in a timely manner as lessons are learned.

b. Leveraging expertise from Civil Space

Recommendation 8 – Prevent redundant reviews for NASA-approved services

REC 8	The FAA should accept NASA procurement of human space flight services as an equivalent level of safety to current and future elements of Part 460 pertaining to occupant safety.
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INTENT:

Minimize the wasteful use of operator and agency resources associated with the FAA independently reviewing systems that have already been reviewed and approved by NASA as part of their certification or qualification processes.

APPROACH:

Similar to FAA interagency coordination with federal ranges to ensure agreement on range safety practices, the FAA and NASA Commercial Crew Program and SubC program should leverage their existing Memorandum of Understanding for interagency coordination and agreement on compliance methods that satisfy both agencies' requirements. This would form the basis for an Equivalent Level of Safety (ELOS) to Part 460, as well as for sections of Part 450 with overlapping requirements, enabling efficiencies in license application development and review while building the FAA's knowledge base through coordination with NASA, rather than at industry expense.

RATIONALE:**ELOS used in legacy licensing.**

Acceptance of NASA Human Space Flight certification as an ELOS for Part 460 was the baseline under legacy licensing practices. The NASA human rating process is extremely rigorous, covering a comprehensive scope and level of detail that far exceed FAA regulations and guidance on occupant safety. Completing NASA certification requires years of extensive effort to verify compliance with occupant safety, safety requirements, and involves thorough review and approval by the most experienced and knowledgeable body in human space flight. Furthermore, NASA certification comprises public safety requirements that have significant overlap with FAA requirements in Part 450.

The NASA SubC program provides an analogous review that can also serve as an ELOS for suborbital flights under Part 460. As described in the NASA Human Space Flight Requirements Section above, providers who fly government astronauts after "qualification" under this program's requirements will have demonstrated a satisfactory safety case, including review of key standards by NASA for equivalent levels of safety with NASA certification. This allows for a more flexible solution without sacrificing safety.

As with the Part 450 rulemaking effort, which sought to streamline requirements and reduce duplication of government and operator efforts to satisfy both FAA and federal range requirements, this recommendation also serves to avoid duplicative efforts and reduce the associated burden on operators and the FAA while maintaining safety.

Ensures all government resources and lessons learned are shared.

Under its SubC program, NASA is pursuing qualification of systems using a more flexible "safety case" method that relies on a fulsome evaluation of safety based on operator designs, processes, and operations rather than up-front communication of requirements. This experience provides many insights into the strengths and weaknesses of different review processes that result in a similar safety result. The FAA should leverage NASA's experience comparing a safety case with a certification regime while accepting both as satisfactory demonstrations of occupant safety.

Recommendation 9 – Leverage NASA and industry expertise

REC 9	The FAA should partner with NASA and commercial vehicle operators to maximize its growth of technical resources to close the gaps in expertise that current and future phases of the regulatory framework demand. An emphasis should be placed on recruiting individuals with highly relevant professional experience as well as maximizing hands-on professional development opportunities within the existing workforce.
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INTENT:

Grow the FAA’s technical capability to match the demands of the future. Urgent action is required to keep up with a future that features increased complexity and more regulatory burden due to the nature of implementing performance-based regulations.

APPROACH:

The FAA should maintain a core team of its own experts to assess novel means of compliance for performance-based regulations. The FAA will be challenged in maintaining an in-house capability sufficient to cover all needs in a timely manner due to the episodic nature of the workload, the breadth of expertise that may be needed for any given activity, and the need to “refresh” technical skills with hands-on experience. The FAA could augment its in-house workforce with contracted expertise, screened for conflicts of interest, or personnel from NASA to provide the requisite experienced engineering knowledge as well as provide training opportunities. NASA maintains a civil service cadre to meet its needs along with some contracted expertise.

Leveraging NASA could be advantageous both in cost efficiency and timely access to “bench depth.” There are useful precedents, both for interagency engagement and establishing review processes. For example, the National Oceanic and Atmospheric Administration (NOAA) National Environmental Satellite, Data, and Information Service (NESDIS) has an episodic need to acquire new weather satellites and, over decades, has maintained agreements with NASA to execute the acquisitions (programmatic and technical teams) under NOAA oversight, as well as engage with NASA on a variety of technical studies to inform its decisions. Another possible strategy is to leverage NASA’s process in conducting life cycle reviews for major science missions in which a standing board of independent experts is convened to engage when the need arises. The composition of the board would be managed to balance needed continuity with the need to evolve its expertise.

In addition, the FAA could provide opportunities for its personnel to do developmental and enrichment assignments with NASA to build technical expertise or invite NASA personnel to do such assignments in AST. Rotations with industry are also encouraged but present additional challenges to manage conflicts of interest. NASA and AST’s incentives are aligned in terms of developing high quality consensus standards, and rotations as described above could further facilitate standards development.

RATIONALE:

The FAA needs technical expertise to assess designs, design changes, and responses to failures in a timely manner and with sufficient depth to carry out its assigned roles. As the number of providers and systems increase along with the diversity of designs, and the systems evolve beyond those with NASA collaboration, the technical workload of the FAA will increase, with or without additional Part 460 responsibilities. It benefits both the FAA and NASA to ensure a workforce maintains awareness across civil and commercial operations.

5. Actions the FAA can take now to ensure the success of the industry and the quality of any future regulatory action

a. Improvements to the informed consent process

Recommendation 10 – Strengthen informed consent process

REC 10	The FAA should contribute to an effort to strengthen the existing informed consent process.
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INTENT:

The FAA and industry can make it easier for individuals to make informed choices based on “apples to apples” comparisons of risk between their space flight options. Once an individual has chosen an operator, a common curriculum could also help set a minimum standard for delivery of detailed hazard information.

APPROACH:

The informed consent requirements in 14 CFR 460.45 are comprehensive but there may be an opportunity to strengthen informed consent in its implementation. The FAA already maintains a guidance document¹⁴⁷ with helpful information on administering informed consent briefings.

The FAA could go further by updating the guidance document with a list of universal hazards that all space flight participants will confront by choosing to go to space. By consulting the informed consent documentation currently used by operators, the FAA can set a benchmark for future entrants and provide SFPs with basic expectations.

In addition, a common format for disclosing universal hazards in line with their mitigation strategies would enable SFPs to make apples to apples comparisons between the space flight options available to them. Alternatively, the FAA could actively participate in an industry-led effort to create a common format to disclose universal hazards. This consensus standard could become a means of compliance to § 460.45 in the future.

RATIONALE:

The appropriateness of the current requirements, as detailed in Recommendation 2, is contingent on a highly effective informed consent process. Individuals have the freedom to participate in inherently risky activities given:

1. They are informed of the risk; and (Part 460)
2. Their actions do not harm members of the non-consenting public. (Part 450)

The informed consent requirements in 14 CFR 460.45, while comprehensive, do not by themselves make it easy for prospective SFPs to make a fully informed choice based on all the vehicle architectures and operations concepts available in the marketplace. SFPs must approach operators and solicit their informed consent briefings while using their own methodology to compare the approaches and relative risk between providers. Although all providers have unique architectures, there are universal hazards that exist for all space flight activities. A common format along with a list of universal hazards would enable SFPs to make a more fully informed choice by comparing these options.

Strengthening informed consent may also make it feasible for the FAA to maintain the framework through more industry growth. Through forward-leaning guidance, the FAA could encourage disclosure of certain

¹⁴⁷ [FAA Guidance on Informing Crew and Space Flight Participants of Risk](#), Version 1.1 (April 4, 2017).

widely used hazard mitigation strategies (i.e., third party QMS certification, NASA oversight, or others) thereby prompting increased feedback from operators and pushing forward the benchmark for new entrants.

Recommendation 11 – The FAA should maintain an industry safety record database to inform SFPs about the general risk of space flight as well as vehicle and operator specific safety records

REC 11	The FAA should maintain an industry safety record database to inform space flight participants about the general risk of space flight as well as vehicle and operator specific safety records as required under § 460.45(c) (“An operator must inform each space flight participant of the safety record of all launch or reentry vehicles that have carried one or more persons on board, including both U.S. government and private sector vehicles.”)
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INTENT:

Establish a consistent set of industry performance statements, developed and maintained by the FAA, to reduce duplicative work across licensees collating data safety records and standardize communication with SFPs who receive this information.

APPROACH:

The FAA should maintain a publicly accessible database that clearly communicates the safety record of launch/reentry vehicles applicable to § 460.45(c). The FAA should also maintain a process where operators can “appeal” the safety record represented in the repository in case it is disputed. The repository should make distinctions between serious injuries and deaths. The FAA should provide the data that satisfies § 460.45(c) in a way that any licensee can provide it to SFPs, without further manipulation by the licensee, so that the SFPs can review and understand the safety record of all launch or reentry vehicles that have carried one or more persons on board, including both U.S. government and private sector vehicles.

RATIONALE:

There is a significant degree of nuance required in representing the evolving safety record of any given launch/reentry vehicle. In this specific case, the FAA can take a leadership role in maintaining a database of the industry safety that licensees or permittees can refer prospective SFPs to as part of the informed consent process. The benefits of the FAA taking on this role are as follows:

Provides Consistency Across All Operators

With the FAA as the nucleus of the industry safety record, there is an unbiased arbitrator of the information maintained. This provides consistency in terms of the information generated, reported, and maintained by each operator and allows the data to be open and auditable. Further, this leads to consistency between operators on what or how the safety record is presented to potential SFPs as part of the informed consent process.

Increases Transparency for SFP

With a centralized source of these statements, there will be consistency in the information all SFPs are reviewing across the industry. This provides better consumer choice to an SFP if they are considering multiple operators for a human space flight experience.

Eliminates Duplicative Effort

Duplicative effort would be reduced by both the licensee and the FAA. For a licensee, they would not have to maintain a safety record “in-house” while every other licensee is taking the same action. For the FAA,

resources would be saved by not having to perform a review each time a safety record is updated as part of the informed consent process by a licensee. This would result in realized resource savings by both the FAA and the licensee and eliminate duplication across industry.

b. Improvements to public safety framework

Recommendation 12 – Use lessons learned from public safety licensing for future occupant safety frameworks

REC 12	The FAA should improve its implementation and harmonization of existing processes under Part 450 and Part 460, which will have beneficial effects for both public and occupant safety.
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INTENT:

Industry representatives on the committee noted challenges with the FAA’s existing implementation of Part 450. Given these challenges and considering the importance of Part 450 licensing within the current regulatory framework, the FAA should prioritize process improvements under Part 450. Under the current regulations, it is not possible to have a vehicle operation licensed solely under Part 460. Regardless, a license is required for a launch or reentry to occur. Therefore an efficient Part 450 process is foundational for the future. There are risks associated with broadening the scope of FAA performance-based regulations while the FAA refines its ability to implement performance-based regulations under existing authority.

APPROACH:

In the near term, the FAA should focus its efforts on improving expertise and guidance under Part 450 of FAA regulations. This focus will have a correlated impact on occupant safety.

RATIONALE:

Based on experience operating under Part 450 on uncrewed launches to date, industry notes that the FAA could improve its ability to apply the performance-based regulations it has adopted. The FAA can also increase stability and predictability for operators by releasing additional guidance on acceptable means of compliance. These improvements to the FAA’s processes, guidance, and resources for evaluating compliance with Part 450 will be addressed by a future Part 450 SpARC. Within the context of the Part 460 SpARC, especially Recommendation 2, industry takes the opportunity to encourage the FAA to prioritize improvements to its Part 450 evaluation process above adopting new performance-based regulations under Part 460. Such improvements to Part 450 will have positive impacts on occupant safety.

Part 450’s performance-based regulations give operators freedom to demonstrate compliance with the regulations. However, the FAA has highlighted the complexities of evaluating compliance under Part 450 on several occasions; the FAA stated “[p]erformance based regulations can present a challenge when it comes to determining what is an acceptable means to comply with a regulation.”¹⁴⁸ The prescriptive requirements of the legacy regulations provided structure and specificity that made compliance determinations by the FAA a more straightforward exercise. Although some of these legacy means of compliance have been deemed acceptable by the FAA for use under Part 450, the introduction of novel means of compliance requires more FAA resources for establishing a compliance determination.

¹⁴⁸ Monteith, Wayne, et al., “[Update to Streamlining FAA Commercial Space Transportation Regulations](#),” p. 11.

The FAA has aimed to facilitate this transition from prescriptive requirements to the new performance-based requirements by utilizing advisory circulars (AC). Advisory circulars “provide guidance on meeting the regulations [since] Part 450 focuses on approving methodologies to obtain a license.”¹⁴⁹ These methodologies, otherwise referred to as means of compliance, can be developed by operators for any aspect of vehicle operation within the scope of the vehicle operator license. This approach to licensing reduces the need for the FAA to issue waivers, and the flexibility for operators is intended to minimize future license modifications. The FAA also has published a guide for acceptable means of compliance for Part 450, Subpart C licensing requirements.¹⁵⁰ This guide points to AC documentation drafted specifically for Part 450 requirements, legacy regulations, Range Commanders Council Standard (RCC) documentation, and AFSPCMAN 91-710 Range Safety User Requirements Manual as well as NASA and international standards.

The FAA has recognized the issues in implementing the Part 450 requirements for both experienced and new operators. In February 2024, the FAA released a statement informing industry that the FAA “intends to establish a new aerospace rulemaking committee (SpARC) to identify ways to further improve how launch and reentry licenses are reviewed and approved without compromising public safety.”¹⁵¹ It is hoped that the results of the SpARC will inform future Part 460 rulemaking and ensure better alignment between the two.

Solving the challenges with performance-based regulations under the launch and reentry public safety framework will directly translate into higher quality future occupant safety rulemaking and licensing activity.

c. Updates that can be carried out today

Recommendation 13 – Clarify FAA policy on Space Flight Participants being assigned public safety-critical roles

REC 13	The FAA should initiate a rulemaking to modify Part 460 to enable space flight participants to perform public safety-critical roles when given the appropriate training.
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INTENT:

Industry strongly recommends that the FAA no longer prohibit SFPs from being allowed to perform safety-critical roles when the operator deems it necessary for public safety. For example, during an emergency, an SFP may be the only one available to perform a maneuver necessary to prevent harm to people on the ground. An operator should be able to choose to have SFPs perform public safety-critical tasks, with or without crew onboard.

APPROACH:

To support this recommendation, the FAA could either issue a policy statement or initiate a rulemaking that recognizes that SFPs may be able to help with public safety in some circumstances. In this instance, certain training requirements could apply. A means of compliance may look similar to the relevant documentation for crew training (or as noted in Recommendation 8, the satisfaction of terms required by NASA during procurement of human space flight services).

¹⁴⁹ [FAA Vehicle Operator Licenses & Permits.](#)

¹⁵⁰ 14 CFR Part 450 Subpart C Accepted Means of Compliance Table.

¹⁵¹ “[FAA Meeting the Demand for Space Launch and Reentry Licenses.](#)” February 21, 2024.

Consistent with the FAA’s current authorities, this change should not affect operators who do not assign occupants roles or tasks that can influence public safety.

RATIONALE:

Training SFPs to have safety critical roles supports the FAA’s public safety goals

Without the flexibility afforded by this approach, a scenario could arise where an occupant could take an action benefiting the public or other occupants, but the requirements for their training or ability to perform tasks would not be allowed by current FAA policy. The FAA’s position on this question has evolved over the years. Now would be a good time for it to evolve further in the interest of public safety.

In its original rulemaking addressing space flight participants, the FAA, responding to a commenter who wished to pay a space launch operator to pilot the operator’s vehicle, determined that it was inadvisable, stating:

For public safety reasons, the FAA will not allow space flight participants to pilot launch or reentry vehicles *at this time*. A space flight participant who wants to pilot a launch or reentry vehicle would have to become an employee or independent contractor of the operator to acquire vehicle and mission-specific training. The operator will be in a better position to evaluate the skills of an employee or independent contractor than of a space flight participant, particularly as those skills relate to the requirements of the operator’s particular vehicle. The FAA acknowledges that this restriction may create a dilemma for someone who wishes to acquire training in order to become employed, but, while the technology is so new, *it is important for public safety that pilots be highly skilled at the outset*.¹⁵²

In 2013, the FAA had to modify its position. At the time, NASA’s astronauts were about to start flying on FAA-licensed launches. This created a dilemma for the FAA because its policy articulated in its 2006 final rule suggested that astronauts could not pilot a launch or reentry vehicle or otherwise engage in operational functions. Because the law at the time—prior to Congress’ creation of a new category of occupants called “government astronauts” in 2015—characterized NASA’s astronauts as space flight participants, and because the FAA had announced it would not allow SFPs to pilot vehicles, NASA was concerned this prohibition would extend to its astronauts. In reply, the FAA assured NASA that it would not and determined that NASA astronauts could engage in operational functions, up to and including piloting a vehicle operating under FAA license, conducting aborts, responding to emergencies, and operating ECLSS.¹⁵³ In this 2013 Legal Interpretation, the FAA also noted:

Chapter 509 does not specify any limitations on a space flight participant’s conduct or operations during a launch or reentry. Similarly, FAA regulations implementing Chapter 509 for space flight participants, codified at 14 CFR part 460, also do not specify any limitations on a space flight participant’s conduct or operations during a launch or reentry. See 14 CFR 460.41, et. seq. The only place where the FAA limits space-flight-participant conduct or operations is in the preamble to the Human Space Flight rule that created part 460.¹⁵⁴

As the FAA recognized in 2013, this means that the FAA may continue to evolve its position now.

¹⁵² *Human Space Flight Requirements for Crew and Space Flight Participants, Final Rule*, [71 FR 75616](#), 75618 (Dec. 15, 2006) (“Human Space Flight Rule”)(emphasis added).

¹⁵³ *Interpretation Concerning Involvement of NASA Astronauts During a Licensed Launch or Reentry*, 78 FR. 72011-72012 (Dec. 2, 2013) (“2013 Legal Interpretation”).

¹⁵⁴ *Id.*

The FAA made its original 2006 statement in a highly specific context, one of both time and circumstances. Like industry, the FAA was new to human space flight and believed that industry would have greater control over its employees than its “customers.” This unsubstantiated belief about human nature should not now stand in the way of public safety. Industry can, through contract terms and conditions, require that space flight participants undergo proper training and follow a launch operator’s processes and protocols. Just as a government astronaut is not an employee of a licensee but may perform operational functions, so may properly trained space flight participants.

The SpARC also notes that if an SFP plays a role in protecting the safety of the public, the FAA would likely acquire jurisdiction over his or her activities on board and could perhaps conduct oversight review in furtherance of public safety.

There is no statutory limit to SFP roles

The FAA may change a policy position without legislation from Congress. The FAA’s prohibition is such a policy and may be found neither in Chapter 509 nor the FAA’s regulations. Accordingly, the FAA could issue a new policy statement to reflect an acknowledgement that its earlier limitations, understandings, and prohibitions should no longer apply and allow space flight participants to engage in safety-critical functions.

Recommendation 14 – Modify existing obsolete prescriptive crew requirements in Part 460

REC 14	The FAA should initiate a rulemaking to provide relief for prescriptive rules in 14 CFR part 460 that do not universally apply to the architectures that emerged over the last 20 years.
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INTENT:

Transform existing rules governing training and qualifications into performance-based rules where operators systematically identify safety-critical roles and deliver training and testing that aligns with the required competencies.

APPROACH:

First, the FAA should evaluate its current Part 460 requirements for overly prescriptive language. Since the implementation of this rule, industry has developed multiple models of operations, particularly when it comes to a mix of autonomous and manual piloting. The FAA should change unnecessarily prescriptive rules in Part 460 into performance-based rules in tandem with Recommendation 14.

RATIONALE:

Original rule was written assuming a standard role for crew vs. SFP

The existing rules in Part 460 were created at a time when the only vehicle architecture involved a piloted vehicle concept. Since that time, the diversity of architectures has increased—for some operators, it does not make sense, for example, to impose a requirement to possess an FAA pilot certificate with an instrument rating when the “pilot” is operating a vehicle that is not like an aircraft, particularly with vehicles that operate autonomously. Likewise, it may not be necessary for all occupants with roles that could influence public safety to have an FAA second-class airman medical certificate per § 460.5(e). Operators should have the flexibility to determine if that is necessary based on their specific use case and the redundancy available in the system.

d. Support Standards Efforts

Recommendation 15 – Develop and allocate AST subject matter experts to collaborate with industry in voluntary consensus standards forums

REC 15	The FAA should develop and allocate subject matter experts to collaborate with industry in voluntary consensus standards forums.
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INTENT:

Improve the ability of AST to utilize consensus standards when authoring regulations, advisory circulars, or other guidance and improve the ability of industry to communicate best practices to AST and develop meaningful documentation

APPROACH:

AST should send representatives to the working meetings for major standards development efforts. These personnel should feel empowered to be active participants in developing industry consensus standards, no differently than an industry member or academic. AST personnel should be particularly active in road mapping activities with standards organizations and collaborating with NASA counterparts to minimize waste. Furthermore, AST should leverage industry standard development groups to provide inputs and comments to its draft guidance documents.

AST should also continue to track standards efforts across multiple organizations. If evaluating standards that overlap or conflict, these inconsistencies can be proactively flagged for industry advisory committees to ensure that operators are able to provide opinions or additional context. Avoiding conflicts is particularly important in the event of drafting regulatory text or guidance where standards are used to inform compliance.

RATIONALE:

Participation is appropriate

AST representatives discussing this topic with committee members stated some hesitancy to become deeply involved with consensus standards efforts to prevent the appearance of a regulator unduly influencing results. SpARC members have not raised any similar concerns and note that the consensus process ensures that all parties' voices are heard. Participation in these efforts can also be a development opportunity for AST to strengthen its relationships with subject matter experts external to their immediate network.

Aggregated experience

AST personnel have a unique perspective from which to approach the standards process given their exposure to multiple, if not all, industry operations. AST should consider where they might be able to collate generic observations from all existing providers, their safety organizations, configurations, and mission constraints to recommend areas of obvious overlap. This can be accomplished without divulging proprietary information or specifics and could be a powerful input into prioritization efforts. Knowing that there is commonality to explore could encourage more fruitful conversations between operators.

Regulator perspective

There are many reasons to write a consensus standard and not all of them need to relate to a prospective or existing regulation. While this is evident in the existing efforts, the FAA acknowledges that they will look to available industry standards when developing guidance on means of compliance for regulations. For standards development efforts that may be appropriate for this type of use, proactive participation by AST representatives can address weaknesses in style or content that would prevent effective adoption.

Recommendation 16 – The FAA should create an ongoing advisory committee.

REC 16	The FAA should establish an ongoing advisory committee to capture industry feedback, demand, and readiness for new occupant safety frameworks.
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INTENT:

Develop a Human Space Flight Advisory Committee to provide a forum for the U.S. human space flight industry, the FAA, and relevant stakeholders to advise the FAA on policy and strategy relating to human space flight safety.

APPROACH:

Within 30 days of submission of the Part 460 Human Space Flight Occupant Safety SpARC Final Report, AST should establish a Steering Committee to advise the FAA on policy and strategy relating to human space flight issues. Within 60 days of the submission of the Final Report, and with the guidance of the Steering Committee, AST should establish a Human Space Flight Advisory Committee to recommend appropriate information, policy and procedure changes, and other activities to support human space flight safety and the continued growth of the U.S. human space flight industry.

RATIONALE:

As noted in this report, the U.S. human space flight industry remains relatively nascent and immature, with few service providers conducting relatively few operations on a non-routine basis. As the industry grows, there is a need for a collaborative forum wherein the human space flight industry, the FAA, standards development organizations, and other relevant U.S. agencies can share lessons learned and prioritize activities to support human space flight safety and the continued growth of the industry. The SpARC recommends that the FAA establish a Human Space Flight Advisory Committee (HSAC), governed by a Steering Committee, which provides such a forum for ongoing collaborative discussions between industry and the FAA.

The Steering Committee should take the form of a collaborative decision-making forum led by U.S. human space flight operators, the FAA, and relevant industry associations. The Steering Committee should develop Terms and Guidelines for participation in the HSAC and monitor and guide the HSAC's activities. The SpARC recommends that the Steering Committee meet on at least a biannual basis to review the HSAC's activities and identify future taskings, briefings, and other efforts relating to the HSAC.

The HSAC would be comprised of U.S. human space flight operators, FAA personnel, industry associations, standards development organizations, NASA, and other U.S. agencies and stakeholders, as appropriate. The intent of the HSAC is to provide an ongoing forum for collaborative discussions and an information exchange between industry and the FAA for the purposes of supporting human space flight safety and the FAA's oversight of human space flight operations and promoting the growth and development of the industry.

The Steering Committee and HSAC would:

- Provide updates on the status of the U.S. human space flight industry, status of industry maturity indicators, and lessons learned from the FAA's oversight of human space flight operations;
- Review and provide feedback on the implementation of the Part 460 Human Space Flight Occupant Safety SpARC Final Report and supporting industry activities, such as the development of human space flight standards;

- Provide a collaborative forum to discuss “lessons learned” and best practices for the human space flight industry; and
- Identify additional relevant activities support human space flight safety and the continued growth of the U.S. human space flight industry.

The SpARC recommends that the Steering Committee and the HSAC be established in a manner similar to the FAA ATO Space Collaborative Decision Making (SpCDM) Steering Committee and Space Operations Committee (SpOC), respectively, which were established as a result of the 2019 FAA Airspace Access Priorities Aviation Rulemaking Committee.¹⁵⁵

e. Grow Resources and Capacities

Recommendation 17 – Expand technical resources

REC 17	The FAA should expand technical resources to manage the growing scope within the FAA’s current authority and more effectively learn from the advancements occurring in the industry.
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INTENT:

Industry representatives on the committee have commented that the FAA (and specifically AST) is alarmingly understaffed and lacks the broad technical expertise necessary to support the workload represented by current commercial space flight licensing and operations. This observation closely aligns with concerns raised by AST itself, as a chart from the FAA/AST report to COMSTAC on April 24, 2024,¹⁵⁶ indicates a lack of attention from senior leadership, a lack of resources, and a lack of advocacy in support of issue resolution.

This resource shortage reasonably becomes a constraint to industry growth when one considers the increase in licensed operations as compared to the growth of AST resources across the same time span. As this chart from the same April 24th FAA/AST report to COMSTAC shows, there has been an increasing divergence between the cadence of licensed operations and available AST resources, in terms of both budget and workforce headcount.

¹⁵⁵ [Airspace Access Priorities Aviation Rulemaking Committee \(ARC\) Recommendations Final Report](#) (Aug. 21, 2019).

¹⁵⁶ [COMSTAC Proposal for a Spaceflight and Traffic Research Institute](#) (April 23, 2024), pp. 62-65.

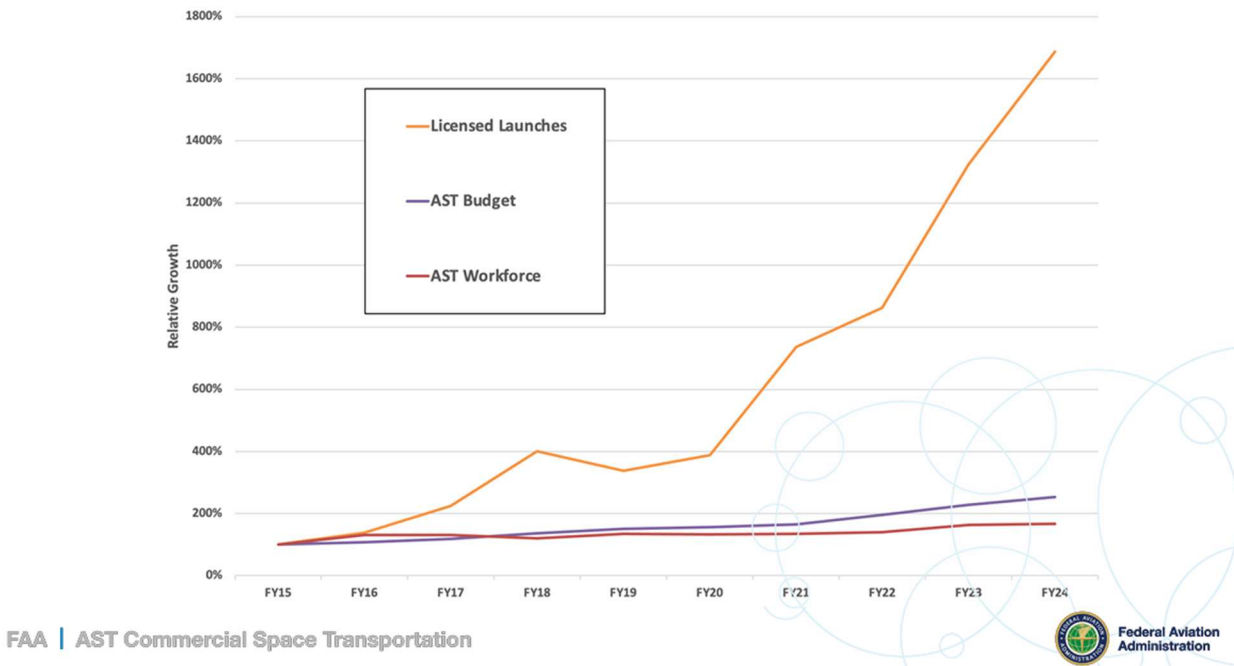


Figure 14: Licensed Launches vs AST Resources¹⁵⁷

The committee expects this growth in licensed operations, as witnessed over the past five years, to continue on a similar slope for the foreseeable future. Correspondingly, it is strongly recommended that the FAA request sufficient resources to support industry in its continued efforts to develop and safely deploy new launch systems, which should include staffing in key roles and tools to increase the efficiency of their headcount.

APPROACH:

AST should first determine the required headcount required to support the demand for licensing, to include new applicants, modifications to existing licenses, and the efforts required to transition legacy licenses to the new regulatory framework. The committee notes a specific need for additional resources in various “technical excellence” areas such as flight hazard analysis, systems safety analysis, systems engineering.

The committee notes that there are ancillary/support resources that also require investment to improve the efficiency, transparency, and repeatability of licensing procedures. The working groups also note how setting up professional development fellowship programs with NASA or the industry could improve the recruiting prospects for certain technical roles within AST.

RATIONALE:

An under-resourced regulator will constrain the economic success of U.S. industry

The existing shortage of AST resources is having a negative effect on the ability of current operators to maintain their flight schedules while simultaneously developing and testing new flight systems and processes. However, one of the most detrimental outcomes that can be expected from this resource shortage is the negative effect it will have on new investment capital entering the space. This is further discussed in the Economic Impact section of this report.

¹⁵⁷ *Id.* at 61.

Understanding resource needs may prompt necessary conversations about long term outlook

The committee recognizes that the FAA faces very real constraints in its ability to increase resources at the same rate of growth and suggests that the FAA consider alternate methods for efficiently conducting analysis and approval processes. The FAA could eliminate all duplicative work done between its review teams and those within the DoD or NASA when a launch site is located on a federal range. Another option might be adopting ODA-type delegations, including potentially third-party delegations, for certain functions that currently burden FAA resources. It is reasonable to expect that extending an ODA process into commercial space flight for the performance and conduct of certain activities could augment FAA resourcing and provide the industry some measure of relief.

Recommendation 18 –Facilitate voluntary data sharing

REC 18	The FAA should facilitate voluntary data sharing between operators.
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INTENT:

Provide a fundamental structure that can capture and communicate industry knowledge and learning associated with safety critical systems and operations. This will provide awareness of technical issues, and prevent repeated lessons learned among industry operators.

APPROACH:

Using the DoD Government Industry Data Exchange Program (GIDEP)¹⁵⁸ as an example, develop an on-going process/system to capture and disseminate safety information relevant to critical systems or operations. Upon discovery of a manufacturing defect on commonly used hardware, unexpected design or operational limitation, or other safety related issue, a manufacturer, operator, or oversight agency would submit relevant information into the central data repository. Upon FAA review, a notice with a link to the information would be pushed to industry stakeholder subscribers who can then apply this information to their specific needs.

Information shared is intended to bring awareness to all industry participants; it need not impede or interfere with intellectual property rights. The FAA should request that industry provide guidelines regarding which information fields would provide the best risk awareness to subscribers. Information sharing also with AST, NASA, and other U.S. government agencies overseeing commercial operations may also be helpful. Such a process and system would benefit commercial launch and reentry even beyond human space flight.

RATIONALE:

Aggregated learning can prevent repetitive errors

Given a functional framework, and the correct protections for using this framework, a database of lessons learned can ensure that existing operators, new entrants, suppliers, and regulators are able to learn at an accelerated rate and prompt increased, timely conversation about common hazards.

This collection of learnings can provide industry feedback on common safety practices and help ensure proactive disposition of known issues between operators. This may also be useful reference documentation for the ongoing process of authoring standards, regulatory guidance, and investigations into mishaps or anomalies.

¹⁵⁸ [Government Industry Data Exchange Program \(GIDEP\).](#)

Provide structure around existing ad-hoc discussions

The space industry remains small, and conversations between operators are known to occur. As the industry grows in both providers and cadence of launches, a structured repository for these lessons learned can ensure that this communication is not lost. This can provide visibility for the FAA and increase their confidence in certain vehicle designs, operations, hazard assessments, and risks documented in informed consent. Any additional insight should be expected to increase the effectiveness of future regulatory action. Where trends emerge, there may also be an opportunity to leverage this information within the insurance industry.

B. Medical Working Group Recommendations

The Medical Working Group defined the scope of their inquiry and recommendations as follows:

- Issues of space flight vehicle occupant safety or issues of potential harm to space flight participants were considered in scope;
- Issues pertaining to health and medical screening or risk assessment were considered in scope;
- Issues pertaining to inclusivity and the SFP population were considered in scope;
- Issues pertaining to SFP training, particularly training that directly impacts occupant safety (for example, emergency action training or training for familiarity with the space flight environment to improve performance once in that environment) were considered in scope, with recognition that other concurrent working groups may additionally address these topics;
- Issues pertaining to public safety or issues of potential harm to the general public were considered out of scope (as these issues were addressed by the Regulatory Innovation and Safety Working Groups); and
- Issues pertaining to environmental harm were considered out of scope (as these issues were addressed by the Regulatory or Safety Working Groups or by other governmental frameworks).

The general objectives of medical regulation in commercial space flight are presumed to be tailored towards the improvement of safety of SFPs. This may result in additional public safety implications, as SFPs or crew with mission-critical activities may ultimately have a public safety role (for example, in the control of a vehicle); however, the Medical Working Group primarily focused on issues related to SFP safety and the ability of a SFP or vehicle crewmember to safely perform mission-critical actions (including vehicle control or self-protective measures, such as emergency egress) to ensure the safety primarily of the vehicle occupants.

Recommendation 19 – Role and Performance-based risk medical risk assessment for human space flight participants

REC 19	The FAA should recommend a matrixed assessment approach that utilizes safety-related roles and responsibilities of the space flight participant for risk assessment to determine the participant’s ability to perform safety-related functions.
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		Risk Assessment Matrix				
Likelihood ↑	5	Medium/ High	Medium/ High	High	High	High
	4	Low / Medium	Medium/ High	Medium/ High	High	High
	3	Low / Medium	Low / Medium	Medium/ High	Medium/ High	High
	2	Low	Low	Low / Medium	Low / Medium	Medium/ High
	1	Low	Low	Low	Low / Medium	Medium/ High
		1	2	3	4	5
		Effect →				

Figure 15: NASA Risk Assessment Matrix¹⁵⁹

INTENT:

The intent is to enable an alignment between the criticality of the roles and responsibilities of the participant (whether they are an employee of the provider, customer purchasing a seat, guest of a customer, or an employee of a customer). The emphasis should be placed on the safety-related activities that the individual is responsible for during the mission from launch through landing.

APPROACH:

The FAA should encourage providers to pursue a structured risk assessment applicable to their individual mission and vehicle conditions. Industry providers should first develop mission parameters, such as duration (time of exposure to a given hazard) or environments (e.g., hypoxia, hypercarbia, altered pressure environments, variable gravity), thus defining a design reference mission. For each design reference mission, providers may create a matrix (ex. 5x5) that compares mission critical responsibilities/tasks (failure results in loss of participant life or loss of a life (lives) on Earth) to individual participant's role during the mission (e.g. pilot, payload operator (1,2,3, etc.)). The matrix is then decomposed into a distribution of risk such as high, medium, and low. A risk threshold may be determined for each zone and acceptable medical risk such as < 1%, 1%, or >1% risk of incapacitating medical event (stroke, cardiac arrest, etc.) or performance decrement (loss of vision, gross or fine motor control, eye hand coordination, etc.) may be articulated for critical responsibilities.

Rather than a “one size fits all” approach, industry providers should consider the roles and responsibilities of each participant in parallel with the provider's acceptable medical risk, prompting health and medical evaluation should excess probability be identified. Each provider should be able to articulate their medical risk assessment approach with sufficient evidence-based data to support the appropriate medical event probability and internal evaluation paradigm. Space flight providers may also refer to other industry standards of medical evaluation, such as current aviation standards, if applicable to the design reference mission or those being articulated through other industry consensus guidance (e.g. the ASTM F47 process for suborbital or orbital space flight).

RATIONALE:

The rationale is to overcome the challenges associated with terminology, such as “crew,” “passenger,” or “astronaut.” It is important to stratify space flight participants based on their safety-related roles and

¹⁵⁹ Antonsen, E. *Human System Risk Management Plan, JSC-66705 Rev. A*. (Johnson Space Center, NASA, 2020).

responsibilities during the mission, such as primary or back-up piloting/commanding actions for launch and landing or the handling of in-mission critical hardware (ECLSS, EVA suits) or resources that may be hazardous (toxic, high flammability, etc.) to themselves and others. Individuals with critical safety-related roles may prompt a higher degree of medical evaluation to ensure that the individual is fit to perform during the mission and reduce the probability of a health event-induced performance decrement resulting in injury to himself or herself, other participants, or the general public. This evaluation can further inform a more robust medical risk assessment, informed consent, and decision-making by the potential space flight participant and/or industry provider.

Recommendation 20 – Space Flight Medical Licensure Clarity

REC 20	The FAA should support improvements of legal clarity for the practice of aerospace medicine.
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INTENT:

The intent is to support medical licensure and insurance expansion to include covered medical services within the scope of practice and needs of the commercial space flight industry across state borders. This ensures that professionals offering such medical care are protected from undue professional and financial risk, thus improving crew and space flight participants' access to quality healthcare services.

APPROACH:

In 2018, the Sports Medicine Licensure Clarity Act (Public Law

115-254, October 3, 2018) was passed to allow sports medicine physicians to provide care for athletic teams traveling out of state. In a similar manner, the FAA should support efforts to ensure aerospace medical physicians are similarly allowed to engage in the management of space flight participants across state lines without the fear of incurring great professional or financial risk. This should include support for the aerospace physician to provide medical care within the scope of practice of the medical professional practicing under an agreement with a commercial provider.

Given the established authority and expertise of the FAA in the aerospace community, ensuring that the FAA endorses efforts to protect aerospace medical professionals across state boundaries during their provision of appropriate aerospace medical care to crew and participants provides much-needed support of the small aerospace medical community.

RATIONALE:

Commercial aerospace medical professionals are responsible for the management and provision of medical care and risk evaluation for crew and space flight participants. Often, engagement in the commercial space flight industry requires crew and participants to travel across state lines to participate in unique training opportunities or launch and landing events. Currently, out-of-state aerospace medical professionals cannot legally treat crew or space flight participants in such locations if they lack the visiting state license or insurance. In such circumstances, the aerospace medicine professional must choose between treating space flight participants or providing appropriate health and medical monitoring and oversight at great professional risk, assuming the cost of licensure and insurance in multiple locations, or handing over care of an ill or injured crewmember or participant to another professional, who may not be familiar with the individual's medical history or aerospace risk factors.

The field of aerospace medicine is small, and aerospace medical providers add great value to the management of space flight participants and crew given their unique and specialized knowledge of the aerospace environment. This value cannot be duplicated by a non-aerospace professional who does not have established expertise regarding the unique aerospace environment of the individual participant's medical

history or evaluation. Aerospace medical providers should not have to choose between managing crew or participants at great professional and financial risk or reducing participant's access to quality health and medical management.

Recommendation 21 – Baseline Expectation of Documentation

REC 21	The FAA should recommend a baseline expectation of documentation internal to each industry provider that establishes and details risk assessment and acceptance as well as corresponding rationale, with an expectation that such documentation will be provided if required by the FAA or other regulatory body at a future time.
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INTENT:

The intent is to ensure documentation of appropriate risk assessment and mitigation specific to each industry provider, inclusive of health and medical risks specific to each space flight participant, as well as recognizing the potential need for review of such documented processes by a future regulatory authority.

APPROACH:

Industry providers should internally establish:

- Risk descriptive language and standards,
- Internal risk posture and acceptance level,
- Internal risk identification process,
- Risk disposition criteria and processes,
- Internal expectations of risk documentation,
- Internal policies regarding data privacy,
- Processes regarding internal auditing and quality assurance, and
- Identification of stakeholders and relative responsibilities.

While a specific reporting requirement is not recommended at this time, it should be a baseline expectation for all providers that review of such internal approaches may be required at a future date for review and determination of most successful approaches to mitigation of health and medical risk with the commercial space flight industry.

RATIONALE:

At the early stage of this industry, it is reasonable to expect that industry providers will internally establish risk expectations and a risk management plan with a clear purpose. This establishes the baselines of internal standards and design requirements within a given company and helps to define the acceptable standards of internal risk. Just as an industry provider would be expected to establish the above processes for vehicular design and iteration, there is a similar expectation that industry providers internally establish these processes for health and medical risks.

C. Economic Impact Working Group Analysis and Recommendation

The Economic Impact Working Group reviewed all the recommendations of the three SpARC working groups – Regulatory and Safety (combined in the report) and Medical – in the context of their real and potential economic impacts on industry. Not all the recommendations lent themselves to economic assessment – for example, many pertained to process or engagement for the FAA itself with no definable economic impact to industry as of yet. Because implementation of recommendations made herein are

unknown, those recommendations that were analyzed lent themselves to qualitative, rather than quantitative, assessment.

1. Economic Impacts of Informed Consent

Several recommendations in the report relate to the current informed consent regime in force under Part 460. Those recommendations are grouped here for the purposes of discussion.

(REC 2): The FAA should continue to implement the current human space flight occupant safety framework, which includes informed consent, as the primary basis for managing risk under Part 460 while the industry remains in a nascent phase.

The cornerstone of the U.S. human space flight regulatory framework is informed consent. Codified by the Commercial Space Launch Amendments Act of 2004 (CSLA 2004), informed consent requires operators to provide detailed disclosures about the risk of launch or reentry, the safety record of the vehicle, and make clear that the U.S. government has not certified the vehicle as safe for carrying crew or space flight participants.¹⁶⁰ The Secretary of Transportation is required to inform a space flight participant “of any relevant information related to risk or probable loss during each phase of flight” gathered by the Secretary.¹⁶¹

The implementation of informed consent has significant economic implications for the U.S. human space flight industry. Its primary economic impact is on insurance premiums and liability costs. By shifting responsibility for risk acknowledgement to space flight participants, the need for liability coverage diminishes, reducing insurance premiums. This can result in measurable savings for both operators and insurers.

Moreover, by requiring space flight participants to provide their informed consent to participate in a given mission, the framework reduces potential liability costs placed on operators. This is particularly important given the high-net-worth individuals that are likely to be the space flight participants and the ones who are most able to conduct costly litigation. It is important to note that although the informed consent framework remains untested in court, as no litigation or precedent has been established regarding the validity or protections of the framework, operators and insurers remain confident of its protections.¹⁶²

(REC 4): The FAA should adopt a new list of indicators that better captures the state of the industry and the regulator. Indicators should be used to judge whether there is a need to introduce new occupant-safety frameworks.

Future expansion, if any, of the Part 460 regulatory framework should proceed cautiously, taking into account the variety of personnel and missions that are already beginning to promulgate. While NASA astronauts will continue to perform government missions, they will be joined increasingly by private researchers, adventurers, commercial astronauts, and human beings who simply want to experience the unique aspects of space travel. As commercial missions and technologies diversify, so too will every aspect of occupant safety. However, diversification in and of itself does not justify additional regulation until such time as the informed consent regime becomes inadequate (see “Rationale” for REC 2 and REC 4 for further discussion). The potential economic implications of premature regulation for industry and market development are discussed in the case studies detailed in Section II of this chapter.

¹⁶⁰ Commercial Space Launch Amendments Act of 2004, Pub. L. No. 108-492, 118 Stat. 39741.

¹⁶¹ 51 U.S.C. § 50905(b)(5)(A).

¹⁶² [COMSTAC Safety Working Group Report](#), May 2023.

Both the U.S. government and industry have very strong incentives to improve the informed consent process. Yet this, too, must be phased and pertinent to the different technical architectures and business models of the HSF providers. This is reflected in:

(REC 19): The FAA should recommend a matrixed assessment approach that utilizes safety-related roles and responsibilities of the space flight participant for risk assessment to determine the participant's ability to perform safety-related functions, and

(REC 21): The FAA should recommend a baseline expectation of documentation internal to each industry provider that establishes and details risk assessment and acceptance as well as corresponding rationale, with an expectation that such documentation will be provided if required by the FAA or other regulatory body at a future time.

Should REC 21 be instituted, it will likely support the compliance of an operator in meeting the requirements of § 460.45(a), which would thereby reinforce the validity of the informed consent protections.

Another, little-discussed impact of the federal informed consent regime is the subsequent creation of the state-informed consent regime. The federally required informed consent document is only one of several other informed consent documents that a space flight participant is likely to sign prior to an operator receiving compensation. Following the CSLA of 2004, several states enacted informed consent statutes to protect the same operators.¹⁶³ The primary difference between the federally required informed consent document and the state-required ones is that the state informed consent document also acts as a complete waiver of liability for the operator, absent gross negligence. The state informed consent frameworks provide operators and insurers with added confidence in the liability protections of the framework.

a. Secondary Impacts

A secondary economic impact of informed consent is private investment and market growth. By reducing the perception of financial risk for operators, informed consent has stimulated investment in the commercial human space flight industry. Metrics that demonstrate this growth are the volume of venture capital and private and public investments in space flight companies since the enactment of the CSLA 2004. Furthermore, the increasingly diverse number of operators and vehicles highlights the economic vitality that is being fostered, in part, by the informed consent framework.

Similarly, when paired with the broader regulatory framework discussed above, the informed consent regime has reduced the regulatory constraints on research and development, lending its hand in creating a diverse and distinct set of innovative operators. The existence of this framework enables operators to focus on cost-effective technological advancements.

The one area where informed consent can pose a significant risk to both operators and insurers is when an operator chooses to fly a government astronaut, as defined by the Commercial Space Launch Competitiveness Act of 2015. The CSLCA of 2015 does not require government astronauts to sign an informed consent document and the FAA has not required them to do so because 1) government astronauts are already aware of the risks they face and 2) signing an informed consent document may interfere with the rights of government astronauts under the Federal Employee Compensation Act. Therefore, the analysis above may only apply to space flight participants and not government astronauts, which may result in

¹⁶³ National Technology Transfer and Achievement Act of 1995, Pub. L. 104-113; Office of Management and Budget, [Circular A-119: Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities](#), 81 Fed. Reg. 4673, Effective Date January 27, 2016.

greater insurance premiums and higher potential liability costs for both operators and insurers. This issue was recently addressed in an advisory circular.¹⁶⁴

b. Final conclusions on informed consent

The informed consent framework of the U.S. human space flight regulatory framework is a critical factor in shaping the industry's economic landscape. It reduces liability and insurance premium costs, fosters innovation, attracts investment, and enables technological advancements. These effects underline the system's role in sustaining the continued growth and global leadership of the U.S. commercial space flight sector.

c. Additional economic impacts of selected proposed recommendations

(REC 1): The FAA should utilize an oversight continuum to evaluate the degree of rigor strictly necessary, consistent with Congressional direction, for future occupant safety regulations that would coexist with the current rules (which are tailored to the adventure/experimental phase of the industry) and comport with AST's statutory direction to establish "...stable, minimal, and appropriate regulatory guidelines that are fairly and expeditiously applied."

The economic implications of utilizing an oversight continuum are significant. Under current regulations, all human space flight activities are governed by Part 460 – a “one size fits all” approach to regulating the industry. In contrast, aviation has multiple regulatory options tailored to a diverse set of applications (a continuum), each considering unique risks to the public and occupants. The existence of the light sport aircraft regulatory framework, for example, enables significant economic activity. The light sport aircraft market "... was valued at USD 956.44 million in 2020, and it is anticipated to register a compound annual growth rate (CAGR) of 5.4%, to reach a market value of USD 1,311.27 million by 2026.”¹⁶⁵

To advance human space flight, maintaining an experimental framework akin to the current requirements in Part 460 would encourage innovation and foster competition by offering a low regulatory barrier to entry. This would support the growth of the industry and drive economic efficiencies. In contrast, shifting to a vehicle certification approach—similar to “type certification” in commercial aviation or the NASA Commercial Crew Program—could have a significant economic impact. Such a change would create higher barriers to entry, discouraging investment and slowing the pace of innovation. The latter approach would also require a significant infusion of resources to staff AST with capabilities similar to the NASA Commercial Crew Program (hundreds of highly trained engineers).

(REC 3): The FAA should adopt a new list of indicators that better captures the state of the industry and the regulator. Indicators should be used to judge whether there is a need to introduce new occupant-safety frameworks.

Understanding industry maturity and direction is the minimal basis for any kind of regulatory action, and it must be based on continuous interaction with the space flight industry. For the FAA to accomplish this, it will depend on robust data sharing between all industry participants, including a full expectation of data security and integrity, and reasonable consideration of protecting proprietary interests. This will come at an economic cost to industry; however, it is a critically important recommendation in the context of the health of the industry and robustness of the overall market.

¹⁶⁴ [FAA Guidance on Informing Crew and Space Flight Participants of Risk Version 1.1](#), April 4, 2017.

¹⁶⁵ [“Light-Sport Aircraft Market – Growth, Trends, COVID-19 Impact, and Forecasts \(2021-2026\),”](#) Yahoo!Finance, October 27, 2021.

In a 2017 report to Congress, AST introduced a list of indicators meant to measure readiness to transition to new safety frameworks beyond the requirements currently enforced in Part 460.¹⁶⁶ In terms of economic impact, *when* new rules are promulgated can be as significant as *what* rules are promulgated. Prematurely releasing new requirements can have unintended consequences, especially in an industry facing high uncertainty and minimal market adoption. In the theory of diffusion of innovation, a new technology must reach a “critical mass” before it can achieve mass market adoption.¹⁶⁷ Overly burdensome or premature rules could delay, or even completely prevent, the HSF industry from achieving “critical mass.”

(REC 8): The FAA should accept NASA procurement of human space flight services as an equivalent level of safety to current and future elements of Part 460 pertaining to occupant safety.

While not guaranteed, the assurance provided by NASA’s procurement of space flight services, with the additional rigor required for acceptance, should eliminate unnecessary cost necessary for separate (and often redundant and less rigorous) compliance requirements that do not result in additional occupant safety benefit.

(REC 11): The FAA should maintain an industry safety record database to inform space flight participants about the general risk of space flight as well as vehicle and operator specific safety records as required under § 460.45(c) (“An operator must inform each space flight participant of the safety record of all launch or reentry vehicles that have carried one or more persons on board, including both U.S. government and private sector vehicles.

The most obvious economic benefit is that the system would result in elimination of some duplication of effort between industry and the FAA, although some of the costs would continue to be borne by both. The FAA’s development and maintenance of such a system should minimize costs on industry, which would only be required to provide regular data updates (e.g., pre- and post-flight).

(REC 17): The FAA should expand technical resources to manage the growing scope within the FAA’s current authority and more effectively learn from the advancements occurring in the industry.

Chronic understaffing of FAA resources has repeatedly been raised by industry to Congress regarding their funding of the agency as a threat to flight schedules (and therefore revenue generation) occurring in tandem with development of new systems. A related and potentially greater concern, however, is the consequent impact to investment capital if flight schedules cannot be met.

Continued understaffing of AST resources will logically result in:

- Longer times required for licensing activities (both initial issuance and modification).
- Reduced ability to monitor and support launch operations.
- Longer times required to conduct mishap investigations.

Each of these outcomes imposes a constraint to startup operators that directly translate to financial burdens. Longer licensing times serve to increase the already high barrier to entry for new companies and will require increased investment/capitalization to support the operational cash flow needed to keep the organization solvent during a license review period. Similarly, constraints imposed on AST’s ability to support a commercial flight cadence directly restrict a company’s revenue model. Each of these scenarios serves to

¹⁶⁶ [Report to Congress: FAA Evaluation of Commercial Human Space Flight Safety Frameworks and Key Industry Indicators](#), October 20, 2017.

¹⁶⁷ Rogers, E.M., *Diffusion of Innovations*. NY: Simon and Schuster, 2003.

discourage the investment of private capital, possibly leading qualified investors to look elsewhere to achieve desired returns.

This directly leads to a reduction of entrepreneurial interest, a reduction in new product introduction (NPI) activity, and a consolidation of the industry into relatively few existing operators that can better withstand the operational cash flow challenges. This outcome directly contradicts the Congressional mandate to encourage private development of commercial space flight.

2. Status of Industry Standards

The development of industry-led voluntary consensus standards is frequently mentioned as an indicator of the maturity of the space industry. Standards development organizations (SDOs) are responsible for reaching consensus among industry operators on specific issues relevant to a standard under consideration.

For the space industry, voluntary industry consensus standards are “guidelines, best practices, and recommendations that describe the specifications, dimensions, and requirements for designing and operating equipment and systems in space.”¹⁶⁸ Industry standards provide a consensus understanding for operators and government agencies on how to ensure the safety, reliability, and compatibility of designing and operating space systems. The Office of Space Commerce maintains a full compendium of space industry standards.¹⁶⁹

Discussions on the future of the human space flight learning period are frequently tied to progress in the development of human space flight industry standards. For a nascent industry, such as the U.S. commercial space industry, the development and implementation of voluntary consensus standards is critical to leveraging lessons learned to improve space flight safety and inform potential future regulation. It is important that the current and future safety framework provides the flexibility for continued safety innovation while also improving the safety of commercial human space flight.¹⁷⁰ Toward those ends, the report includes two recommendations related to standards development, and an additional recommendation that may be related to improvement of standards over time:

(REC 6): The FAA should leverage any available industry standards and accept them as means of compliance to current and future rules where practical, and

(REC 15): The FAA should develop and allocate subject matter experts to collaborate with industry in voluntary consensus standards forums.

The development of industry voluntary consensus standards, clearly, is widely supported by both the U.S. government and industry. Commercial space industry standards hold utility as consensus best practices that promote safety and efficiency, indicators of the maturity of the industry, and information to guide potential future regulatory action, assuming that they are sufficiently robust and timely. Active participation by the FAA and industry in the standards development process is understood to result in more comprehensive standards capable of informing government actions. Finally, enabling increased information sharing among industry operators is generally considered to promote both more detailed industry standards as well as a better understanding of the adoption of such standards by industry.

¹⁶⁸ [U.S. Department of Commerce Office of Space Commerce, “Space Industry Technical Standards.”](#)

¹⁶⁹ [U.S. Department of Commerce Office of Space Commerce, “Space Industry Technical Standards Compendium”](#) (Updated June 2024).

¹⁷⁰ [COMSTAC Safety Working Group Report](#) (May 2023).

One often-missed benefit of industry-developed standards is that they allow companies to anticipate both requirements as well as understand and manage costs well in advance of full consensus. Government regulations, while often developed in concert with industry, can have unintended negative economic consequences, compounded by shorter timelines for implementation.

3. Importance and Impact of Quality Management Systems

The management of sophisticated technical and human safety systems demands attention to detail and anticipatory decision-making systems. Despite the current market diversity of HSF providers, the need for QMS is clear and must be consistent with the provider's individual business plan.

Rather than write a recommendation specifying a particular QMS or equivalent, the Regulatory and Safety Working Groups of the SpARC created a test to determine if a specific regulatory requirement would be a good candidate for early adoption in a phased approach to rulemaking. Early rules can have a meaningful positive impact on safety, while maintaining low costs to implement and enforce.

The FAA should not presently dictate specific technical details for quality management systems, either for existing providers or for new entrants. Recognized industry standards, such as AS-9100, and others, should be expected to be part of any quality management system used in this industry. Overscripting technical or data requirements for these systems could present an unnecessary cost for industry and discourage the emergence of new entrants.

4. Importance of the FAA's Economic Impact Analysis, and a Final Recommendation

In the Human Space Flight Requirements for Crew and Space Flight Participants final rule Regulatory Evaluation section, published in 2006, the FAA shares its regulatory evaluation approach and findings related to several executive orders and laws:

Changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 directs that each Federal agency shall propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 (Pub. L. 96-354) requires agencies to analyze the economic impact of regulatory changes on small entities. Third, the Trade Agreements Act (Pub. L. 96-39) prohibits agencies from setting standards that create unnecessary obstacles to the foreign commerce of the United States. In developing U.S. standards, this Trade Act requires agencies to consider international standards and, where appropriate, that they be the basis of U.S. standards. Fourth, the Unfunded Mandates Reform Act of 1995 (Pub. L. 104-4) requires agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditure by State, local, or tribal governments, in the aggregate, or by the private sector, of \$100 million or more annually (adjusted for inflation with the base year of 1995). This portion of the preamble summarizes the FAA's analysis of the economic impacts of this final rule.

In conducting these analyses, FAA has determined this rule: (1) Has benefits that justify its costs, (2) is a "significant regulatory action" as defined in Executive Order 12866 because it raises novel policy issues under the legal mandate of the CSLAA, and is "significant" as defined in DOT's Regulatory Policies and Procedures; (3) will not have a significant economic impact on a substantial number of small entities; (4) will have a neutral impact on international trade; and (5) will not impose an unfunded mandate on state,

local, or tribal governments, or on the private sector. These analyses are available in the docket.¹⁷¹

The regulatory evaluation goes on to demonstrate evidence to support the conclusions:

1. POTENTIALLY IMPACTED PARTIES		
PRIVATE SECTOR		
■ Commercial operators who will be operating launch or reentry vehicles with crew and space flight participants on board ■ Flight crew ■ Remote operator ■ Space flight participants		
GOVERNMENT		
■ Federal Aviation Administration		
2. ASSUMPTIONS AND GROUND RULES USED IN ANALYSIS		
■ All monetary values are expressed in 2004 dollars ■ The time horizon for the analysis is 10 years (2006 to 2016) ■ Costs are discounted at 7% ■ Hourly Burdened Industry Wage Rate is \$69.40 ■ Hourly Burdened Government Wage Rate is \$52.04 ■ The high launch forecast used in the analysis is 10,142 over ten years ■ The low launch forecast used in the analysis is 5,081 over ten years ■ Requirements that were fulfilled by the SpaceShipOne launches or that constitute prudent business practice do not impose costs ■ Preparation time expended by commercial entities for specific requirements that might cause industry to incur costs because the new requirements are not current practice is as follows:		
Requirement	Hrs/operator	Hrs/mission
§ 460.9: Informing Crew of Risk	4	1
§ 460.19 (§ 440.17()): Crew Waiver of Claims Against U.S. Government	4	1
§ 460.45: Operator Informing Space Flight Participant of Risk	120	2
§ 460.49 (§ 440.17(e)): Space Flight Participant waiver of claims against U.S. Government	4	1

Figure 16: Excerpt from Part 14 CFR Part 460 Final Rule, Regulatory Evaluation section¹⁷²

A key assumption in the analysis is that “Requirements that were fulfilled by the SpaceShipOne launches or that constitute prudent business practice do not impose costs.”¹⁷³ The assumption has significant implications for the results of the impact analysis; consider the verification requirement in 14 CFR 460.17 to perform flight testing before carrying any SFPs onboard. An integrated test flight of an orbital spacecraft can cost on the order of \$100 million dollars or more, enough to trigger the threshold in the FAA’s analysis above under the Unfunded Mandates Reform Act of 1995. However, since SpaceShipOne did such a test, or it may be considered a “prudent business practice,” it is excluded from the impact on the private sector.

¹⁷¹ [Human Space Flight Requirements for Crew and Space Flight Participants final rule](#), 71 FR 75630, December 15, 2006 at 75628-75629.

¹⁷² *Id.* at 75629.

¹⁷³ *Id.*

Recommendation 22 – Inclusion of Estimated Costs in Rulemaking

REC 22	The FAA should include the estimated cost of all proposed and modified rules in future rulemaking.
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INTENT:

To fully capture the “worst case” cost of a rulemaking, the FAA should not “down select” the number of rules that are analyzed based on what it assumes are good business practices.

APPROACH:

Analyze the cost impact of all proposed rules in future rulemakings.

RATIONALE:

One of the assumptions in the FAA’s regulatory evaluation was, “Requirements that were fulfilled by the SpaceShipOne launches or that constitute prudent business practice do not impose costs[.]”¹⁷⁴ There is a conflict between the FAA’s assumption in the Part 460 final rule and its Congressional mandate to maintain “...stable, minimal, and appropriate regulatory guidelines that are fairly and expeditiously applied[.]”

As an example, the FAA excludes the cost of executing an integrated test flight prior to bringing SFPs onboard for a flight (see 14 CFR 460.11) given that it expects providers would do so even in absence of the Part 460 requirement. If the assumption is true, the rule to require an integrated test flight goes beyond Congressional intent in 51 U.S.C. § 50901 to only maintain “minimal” regulations. If the assumption is not true, it would impose significant cost on the industry, as a single integrated test flight without any paying customers could cost tens, or even hundreds, of millions of dollars and should be included in the regulatory evaluation.

The FAA should work closely with industry to understand the direct and secondary impacts for any regulatory frameworks ultimately developed under Part 460. Understanding economic impact is essential to limiting unnecessary burdens on industry, given the collective goal of expanding the HSF market while ensuring safety.

¹⁷⁴ COMSTAC Human Space Flight Working Group, “[Report to Congress: U.S. Department of Transportation Evaluation of Commercial Human Space Flight Activities Most Appropriate for New Safety Framework](#)” (July 11, 2023).

Appendix

Appendix A – SpARC Member Voting Responses and Ballots

The SpARC believes this report fulfills the tasks in the mission of the Charter. The recommendations contained in this report were robustly debated and the report was accepted by the full SpARC prior to submission to the FAA.

In support of a transparent SpARC process, members were offered the opportunity to include a (2 page) concurrence or non-concurrence on the final document. All submissions are included in this report.

The SpARC completed its deliberations and report drafting on March 25, 2025. Voting ballots were distributed to the voting SpARC members on March 26, 2025. The tally is as follows:

22 – Concur as Written

1 – Concur with Comment

0 – Concur with Exception

0 – Abstain

0 – Non-Concur

Primary Representative	Organization	Alternate Representative	Voting Response
Christopher Allison	Sierra Space	Tom Marshburn	Concur
Jason Andrews	ORBITE, Inc	Brienna Rommes	Concur
Sirisha Bandla	Virgin Galactic	William Robertson, Kyle Slover	Concur
Arthur W. “Bill” Beckman	The Boeing Company	Lisa Loucks, Christopher Ferguson, Allan Beiderman	Concur with Comment
Dr. Rebecca Blue	University of Texas Medical Branch		Concur
Allen Cutler	Coalition for Deep Space Exploration		Concur
Mary Lynne Dittmar (ret.), Industry Chair	Axiom Space	Alicia Woodley, Ramzi Masri-Elyafaoui, Mike Harrison	Concur
Daniel Dumbacher (ret.)	American Institute of Aeronautics and Astronautics (AIAA)	Ryan Cooperman Chris Crumbly	Concur
Mike French	Space Policy Group		Concur

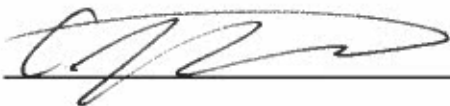
Primary Representative	Organization	Alternate Representative	Voting Response
William “Bill” Gerstenmaier	Space Exploration Technologies Corp (SpaceX)	Matthew Pleatman, Jillian Yuricich	Concur
Matthew Granger	Lockheed Martin Space		Concur
Michelle Hanlon	Air and Space Law at the University of Mississippi School of Law		Concur
Mark Hitt	Space Perspective		Concur
Jamey Jacob	Oklahoma State University, School of Mechanical and Aerospace Engineering		Concur
Glenn King	National Aerospace Training and Research Center (NASTAR)		Concur
Lorraine Martin	National Safety Council	Richard Fairfax	Concur
Maggie McNeece	Blue Origin, LLC		Concur
Laura Montgomery	Ground Based Space Matters, LLC		Concur
Roger Nober	George Washington Regulatory Studies Center		Concur
Kevin O'Connell	Space Economy Rising		Concur
Michael Ryschkewitsch	Johns Hopkins Applied Physics Lab		Concur
Maraia Tanner	Star Harbor		Concur
Isaiah Wonnenberg	Commercial Space Federation		Concur

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Christopher Allison
Voting Member Organization	Sierra Space

As a voting member and full participant of the [INSERT NAME] SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature:  Date: 3/26/25

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ Date: _____

Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence

Voting Member Name	Jason Andrews
Voting Member Organization	Orbite Inc

As a voting member and full participant of the [INSERT NAME] SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature:

DocuSigned by:
Jason Andrews
25B99E9024FB4C0...

Date: 4/3/2025

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ Date: _____

Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Sirisha Bandla
Voting Member Organization	Virgin Galactic

As a voting member and full participant of the Part 460 SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature:  _____ Date: 3/31/2025

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ Date: _____

Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Arthur W. "Bill" Beckman
Voting Member Organization	The Boeing Company

As a voting member and full participant of the [INSERT NAME] SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature: _____ **Date:** _____

2. Concur with Comment or Exception(s):

REC 19, pages 5, 88, 93: The matrixed assessment should characterize safety-critical responsibilities of ALL occupants (not just SFPs) and remote (ground) operators.

Table 7, page 58: Under FAA Indicator Family "Safety of the industry" proposed indicators, in addition to the stated "proactive observation of unaddressed safety issues...", should include "recommendations following investigation of a space flight mishap or near-miss." Rationale: This is consistent with FAA's existing rulemaking authority, and proactive indicators may not reveal unsafe practices identified by mishap investigation.

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

For Bill Beckman

Voting Member Signature: _____ **Date:** 2 April 2025

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ **Date:** _____

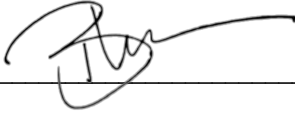
Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Rebecca Blue, MD
Voting Member Organization	University of Texas Medical Branch

As a voting member and full participant of the [INSERT NAME] SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature:  _____ Date: 3/31/2025

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ Date: _____

Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Allen Cutler
Voting Member Organization	Coalition for Deep Space Exploration

As a voting member and full participant of the 460 SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature: _____



Date: 4/2/2025

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____

Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____

Date: _____

Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Mary Lynne Dittmar (retired)
Voting Member Organization	Axiom Space

As a voting member and full participant of the [INSERT NAME] SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature: Mary Lynne Dittmar Date: 03/27/2025

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ Date: _____

Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Daniel L Dumbacher (retired)
Voting Member Organization	American Institute of Aeronautics and Astronautics (AIAA)

As a voting member and full participant of the [INSERT NAME] SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature:  Date: 28 March 2025

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ Date: _____

Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Mike French
Voting Member Organization	Space Policy Group

As a voting member and full participant of the [INSERT NAME] SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature: Mike J. French Date: 4/1/25

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ Date: _____

Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	William H. Gerstenmaier
Voting Member Organization	Space Exploration Technologies

As a voting member and full participant of the [INSERT NAME] SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature: William H Gerstenmaier Date: 02 April 2025

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ Date: _____

Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Matt Granger
Voting Member Organization	Lockheed Martin

As a voting member and full participant of the Human Space Flight Occupant Safety SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature:  Date: 3/31/2025

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ Date: _____

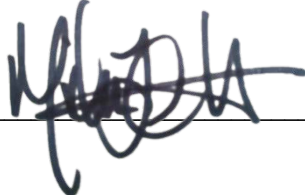
Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Michelle Hanlon
Voting Member Organization	University of Mississippi

As a voting member and full participant of the 460 SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature:  _____ Date: April 2, 2025

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ Date: _____

Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Mark Hitt
Voting Member Organization	Space Perspective

As a voting member and full participant of the Part 460 SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written. *mrh*

Voting Member Signature: _____ *Mark Hitt* _____ Date: _____ 28 March 2025 _____

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ Date: _____

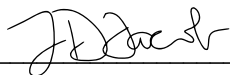
Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Jamey Jacob
Voting Member Organization	Oklahoma State University

As a voting member and full participant of the Human Space Flight Occupant Safety SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature:  Date: April 1, 2025

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ Date: _____

Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Glenn King
Voting Member Organization	The NASTAR Center

As a voting member and full participant of the [INSERT NAME] SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature:  Date: March 26, 2025

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ Date: _____

Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Lorraine Martin
Voting Member Organization	National Safety Council

As a voting member and full participant of the [INSERT NAME] SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature: Lauren M. [Signature] **Date:** 27 March 2025

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ **Date:** _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ **Date:** _____

Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Maggie McNeece
Voting Member Organization	Blue Origin

As a voting member and full participant of the [INSERT NAME] SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature: /s/ Maggie McNeece Date: 4/1/2025

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ Date: _____

Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Laura Montgomery
Voting Member Organization	Ground Based Space Matters, LLC

As a voting member and full participant of the FAA's 460 SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature: _signed/ Laura Montgomery **Date:** _____4/2/25_____

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ **Date:** _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ **Date:** _____

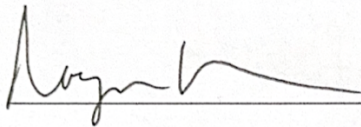
Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence

Voting Member Name	Roger Naber
Voting Member Organization	GW Regulatory Studies Center

As a voting member and full participant of the [INSERT NAME] SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature:  Date: 3/28/25

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ Date: _____

Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Kevin M. O'Connell
Voting Member Organization	Space Economy Rising

As a voting member and full participant of the Part 460 SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature: Kevin M. O'Connell Date: April 1, 2025

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ Date: _____

Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Michael Ryschkewitsch
Voting Member Organization	Johns Hopkins Applied Physics Lab

As a voting member and full participant of the [INSERT NAME] SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature:  Date: 3/26/2025

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ Date: _____

Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Maraia Tanner
Voting Member Organization	Star Harbor

As a voting member and full participant of the [INSERT NAME] SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature:  Date: 3/31/2025

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____ Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____ Date: _____

Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.

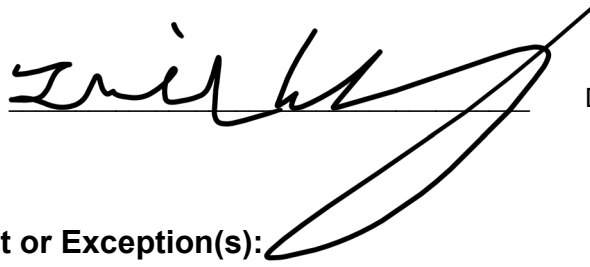
**Human Space Flight Occupant Safety
Aerospace Rulemaking Committee (SpARC)
Statement of Concurrence / Non-Concurrence**

Voting Member Name	Isaiah Wonnenberg
Voting Member Organization	Commercial Space Federation

As a voting member and full participant of the [INSERT NAME] SpARC, I hereby acknowledge that I have reviewed the Final Report and recommendations and make the following statement:

1. Concur with the Final Report as written

Voting Member Signature: _____



Date: 04/02/2025

2. Concur with Comment or Exception(s):

Provide comment or exception in the text box above. Member may submit a separate paper on company letterhead if additional space is required. Separate papers may not exceed 2 pages in length.

Voting Member Signature: _____

Date: _____

3. Non-Concur. Letter of Dissent must be provided.

Voting Member Signature: _____

Date: _____

Letters of Dissent must be on company letterhead and may not exceed 2 pages in length.