

## COMSTAC Safety WG Report- DRAFT

### Preface

The COMSTAC Safety Working Group (SWG) was tasked with formulating human spaceflight best practices to guide industry in anticipation of updates to human spaceflight regulations upon expiration of the commercial industry “Learning period” under the Commercial Space Launch Competitiveness Act (CSLCA).

Specifically, the SWG was tasked to:

- Determine the extent to which voluntary consensus standards are being used by industry
- Identify any existing industry-developed voluntary consensus standards appropriate to serve as means of compliance or regulation
- Make recommendations on how to implement a voluntary safety reporting system for the commercial space transportation industry

It is neither the intent nor the role of the COMSTAC SWG to recommend regulation. Once the moratorium on new human spaceflight regulations, currently in force until 2023, expires (or if it should be terminated for any reason) an evolved safety framework must provide the basis for systems and operations that instill public confidence.

### Executive Summary

FAA has a critical role in ensuring the safety of human spaceflight while establishing a safety framework that enables flexibility for industry to continue with innovation. In the absence of clear and sufficient regulation, safety risk might negatively impact growth of the industry. Excessive regulation could also threaten growth by burdening industry with excessive costs and complexity that are not necessary to protect safety.

While the current commercial human spaceflight safety framework provides value to the public and crew it does not have the specificity nor the mandate necessary to address non-crew participant safety. The commercial human spaceflight industry has grown rapidly and **has begun to develop** voluntary standards that could inform potential future regulations and leverage lessons learned in order to prevent mishaps and improve spaceflight safety, including both public and occupant safety. Utilizing this knowledge is critical to further reducing risk and supporting continued development and evolution of industry.

The COMSTAC has determined that while the industry is still learning, it has developed an valuable knowledge base **on which to build** voluntary standards that may inform potential future regulations whenever the current moratorium terminates. The development of new standards and regulations over time must consider the diverse levels of operator experience and types of systems, and the right balance between regulation and voluntary consensus standards is necessary to ensuring continued evolution of a vibrant human spaceflight industry. Industry-led standards efforts have yielded progress, yet the pace of these efforts has been insufficient to inform the development of a human spaceflight regulatory environment once the moratorium ends. FAA leadership is needed to facilitate rapid progress on the safety framework to serve as a foundation for a safe and competitive industry.

## **COMSTAC Safety WG Report- DRAFT**

The COMSTAC determined that published voluntary spaceflight safety standards are in minimal use by US commercial industry, but several should be investigated by the FAA as potential input to future regulations and/or guidance.

The COMSTAC agreed that companies should implement internal safety reporting systems with the intent to eventually integrate with a future industry-wide voluntary space safety reporting system modeled after the Aviation Safety Action Program (ASAP) used in commercial aviation.

### **Background**

In 2004, as the FAA was given authority to regulate commercial human spaceflight, a moratorium was placed on new commercial human spaceflight regulations to allow the fledgling industry an opportunity to innovate, grow and mature through flight experience. The moratorium was originally set to expire in 2012, but was extended twice, first to 2015 and then to 2023.

CSLCA Section 111 (3) directed the FAA to continue work with the commercial space sector COMSTAC 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. In 2016, the COMSTAC stated its support for ASTM International as the organization under which US industry would develop and publish voluntary consensus standards. It also noted the benefit of US industry participation in international standards development through the International Organization for Standardization (ISO) Space Systems and Operators standards subcommittee. The COMSTAC assisted in formation of the ASTM Committee on Commercial Spaceflight to prioritize, develop, and promote consensus standards and recommended practices to benefit safety and inform future licensing and regulatory efforts.

Section 111 (8) of the CSLCA requires an independent review conducted by a systems engineering and technical assistance organization or standards development organization by December 2022. The review is intended to address commercial human spaceflight industry and Federal Government readiness to transition to an evolved safety framework and make recommendations as to the appropriateness of regulatory action and continued development of voluntary consensus standards. Readiness will be assessed based on progress in adopting voluntary consensus standards and meeting key metrics including knowledge and experience.

### **Commercial Aviation Regulation and Lessons Learned**

Although there have been a multitude of developments within the commercial spaceflight industry, we are in our infancy compared to other transportation sectors, that operated under a mature set of standards and regulations. The COMSTAC has determined that we must review lessons learned in the commercial aviation world for potential relevance. In the 1920s, the nascent commercial airline industry identified a need for improved safety standards; subsequently, the Secretary of Commerce was charged with developing and enforcing air traffic rules, licensing pilots, and certifying aircraft. In 1938, the independent Civil Aeronautics Authority (CAA) was established with an Air Safety Board to conduct accident investigations and advise on accident prevention. Twenty years later, following a series of accidents and in anticipation of commercial jetliners, the Federal Aviation Agency was created, assuming CAA functions and updating decades-old safety standards. At that time, the need for a national aviation incident data system was identified. In 1967, the Federal Aviation Agency was renamed Federal Aviation

## **COMSTAC Safety WG Report- DRAFT**

Administration and assigned under the newly created Department of Transportation, which also included the National Transportation Safety Board (NTSB).

In 1975, soon after an NTSB aircraft accident investigation revealed a related near miss on another carrier only weeks before, the FAA implemented its Aviation Safety Reporting Program, supported by the Aviation Safety Reporting System—a voluntary safety program still in effect that compiles confidential incident reports and hazard alerts in a published database.

Following economic deregulation of the industry in 1978, a highly competitive airline industry emerged, including formation of many new companies. This created an enormous workload for FAA as they were required to review every application to certify a new airline; its resources taxed, the FAA focused efforts on new applicants.

Lessons learned from almost a century of aviation safety regulation have contributed to the development of one of the world's safest transportation systems and many of these lessons are also applicable to the emerging commercial human spaceflight industry. Still, the significant differences between the aviation and the current space transportation sector must be acknowledged. The diversity of spacecraft vehicle designs and operational procedures is a notable difference when compared to commercial aircraft. The lack of any experience in routine commercial operations among the space transportation firms is another important difference.

The FAA is in an optimal position to apply the appropriate lessons from aviation industry experience, focusing on occupant safety while minimizing regulatory burdens. Regulation of occupant safety is a natural complement to the FAA's current focus on public safety, and judicious preparation for future regulations, informed by industry and the unique nature of current commercial spaceflight systems, is to the benefit of all.

### **Current State of the Commercial Human Spaceflight Industry**

#### **Human Spaceflight Experience**

Considerable progress has been made in the last few years with respect to commercial industry knowledge on human spaceflight. Numerous private space companies are currently operating or developing systems to provide services for commercial human space transportation. Several of these are guided by NASA human spaceflight design and certification requirements. Others are subject to a subset of human spaceflight requirements that apply to docking and delivery to the International Space Station (ISS). Many, but not all, of the lessons NASA has learned and integrated into their requirements prove useful for informing commercial operators. Industry has already gained much relevant experience and learned lessons through many years of engineering development, review, ground tests and test flights, a few with their own crew as well as with government astronauts. Accidents and serious incidents, while regrettable and inevitable in any transportation sector, have occurred and offer valuable data points in this regard.

FAA has also significantly expanded its human spaceflight knowledge base in that time. In licensing NASA Commercial Crew and Commercial Resupply Services, FAA has had a close working relationship with NASA in areas of mutual concern. Additionally, through licensing and experimental permitting of new human spaceflight systems, FAA has experienced first-hand learning from, and along with, commercial providers. All of these programs have benefitted from an innovative and

## COMSTAC Safety WG Report- DRAFT

accommodating FAA licensing regime. Occupant safety has emerged as an important variable that will need to be considered in future licensing and operations, when the current moratorium expires or if an event should make it necessary for FAA to act under their authority granted by 51 U.S.C. § 50905 (c)(2)(C).

### Voluntary Consensus Standards

With support from the COMSTAC and FAA, the ASTM International Committee on Commercial Spaceflight (F47) has grown to approximately 100 members representing industry stakeholders, government, and academia. Several members with aviation backgrounds also serve to leverage that industry's best practices as appropriate for commercial space. ASTM standards development has focused on launch and reentry operations, with the majority of topics contributing to a safety framework for FAA licensing and permitting. The committee includes human spaceflight subcommittees (see Table 1 below), but only a few standards currently in development address human spaceflight (HSF) safety (see Table 2 below). Since the formation of the committee, FAA has had significant involvement as observers in the development process.

**Table 1 - ASTM F47 Subcommittees**

F47.01	Occupant Safety of Suborbital Vehicles
F47.02	Occupant Safety of Orbital Vehicles
F47.03	Unoccupied Launch and Reentry Vehicles
F47.04	Spaceports
F47.05	Cross-Cutting
F47.90	Executive
F47.91	Terminology
F47.92	Standards Roadmapping
F47.93	Regulatory Liaison

While industry has contributed significant time and effort to this standards development process, overall development of commercial consensus standards has been a slow process, a phenomenon which is not uncommon in other industries. Some factors that have impacted development of commercial human spaceflight standards include vehicle diversity, export control regulations, and limited flight data.

While only a few standards have been published, many more are in various stages of development

**Table 2 - ASTM F47 Standards**

Number	Title	HSF	Status
F3344-19	Standard Guide for Storage, Use, and Handling of Liquid Rocket Propellants		Published
F3377-19	Standard Terminology Relating to Commercial Spaceflight		Published
WK61254	Spacecraft vehicle types		In ballot
WK59508	Failure Tolerance for Occupant Safety of Suborbital Vehicles	Yes	In work

**COMSTAC Safety WG Report- DRAFT**

WK70011	Crew Safety	Yes	In work
WK64814	Safety-Critical Personnel Training and Qualification	Yes	In work
WK70413	Space Data Exchange to Support the Integration of Space Operations into Air Traffic Management		In work
WK65152	Reportable safety related events	Yes	In work
AC402	Common Standard format for Launch site requirements		In work

The ISO Space Systems and Operations technical committee (TC 20/SC14) is composed of 13 international members, primarily from Europe and Asia, and 10 observing members. While the US space industry at large is involved, with liaisons from several US national technical standards groups, the commercial launch industry is not generally engaged in ISO standards development. The content of ISO standards is primarily focused on the satellite industry (see subgroups in Table 3 below).

ISO commercial space standards are relatively unknown to the US commercial launch industry and have limited utility for launch and reentry operations. As ISO standards development lacked participation of the US commercial space industry, they do not reflect voluntary consensus by the industry stakeholders to which FAA commercial spaceflight regulations apply.

**Table 3 - ISO TC20/SC14 Subgroups**

ISO/TC 20/SC 14/AG 1	Chairman’s advisory group (CAG)
ISO/TC 20/SC 14/AG 2	Terminology task force
ISO/TC 20/SC 14/WG 1	Design engineering and production
ISO/TC 20/SC 14/WG 2	System requirements, verification and validation, interfaces, integration, and test
ISO/TC 20/SC 14/WG 3	Operations and support systems
ISO/TC 20/SC 14/WG 4	Space environment (natural and artificial)
ISO/TC 20/SC 14/WG 5	Space System Program Management and Quality
ISO/TC 20/SC 14/WG 6	Materials and processes
ISO/TC 20/SC 14/WG 7	Orbital Debris Working Group

Other standards groups, such as the International Association for the Advancement of Space Safety (IAASS) led Spaceflight Safety Institute have sought to compete with ASTM in the standards development effort but have done so without participation of most US stakeholders. Furthermore, with the US commercial launch and human spaceflight industry far more robust than its international counterparts, US companies have more to gain from collaborating on a domestic safety framework that satisfies FAA licensing requirements than from engaging with international entities that have yet to develop similar capabilities.

The SWG reviewed existing commercial space standards published by multiple organizations to determine applicability to the human spaceflight safety framework. Numerous standards were found to have relevance and could serve as a starting point for industry consensus. Some published standards were not available; others were based on government programs which do not necessarily

## COMSTAC Safety WG Report- DRAFT

consider relevant aspects of commercial launch and reentry system development and operations. Standards review documentation is included at Attachment 1.

Many of the commercial human spaceflight firms are developing and deploying systems incorporating NASA requirements for the Commercial Resupply Services and Commercial Crew programs in order to meet NASA's requirements as a potential customer; however, this is not true for all companies seeking to operate commercial human spaceflight systems. While documents from these NASA programs may offer a basis for a future human spaceflight safety framework, they are based on orbital transportation to and from the ISS, and do not necessarily serve a competitive and innovative commercial industry with diverse systems and mission applications.

Commercial human spaceflight license applicants are held to 14 CFR Part 460 Human Space Flight Requirements which outline topics to be considered. Companies developing commercial human spaceflight systems not subject to NASA requirements have discretion in complying with the FAA licensing requirements. For commercial human spaceflight companies, safety is at the forefront of all planning and development. If a developed vehicle is unsafe, the company will not be able to attract customers and will rapidly meet with failure.

### Lessons Learned

In 2014, an accident occurred on SpaceShipTwo during a test mission conducted under an FAA experimental launch permit, in a vehicle system prior to its final commercial configuration. In its accident investigation report, the National Transportation Safety Board (NTSB) identified several safety issues relevant to the commercial human spaceflight safety framework. The NTSB concluded that the current form of general guidance on how to analyze human factors and evaluate effectiveness of designs and controls is rather broad and open to multiple approaches.

While this openness is beneficial for companies fielding very diverse spaceflight systems, the area of human factors might benefit from a more standardized approach. Specifically, the existing regulatory requirement, "take precautions necessary to account for human factors that can affect a crew's ability to perform safety-critical role" is broad and not as effective as it could be nor give enough guidance on methods for compliance.

### Future Safety Framework

COMSTAC is not charged with making recommendations on regulations. Rather, it helps develop consensus standards that may inform future regulations with the awareness that, independent of the moratorium, 51 U.S.C. § 50905 (c)(2)(C), allows FAA to issue commercial human spaceflight regulations based on safety lessons learned at any time. These exceptions are limited to restricting or prohibiting design features or operating practices that:

- have resulted in a serious or fatal injury to crew, government astronauts, or space flight participants during a licensed or permitted commercial human space flight; or otherwise
- 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 to crew, government astronauts, or space flight participants.

## COMSTAC Safety WG Report- DRAFT

While the language is stated in a negative sense, it's reasonable to conclude that the intent gives FAA the authority to implement safety-critical recommendations of the NTSB report through near-term rulemaking. In this case, industry engagement is crucial to ensure a balanced approach. For example, future human spaceflight regulations must be flexible to consider a variety of experience, vehicle types, missions, and environments. An occupied spacecraft conducting a low earth orbit mission will have different design constraints and operating conditions than a suborbital spacecraft, an extended duration spacecraft, or an expendable launch vehicle carrying an occupied vehicle.

A future safety framework must also take into account the wide spectrum of operator experience, avoiding prescriptive measures but providing sufficient detail to ensure new applicants have the information necessary to develop safe systems and operations, and for the FAA to thoroughly and effectively evaluate the application.

A future safety framework must also address financial risk. Regulatory language clarifying liability for spaceflight participants is necessary in 14 CFR Part 440, Financial Responsibility to reduce uncertainty in the insurance marketplace and mitigate cost impacts that could inhibit industry growth.

### Recommendations

The following recommendations represent best practices from a top-level policy and process perspective. They leverage the FAA's experience in successfully regulating aviation safety, and they allow for a collaborative effort between industry and government to create a safe environment for commercial spaceflight participants as well as the general public. They also create a cooperative framework that ensures future regulations will not be overly burdensome, and that allows the FAA to actively support this growing industry.

1. FAA form a Commercial Spaceflight Safety Space Rulemaking Committee (SRC) to focus industry efforts on voluntary standards development, help the space community apply relevant lessons learned, and inform future regulations on commercial spaceflight in general as well as human spaceflight. Based on recent experience with FAA Aviation Rulemaking Committees on commercial space topics, an SRC would be the most effective forum to accelerate industry consensus while ensuring wide participation and fair, thoughtful application across the broad industry base. SRC scope should include the following tasks:
  - a. Commercial spaceflight industry standards and best practices development
    - i. Prioritize best practices and standards development activities
    - ii. Assess suitability/adaptability of existing commercial and government practices and standards to support a future safety framework
    - iii. Provide guidance on and evaluation of consensus standards in development to supplement regulations and identify means of compliance
  - b. Spaceflight safety lessons learned implementation
    - i. Provide inputs to FAA on communication of space safety lessons learned
    - ii. Evaluate lessons learned for incorporation into industry standards and best practices
    - iii. Review aviation safety voluntary reporting practices and systems for applicability to the commercial space industry
    - iv. Provide recommendations on implementation of a voluntary safety reporting system, including scope and information to be shared across industry
  - c. Regulatory development

## COMSTAC Safety WG Report- DRAFT

- i. Prioritize regulatory reform efforts supporting Streamlined Launch and Reentry Licensing Regulations (SLRLR)
  - ii. Identify updates to 14 CFR Part 440 Financial Responsibility needed to address human spaceflight, including clarifying liability for spaceflight participants
  - iii. Address 14 CFR Part 460 Human Space Flight Requirements scope and identify regulatory priorities
  - iv. Provide recommendations on development of new commercial human spaceflight regulations to implement lessons learned from flight experience and build a safety framework that supports new commercial entrants.
2. FAA retain a systems engineering and technical assistance organization (e.g., MITRE, Aerospace Corporation) as soon as possible to conduct the CSLCA-required independent review on readiness for an evolved commercial human spaceflight safety framework
3. FAA develop a reportable incident database with the goal to provide public access for certain safety-critical data based initially on the required informed consent process (SLRLR rulemaking process could address regulatory aspects).
4. FAA plan for implementation of an industry-wide voluntary space safety reporting system based on the ASAP program, and provide guidance to industry on development of internal reporting systems that will interface with the industry-wide system.
5. COMSTAC and FAA AST support industry development of a voluntary safety reporting system.
6. FAA and COMSTAC continue to support the ASTM International Committee on Commercial Spaceflight as the technical standards organization responsible for development of US commercial industry consensus standards.