

*Do we need an Annex 13 for Commercial Space Accident Investigations?*

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**Abstract**

The U.S. commercial space industry has grown rapidly over the last several years, FAA-licensed commercial launches have increased from 4 in 2010 to 33 in 2018. This increase was partly the result of policy changes after the retirement of the space shuttle that have required NASA to use commercial launch/reentry systems for International Space Station (ISS) resupply and astronaut transfer. As a result, commercial space launches and reentries will likely continue to increase, which will inevitably result in an increased risk of mishaps that will need to be investigated.

The NTSB Office of Aviation Safety (OAS) has been working with the space industry for over 25 years and has led two major investigations into mishaps that occurred during commercial space launches: the February 9, 1993, commercial space launch anomaly of an Orbital Sciences Corp. Pegasus SCD-1, and the October 31, 2014, in-flight breakup of the Scaled Composites SpaceShipTwo. In addition, OAS investigators have assisted NASA and the Congressional investigative boards with the investigations of the two space shuttle accident mishaps (1986 and 2003) and also assisted NASA with the investigation of the 2004 Genesis Spacecraft reentry accident mishap. More recently, OAS investigators assisted with the investigation of the 2014 Orbital Sciences Antares launch failure and with two SpaceX mishaps (a 2014 launch failure and a 2016 pad explosion).

This paper will detail the differences between investigating a commercial space and a civil aviation accident, specifically describing the NTSB's authority for investigating commercial space mishaps, the differences in procedures that OAS is developing, and the unique challenges investigators must deal with when conducting investigations in this emergent industry. Finally, the paper will discuss the current international treaties affecting space launch and reentry and whether a "space Annex 13" is needed to ensure standard protocols and thorough investigations of commercial space mishaps throughout the world.

The growth of the U.S. commercial space industry has accelerated over the last several years; FAA licensed commercial launches have increased from 4 in 2010 to 33 in 2018. This increase was partly the result of policy changes after the retirement of the space shuttle that have required NASA to use commercial launch/reentry systems for International Space Station resupply and astronaut transfer. As a result, commercial space launches and reentries will likely continue to increase, which will inevitably result in more mishaps. Over the last 25 years, the NTSB Office of Aviation Safety (OAS) has been developing technical expertise and building relationships with stakeholders involved in this emerging mode of transportation to ensure that the NTSB and stakeholders are prepared to investigate any commercial space accident or incident. Although there are similarities between commercial space and aviation investigations, the industry structure, technologies, national security laws, and international treaties that govern space operations dictate that the investigations will be considerably different. Ultimately, these differences will also drive how States interact during an international accident or incident investigation.

The NTSB has been leading or supporting commercial space accident investigations for more than 25 years and has conducted two major space vehicle investigations. In 1993, the NTSB investigated the procedural anomaly that occurred during the launch of an Orbital Sciences Corporation Pegasus expendable launch vehicle.<sup>1</sup> The investigation found safety issues related to command, control, and communications responsibility; launch crew fatigue; launch interphone procedures; efficiency of launch constraints; and the lack of common launch documents. In its final report, the NTSB issued 17 safety recommendations to the Department of Transportation, NASA, and Orbital Sciences. In 2014, the NTSB investigated the accident of the SpaceShipTwo reusable suborbital spaceplane that broke up during a rocket-powered test flight, killing the copilot.<sup>2</sup> The NTSB identified safety issues regarding the lack of human factors guidance for commercial space operators, the efficacy and timing of the preapplication consultation process, limited interactions during the experimental permit evaluation process, deficiencies in the evaluation of hazard analyses, and the need to improve the lessons learned database. The NTSB issued a total of 10 recommendations to the Federal Aviation Administration Office of Commercial Space Transportation and the Commercial Spaceflight Federation.

In addition to these NTSB-led investigations, NTSB investigators have assisted in multiple spacecraft accident investigations. Throughout the 7-month Columbia space shuttle investigation in 2003, over 40 NTSB investigators assisted both the Columbia Accident Investigation Board and NASA with ballistic analysis, debris recovery, wreckage examination, and vehicle reconstruction.<sup>3</sup> Several NTSB investigators also assisted NASA in 2004 with the investigation of the Genesis sample-return capsule that crashed into the Utah desert. NTSB investigators documented the accident scene, organized the wreckage recovery, and examined

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<sup>1</sup> National Transportation Safety Board. 1993. *Launch Procedure Anomaly Orbital Sciences Corporations Pegasus/SCD-1*. NTSB/SIR-93-02. Washington, DC: NTSB.

<sup>2</sup> National Transportation Safety Board. 2015. [\*In-Flight Breakup During Test Flight Scaled Composites SpaceShipTwo, N339SS\*](#). NTSB/AAR-15/02. Washington, DC: NTSB.

<sup>3</sup> The NTSB also assisted in the 1986 Challenger space shuttle investigation.

the vehicles' wiring harness for evidence of micrometeorite impact damage. More recently, NTSB investigators have observed or taken part in several operator-led mishap investigations, including the October 2014 Orbital Science (ATK) Antares engine failure shortly after liftoff; the June 2015 launch failure of the Space X CRS-7 mission; the September 2016 pad explosion of the SpaceX Falcon 9 with the Amos-6 communications satellite; and the April 2019 SpaceX Dragon explosion that occurred during a ground test. This “on-the-job training” has provided NTSB investigators with significant and critical experience in the commercial space industry, which has helped the OAS to prepare to lead the investigations of future commercial space accidents and incidents.

The space industry has historically been led by the government and military, so the commercial sector is relatively young, especially when compared to the aviation industry. The US commercial space industry officially launched in 1984 when the Commercial Space Launch Act (Space Act) was signed into law. The Space Act created the Office of Commercial Space Transportation (AST) in the Department of Transportation, and in 1995, AST was moved within the Federal Aviation Administration (FAA). The mission of the FAA AST is to ensure protection of the public and property; protect national security and foreign policy interests of the United States; and to encourage, facilitate, and promote US commercial space transportation. As part of its oversight responsibilities, the FAA AST issues licenses and experimental permits for commercial launches and reentries of orbital and suborbital rockets.<sup>4</sup> However, unlike the FAA’s aviation regulatory goal of providing the safest system in the world, the US Congress has charged the AST to primarily focus on protection of the public—and not “mission assuredness.”

This is not to say that the US Congress does not want a safe commercial space industry. The Space Act, which was most recently amended in 2015, states that the FAA AST should “encourage, facilitate, and promote the continuous improvement of the safety of launch vehicles designed to carry humans.” However, Congress also does not want to discourage industry development since human space flight is still inherently risky. So the Space Act includes a provision for a “learning period,” which limits any regulation “restricting or prohibiting design features or operating practices” unless resulting from an accident that caused a serious injury or fatality to a person onboard, or from a serious incident that almost caused a serious injury or fatality. This learning period, also known as human space flight regulation moratorium, is currently in effect until October 2023.

This is quite different from aviation regulations that have developed over the years to cover almost all aspects of an aircraft design and operational rules to ensure and improve the safety of passengers and crew. Unlike aviation regulations, AST regulations refer to any person aboard a commercial space vehicle who is not a crewmember as a “space flight participant” and not a “passenger.” In addition, these “space flight participants” are required to acknowledge the risks by signing an “informed consent” that identifies the risks or probable loss during each phase of launch/reentry and the safety record of the launch/reentry vehicle type (describing the

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<sup>4</sup> Other agencies also regulate commercial space-related activities, including the Federal Communications Commission, National Oceanic and Atmospheric Administration, Department of State, and Department of Commerce.

launch/reentry failures, if any). The launch/reentry operator must also purchase a specific amount of liability insurance, determined by AST for each launch, to cover any third-party loss (injury, death, property damage, etc.), which can be up to \$500,000,000. Since this liability amount might be insufficient for an exceedingly “bad day,” the Space Act also requires the federal government to indemnify launch/reentry companies for claims that exceed their required insurance coverage, which could be up to \$3 billion (in 2016 dollars).

NTSB involvement with the commercial space industry is similar to the aviation industry. The NTSB investigates any launch/reentry accidents and certain incidents, and that authority is derived from the NTSB’s general authority under 49 *Code of Federal Regulations (CFR)* 1131(a)(1)(F), which states that the NTSB shall investigate “any other accident related to the transportation of individuals or property when [the accident is] catastrophic.”<sup>5</sup> Although this statement is not as clear as 49 *CFR* 1131 (a)(1)(A), which states that the NTSB shall investigate all “aircraft accidents,” the NTSB’s interpretation of this statute is reasonable and is accepted by the commercial space industry.<sup>6</sup>

The process to clearly specify the NTSB’s authority to investigate commercial space accidents has begun; however, statutory changes are seldom fast. In addition to the NTSB statutory authority, the NTSB also entered into a memorandum of agreement (MOA) with the FAA in 2000 to ensure both agencies understand when the NTSB would initiate an investigation of a non-manned commercial launch accident. The MOA defines an accident that the NTSB would investigate as: a mishap when any portion of a commercial space vehicle or payload impacts outside the impact limit lines; a fatality or serious injury to a person not associated with the launch activities; or damage greater than \$25,000 to property not associated with the launch activities. This agreement was initiated during a time when human space flight and commercial reentry operations were not anticipated for many years; thus, although the MOA is still in effect, it is out of date and does not address those operations. Work on updating this outdated MOA is ongoing. In addition to this MOA, the NTSB has a memorandum of understanding with the FAA and the US Air Force, which defines the relationship between all three agencies during space investigations and describes the participation and information exchange procedures.

Although the NTSB regulations do not contain specific definitions related to commercial space mishaps, 14 *CFR* 401.5 contains definitions for commercial space launch and reentry accidents or incidents that assist the OAS in determining whether to initiate an investigation.<sup>7</sup> A *launch accident* is when there is a fatality or serious injury to a space flight participant or crew member; a fatality or serious injury to any person who is not associated with the flight; impact of launch vehicle, its payload or any component outside the impact limit lines (for expendable) or outside a designated landing site (for reusable); or damage to third-party property greater than \$25,000. A *reentry accident* occurs when the reentry vehicle, its payload, or any component

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<sup>5</sup> See Appendix A in NTSB/AAR-15/02 “*In-Flight Breakup During Test Flight Scaled Composites SpaceShipTwo*”

<sup>6</sup> Each launch licensee or permittee is required to report and comply with an NTSB investigation, 14 *CFR* 420.59 and 437.75.

impacts outside a designated reentry site; a fatality or serious injury to a space flight participant or crew member or a person not associated with the reentry; or damage to third-party property greater than \$25,000. In addition, for those mishaps that do not rise to level of an accident, the regulation also contains definitions for launch and reentry incidents to better define what mishaps the NTSB would likely investigate.<sup>8</sup> A *launch/reentry incident* is an unplanned event during the launch or reentry that would involve a malfunction of a flight safety system or safety-critical system, or a failure of the licensee's or permittee's safety organization, design, or operations. FAA AST has recently proposed to modify these definitions to more closely align with those used by the military and NASA by having four “classes” of mishap events rather than just accidents and incidents. The NTSB will likely issue its own definitions along these lines in the next few years.

As indicated by these definitions, it is clear that it takes a more serious mishap to constitute a commercial space accident; an event involving an aircraft is classified as an accident if there is substantial damage to the aircraft or serious injury to a person. Loss of the space vehicle alone does not automatically necessitate an NTSB investigation. However, now that the industry is moving toward human spaceflight, should a mishap occur, the NTSB would investigate it if there is a fatality or serious injury.

As previously discussed, the NTSB has been engaged with the space industry for the last 25 years through our commercial space program within the OAS. The program has matured along with the industry in order to ensure that the NTSB is prepared to investigate any future space vehicle accident or incident. The goals of the NTSB’s commercial space program are to develop the specialized investigative processes and procedures necessary to investigate this emergent mode of transportation, build critical relationships with industry stakeholders, and ensure NTSB investigators have the specialized knowledge necessary to lead commercial space investigations.

Although there are some similarities with aviation, there are distinct and unique aspects of the commercial space investigations that necessitate that they be investigated as its own distinct mode of transportation. As with all modes of transportation, the NTSB will use the party system to investigate commercial space accidents/incidents. The overall structure will be similar to major aviation investigations but will likely have fewer parties to the investigation since most of the rocket and vehicle components will be produced by the launch operator.<sup>9</sup> In addition, the OAS’s goal for completion of major aviation accident reports is to issue a final report within 12-18 months, which is acceptable in the aviation industry since normal operations generally continue throughout that timeframe. However, for every launch or reentry accident to a space vehicle, the vehicle and/or range is grounded until at least the initial causes are determined. Therefore, the OAS’s investigative process will likely have to be accelerated, although even targeting 8-12 months for a final report may be too long. To address this issue, NTSB staff are

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<sup>8</sup> There is no similar definition for an aircraft “incident” under 830.5, rather, an aircraft incident is considered anything that is not an accident.

<sup>9</sup> The Asiana 214 investigation had eight parties/technical advisors versus three primary parties for SpaceShipTwo.

evaluating the possibility of modified procedures to release preliminary analytical findings (prior to the final report) to allow for the resumption of launches or reentries.

Probably the most significant difference between an aviation and space investigation will be in the transparency of the investigation. Normally, the NTSB releases factual data through press conferences (while on scene), press releases (post on scene) and then via the public docket, which contains all relevant factual information NTSB investigators collected during the investigation. The NTSB even has the authority to release confidential commercial information (proprietary data)—that is normally protected—to support the conclusions, safety recommendations, or the probable cause of an accident. However, the space industry has regulations (export control policies) in place to safeguard critical defense-related technologies in order to protect US national security and foreign policy objectives: the International Traffic in Arms Regulations (ITAR) and the Export Administration Regulations (EAR). The NTSB is not exempt from these regulations and cannot release data that is subject to ITAR or EAR, even if it is directly related to the probable cause; thus, these regulations would impact the NTSB’s ability to release information on space accidents. As a result, the OAS has developed an internal procedure to work with the US Department of State and Department of Commerce to review all factual data/reports and in the final report before public release. This extensive review process will inevitably delay the release of factual information until the end of the investigation rather than being released as soon as possible (typically about 6 months into the investigation for major investigations). The ITAR/EAR review will also likely result in extensive redactions to the factual reports contained in the public docket. Even more significantly, on a highly technical accident, portions of the final report may also have to be redacted and, in extreme cases, the NTSB may be required to hold the final Board meeting in a closed session in order to discuss data that is ITAR/EAR restricted. For an agency that normally prides itself on openness and transparency, these restrictions on release of data will be a challenge and an appropriate public/media education effort will be necessary to communicate why the restrictions are essential.

Any commercial space orbital launch or reentry accident could become an “international” accident depending on the trajectory of the launch/reentry.<sup>10</sup> Space operations are governed by an international treaty entitled the “Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space,” commonly referred to as the Outer Space Treaty. This treaty has driven much of the US space regulation structure.<sup>11</sup> Although the treaty does not directly address accident investigation, it does address the responsibilities of each State in the event of a mishap. If a launch or reentry vehicle impacts in another State’s territory, that State has two responsibilities: render “all possible assistance” to any persons onboard, and to “safely and promptly” return persons and the vehicle or components.<sup>12</sup> Article VII to the Outer Space Treaty declares that the State that authorized the launch or reentry is “internationally liable” for damage caused by the vehicle or components to any persons or property. This type of liability-

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<sup>10</sup> Suborbital launches will likely remain in “domestic” airspace until “point-to-point” service is initiated to international destinations.

<sup>11</sup> 109 countries have ratified the treaty and another 23 have signed the treaty but not fully ratified it internally.

<sup>12</sup> *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space*, Annexes V and VIII.

focused language likely stemmed from the fact that, when the Treaty was originally developed in 1967, all the space operations were one-of-a-kind rockets operated by State governments. The Outer Space Treaty does encourage international cooperation multiple times throughout the treaty; for example, Article X states that States should afford an opportunity to other States to observe launches and reentries. Cooperation, of course, is essential for conducting international investigations, but a States specific rights and responsibilities also need to be defined for any future international investigative treaty.

ICAO Annex 13 has provided the basic structure for international aviation investigations for over 50 years, detailing the cooperation necessary as well as a State's rights and responsibilities during an investigation. However, the standards and recommended practices in Annex 13 are not directly applicable to the unique aspects of the commercial space industry (as discussed in this paper). One of the more significant differences between space and aviation is that launch operators are typically the manufacturer AND operator of their vehicle, unlike aviation where there are separate manufacturers and separate operators around the world. Accordingly, using Annex 13 terminology, the State which authorized the launch would be the State of Registry, Design, Manufacture and Operator, and the State where the vehicle or components impacted would be the "State of Occurrence." Although the "State of Occurrence" would have a considerable need to understand the facts, conditions and circumstances of the accident, it would be nearly impossible for the "State of Occurrence" to conduct a thorough investigation of the mishap, since the expertise resides entirely with the launch operator—especially since the operator would likely be prohibited by law (due to export regulations) to transfer information. Likewise, the ITAR and EAR national security regulations would also make it difficult for the "State of Occurrence" to send observers to a "State of the Operator" led investigation. Furthermore, if there are no distinct operators of the accident launch or reentry vehicle in the "State of Occurrence," there would be no safety reason for them to conduct an investigation since any lessons learned would likely only affect the State conducting the launch (any broad/universal safety findings would be released by the launching State).

Therefore, given the domestic and international regulatory environment, the national security laws, and the unique technical structure of the industry, I do not believe that—at this time—a formal "commercial space Annex 13" is necessary. However, informal international cooperation will be vital to ensuring that safety investigators are prepared to meet the technical and organizational challenges of investigating commercial space vehicle accidents. The existing Annex 13 aviation accident investigation authorities, and professional organizations—such as ISASI—will serve as excellent resources in building these relationships. The collaborative efforts between State authorities will help the investigative community refine the specific processes and procedures for investigating commercial space accidents, discover or develop training opportunities, gain understanding of various regulatory structures, and observe commercial space operations. At some point in the future, a more formal safety structure may be needed as the commercial space industry grows and matures (point-to-point service, etc.). However, until that time, the spirit of international cooperation, which has been cultivated by Annex 13, will help ensure that the investigative community is prepared to assist this emerging mode of transportation to improve safety following any commercial space mishap.