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Safety as a Synergistic Principle in Space Activities

Diane Howard[*]

ABSTRACT

The two space anomalies that occurred in October 2014 brought home, once again, the fact that space activities are dangerous. The U.S. Congress had acknowledged this fact by characterizing space transportation as "inherently risky" in the Commercial Space Launch Amendments Act of 2004. While that description does not go as far as to say space activities can never be safe or are completely unsafe, it includes the tacit understanding that space transportation provides complex and sometimes unique challenges. While some of these challenges are engendered by the realities of space systems operationally, others arise from the perspective of how much safety is legally required and for whom.

The immediate article attempts to provide an overview of the legal underpinnings of space safety and some of the implications arising from current space policy. It will begin with some historical context, proceed to describe the current international and domestic legal and policy environment, identify some key emerging issues, and end with brief recommendations.

I. INTRODUCTION

Space activities today include both public and private sector actors performing multidimensional operations in variable environments. Space safety, as applied to these activities, has been defined as the protection of human life and/or spacecraft during all phases of a space mission, regardless of whether this is a "manned" or "unmanned" activity. The concept of space safety covers: (a) all aspects from pre-launch, launch, orbital or sub-orbital operations, through re-entry and landing; (b) the protection of ground and flight facilities and surrounding population and buildings in proximity to launch sites; and (c) the protection of space-based services, infrastructure and unmanned satellites.[1]

But what does this statement really mean? Whose human life? Is this limited to the general public, uninvolved with the space activity in any way,

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1 TOMMASO SGOBBA, ET AL., SPACE SAFETY REGULATIONS AND STANDARDS xli (Joseph N. Pelton & Ram S. Jakhu eds., Elsevier 2010).

i.e., third parties? Or, should it perhaps include those second parties like crew or paid participants/passengers? And where is the sweet spot, protecting whomever regulators determine to be included in that catch-all phrase "human life," while also allowing innovation to flourish and business models to survive?

Going slightly deeper, protection from what? Threats can be internal to the activity—stemming from systemic or mechanical failure—or external, as in a force majeure. Safety as a social science is relatively new. While the human condition has included mishaps resulting in injury or death as far back as is recorded, the incidence of these "accidents" increased significantly in the early 1800s during the Industrial Revolution.[2] Workers were exposed to dangerous machinery and more hazardous working conditions. The early cultural emphasis was placed upon the victim as responsible for his safety, a phenomenon known as "blame the victim" which is the underpinning of contributory negligence schemes.[3] However, simply holding the victim responsible did little to discover the root cause of accidents. The early 1900s marked the onset of organized research efforts into accident causation resulting in a flurry of published safety information.

The National Safety Council began its work to promote industry safety in 1913.[4] Much of the research was funded by insurers and was predicated upon two foundational ideas: (1) safety was cost effective, and (2) the cause of most accidents was believed to be mental error or the psychology of the victim. This second concept flowed from the standpoint that the accident was a form of self-harm, a convenient position for an insurer.[5]

However, despite the fact that these ideas remained prevalent for the next fifty years, accident prevention research provided no useful guidance or satisfaction. No linkage could be found between accident-prone individuals and a consistent personality profile thus no long-term improvement on accident statistics was achieved. Ultimately, the work of two researchers in the mid-1900s, Gibson and Haddon, shifted the emphasis from a victim's shortcomings to what actually caused the injury.[6] This understanding of spotting hazards (either from equipment or procedures) before a damaging event was the first step toward developing practices that could mitigate injury

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2 Michael Guarnieri, *Landmarks in the History of Safety*, 23 J. SAFETY RESEARCH 151, 152 (1992).

3 RON MCKINNON, CHANGING THE WORKPLACE SAFETY CULTURE 18 (CRC Press, 2013).

4 For a timeline of safety history, see the National Safety Council's website, available at http://viewer.zmags.com/publication/89ffce6b#/89ffce6b/1 (last visited Feb. 1, 2015).

5 Guarnieri, *supra* note 2, at 152.

6 William Haddon, *Approaches to Prevention of Injuries*, *in* AMERICAN MEDICAL ASSOCIATION CONFERENCE ON PREVENTION OF DISABLING INJURIES (1983), http://www.iihs.org/frontend/iihs/documents/masterfiledocs.ashx?id=692 (last visited Feb. 1, 2015).

and promote a culture of safety.[7]

By this time in the mid-1960s, space activities had also resulted in a well-publicized fatality. Apollo 1 was not launched because a cabin fire during a rehearsal test killed all three crew members and destroyed the Command Module.[8] The two shuttle crashes, though caused by different physical events, had "common root causal factors" that included communications breakdowns, problematic systems engineering and integration, lack of accountability, and inconsistent governance.[9] The harsh reality that conducting space activities came at as steep a price as any other activity could not be avoided. Nor could a space actor circumvent the realities flowing from the high profile of the activities, as well as the instantaneous transmission of any trouble via globally interconnected information channels.

This last point is brought home by the two earlier referenced anomalies in U.S. commercial space transportation in October 2014—by Orbital Sciences as it attempted to deliver cargo to the International Space Station, and by Virgin Galactic as it performed a test flight under an experimental permit.[10] The latter resulted in both a fatality and a serious bodily injury.[11] Almost immediately, the entire space sector was abuzz with the news and wondering what the ramifications could be. What kind of governance response was legally required? What policies would any response implicate? And, how would a U.S. position impact space activities elsewhere, if at all?

II. Space Safety in the International Context

Although there is no specific treaty mandate regarding safety, both the Outer Space Treaty and the Liability Convention implicate, by necessity, safe activities of a launching State.[12] Launching States are those that either launch

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7 Trevor Kletz, *The History of Process Safety*, 25 J. Loss Prevention in the Process Industries 763, 764 (2012).

8 *Photos of the Apollo 1 Fire: NASA's First Disaster*, SPACE.com (Jan. 27, 2013), http://www.space.com/10674-apollo-1-fire-nasa-disaster.html.

9 David Jones et al., *Self Evaluation Tool: Key Lessons Learned from the Columbia Shuttle Disaster (adapted to the process industries),* American Institute of Chemical Engineers (2005), *available at* http://www.aiche.org/ccps/topics/elements-process-safety/commitment-process-safety/process-safety-culture/building-safety-culture-tool-kit/process-safety-culture/key-lessons-columbia-disaster; Bryan O'Connor, *Organizational and Cultural Lessons Learned from Challenger and Columbia*, NASA.gov, http://www.nasa.gov/pdf/396770main_mf18_oconnor.pdf (last visited Feb. 1, 2015).

10 *NASA's Wallops Flight Facility Completes Initial Assessment After Orbital Launch Mishap*, NASA.gov (Oct. 29, 2014), http://www.nasa.gov/press/2014/october/nasa-s-wallops-flight-facility-completes-initial-assessment-after-orbital-launch/#.VM51LF7F-lI (last visted Feb. 1, 2015); Tariq Malik, *Virgin Galactic SpaceShip Two Crash: Full Coverage and Investigation*, space.com (Dec. 19, 2014), http://www.space.com/27629-virgin-galactic-spaceshiptwo-crash-full-coverage.html.

11 *Id.*

12 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer

or procure the launch, or from whose territory or facility a space object is launched.[13] The launching State is responsible in perpetuity for damage from its space object.[14]

Similarly, both Article VIII of the Outer Space Treaty, along with the Registration Convention itself, have been viewed as implicit legal links to assigning responsibility for safe space activities.[15] This responsibility is framed in terms of retained jurisdiction and control by the State upon whose registry a space object is launched. The Outer Space Treaty Article VI provides further legal basis for a safety requirement by putting the onus on the State granting the license to authorize, or endorse the space activities of its nationals, and then to continually monitor and supervise.[16]

International obligations to conduct space activities safely are also implicit in Article IX of the Outer Space Treaty, requiring avoidance of harmful interference with activities in the peaceful use and exploration of outer space.[17] This obligates States to ensure that operators perform safely, at least with sufficient due diligence expended to reasonably avoid actions that will have adverse effect on the activities of other State parties.[18]

The first set of principles and guidelines pertinent to space that set forth an express safety obligation is the 1992 *Principles Relevant to the Use of Nuclear Power Sources in Outer Space*.[19] The Preamble recognizes that thorough safety assessment, including probabilistic risk analysis, is the necessary basis for reducing risk to the public from the use of nuclear power sources. Principle 3 delineates guidelines and criteria for safe use while Principle 4 describes the general elements of safety assessment and obligates

Space, including the Moon and Other Celestial Bodies, Jan. 27 1967, 18 U.S.T. 2410, U.N.T.S. 205 [hereinafter Outer Space Treaty]; Convention on International Liability for Damage Caused by Space Objects, Mar. 29, 1972, 24 U.S.T. 2389, 961 U.N.T.S. 187 [hereinafter Liability Convention].

13 *See* Outer Space Treaty, *supra* note 12, at art. VII; *see also* Liability Convention, *supra* note 12, at art. I (c).

14 Liability Convention, *supra* note 12, at art. I.

15 Ram S. Jakhu & Yaw O. T. Nyampong, *Are the Current International Space Treaties Sufficient to Regulate Space Safety, and Establish Responsibility and Liability?*, in PROCEEDINGS OF THE 2D IAASS CONFERENCE: *SPACE SAFETY IN A GLOBAL WORLD* (May 14, 2007).

16 "The activities of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty." Outer Space Treaty, *supra* note 12, at art. VI.

17 Article IX directs States Parties to conduct their space activities with due regard to the corresponding interests of all others, to avoid harmful contamination of the Moon and other celestial bodies and adverse changes to Earth's environment, and a duty to consult if there is some indication of harmful interference with activities of other parties. Outer Space Treaty, *supra* note 12, at art. IX.

18 For a wonderful analysis of the obligations found in Article IX, see Michael C. Mineiro, *FY-1C and USA-193 ASAT Intercepts: An Assessment of Legal Obligations under Article IX of the Outer Space Treaty* 34 J. Space L. 321, 332-40 (2008) [hereinafter Mineiro IV].

19 Principles Relevant to the Use of Nuclear Power Sources in Outer Space, G. A. Res. 47/68, U. N. DOC. A/RES/47/68 (Dec. 14, 1992).

launching states to make public the results of the safety assessment prior to launch as per Article XI of the OST. Safety assessment and risk analysis continue to play the most crucial role in all aspects of safe space activities.[20] The safety assessment is to cover all "relevant phases of the mission" including the launch.[21]

It has been inferred that the space treaties create a legal obligation for States to adopt and implement national space legislation, including safety standards and procedures.[22] As with other international treaties, these treaties are subject to various national treaty application systems.[23] Safety is an intrinsic component of most authorizing processes.[24]

III. SAFETY AS A POLICY DRIVER

What role does safety play in national space laws? Examination of the domestic space laws of nineteen different jurisdictions for common elements and policy drivers reveals the significance of safety as both an element of domestic space law and as a policy driver underpinning those laws.[25] Analysis showed that safety was the element most prevalently found in

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20 *Id.* principle 4(1).

21 *Id.*

22 Jakhu & Nyampong, *supra* note 15, at 5.

23 John H. Jackson, *Status of Treaties in Domestic Legal Systems: A Policy Analysis*, 86 AM. J. INT'L L. 310 (1992). Jackson offers an incisive analysis of the pros and cons of self-executing or direct application treaties, concluding that there are sound policy reasons to avoid direct application treaties, without more, where there are democratic institutions in place to avoid direct application in tandem with higher status for treaty norms than for later in time statutory law. *Id.* at 313. Countries permitting self-executing treaties allow the treaty to take a statute-like role in the domestic legal system without an act of transformation. *Id.* at 310. "Self-executing treaties are binding domestic law upon ratification whereas non-self-executing treaties require implementing legislation to become effective." Benjamin Perlman, *Grounding U.S. Commercial Space Regulation in the Constitution*, 100 GEO. L.J. 929, 952 (Mar. 2012). These States are considered monist, primarily because there is no distinction between the legal system as applied to public bodies and the system that applies to private citizens. Fiona De Londras, *Dualism, Domestic Courts, and the Rule of International Law*, in IUS GENTIUM: THE RULE OF LAW IN COMPARATIVE PERSPECTIVE 221, (Mortimer Sellers and Teadusz Tomaszewski, eds., Apr. 16, 2009) (on file with University College Dublin); John Laws, *Monism and Dualism*, LA REVUE ADMINISTRATIVE 18-22, 18 (Presses Universitaires de France: 53e Annėe, No. 2, 2000). Monist States allow direct application of treaties. States can be dualist, requiring an act of transformation for a treaty to become effective. This is usually a government action by the State and is done in terms of incorporating the treaty norm into domestic law, perhaps via a statute that utilizes some or all of the treaty language. Jackson, *supra* note 23 at 315. The implementing statute may use different language and clarify or elaborate upon that found in the treaty; the domestic law is the transformatory act.

24 Other than the listed jurisdictions that dealt with government-only activities, all others in the table included safety as a driver of regulation.

25 Diane Howard, The Emergence of an Effective National and International Spaceport Regime of Law (Nov. 2014) (unpublished doctoral dissertation, McGill University) (on file with McGill Library, McGill University). The countries included in the study were Australia, Austria, Belgium, Brazil, Canada, China, France, Indonesia, Japan, Kazakhstan, the Netherlands, Nigeria, Norway, Russia, South Korea, Sweden, Ukraine, United Kingdom, and the United States.

domestic space law (seventy-one percent of the jurisdictions included).[26] More importantly, the value on safety is of vital importance in most systems; safety was included as a value in seventy-five percent of the space laws and policies examined, second only to the value placed upon international obligations and cooperation.[27] However, safety can be assessed using different methodology and standards in different jurisdictions, an issue to be explored *infra*.

IV. SAFETY IN U.S. DOMESTIC SPACE LAW

The safety component of a U.S. license or permit fulfills the international obligations found in Articles VI, VII, VIII, and IX of the Outer Space Treaty.[28] Safety assessments are necessary to obtain either a spaceport, launch, or launch operator license, or an experimental permit.[29] The U.S. Congress, through the Commercial Space Launch Act of 1984 (CSLA), directs the Office of Commercial Space Transportation (AST) to regulate private sector launches, reentries, and related services (this includes spaceport operations) "only to the extent necessary . . . to ensure compliance with the 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."[30]

Safety assessment is part of the U.S. authorizing process.[31] The requirements to receive a license include meeting the AST's parameters of acceptable or tolerable risk.[32] Paul Wilde, Flight Safety Analysis Team Lead at the Federal Aviation Administration (FAA), correctly asserts that serious injury and/or death are not acceptable outcomes and that no U.S. agency would deem them routine or permissible.[33] Rather, since it is virtually impossible to completely eliminate all risk, he says that the term "tolerable

26 *Id.* at 54.

27 *Id.* at 82.

28 14 C.F.R. §§ 420 et seq.; *see also* J. Randall Repcheck, *Safety and Promotion in the Federal Aviation Administration—Enabling Safe and Successful Commercial Space Transportation*, *in* PROCEEDINGS FOURTH IAASS CONFERENCE (May 2010) [hereinafter Repcheck I].

29 51 U.S.C. § 50901(a)(7) (2012).

30 *Id.*

31 J. Randall Repcheck, *FAA's Implementation of the Commercial Space Launch Amendments Act of 2004—the Experimental Permit*, in PROCEEDINGS OF THE FIRST IAASS CONFERENCE, SPACE SAFETY, A NEW BEGINNING (Dec. 2005) [hereinafter, Repcheck II]. Although the paper describes a different aspect of the CSLAA of 2004, the experimental permit, than that with which we are here concerned, the FAA's role in quantifying risk levels is the same.

32 *Id.* The paper describes the experimental permit rather than license but the FAA's role in quantifying risk levels is the same.

33 Paul Wildeet al., *Public Safety Standards for the Launch and Entry of Spacecraft*, *in* PROCEEDINGS OF THE FIRST IAASS CONFERENCE, SPACE SAFETY, A NEW BEGINNING (ESA SP-599, Dec. 2005) [hereinafter Wilde I].

risk" is a more correct description of the risks that would pass muster in an oversight of launch safety.[34]

FAA AST oversight is imposed in the form of quantitative risk analyses regarding Expected Casualty rates to third parties.[35] These quantitative standards only apply to the safety of the uninvolved public. As of this writing, the FAA mandates no acceptable levels of risk for spaceflight participants or passengers and no qualitative requirements for the crew.

Severity / **Likelihood**	Catastrophic I	Critical II	Marginal III	Negligible IV
Frequent (A)	1	3	7	13
Probable (B)	2	5	9	16
Occasional (C)	4	6	11	18
Remote (D)	8	10	14	19
Extremely Remote (E)	12	15	17	20

Table 1: FAA AST AC 437.55-1 Risk Matrix

The FAA makes safety approval determinations related to commercial spaceflight based upon performance-based criteria, which it applies in hierarchical order, as seen in Table 1.[36] It uses these criteria to assess the effect on the health and safety of the uninvolved public. In order, they are: (1) FAA or other appropriate Federal regulations; (2) government-developed or adopted standards; (3) industry consensus performance-based criteria or standard; and (4) applicant-developed criteria.[37] The last category allows manufacturers to define their own performance standards, and could carry some potential risk or conflict of interest.[38] In August, 2014, the FAA published its *Recommended Practices for Human Spaceflight Occupant Safety*, which does not yet rise to the level of adopted standards (the second criterion), but does invite industry to develop consensus criteria (the third) based upon a sharing of applicant-developed criteria (the fourth).[39]

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34 *Id.*

35 Andy Quinn, *Acceptable Levels of Safety for the Commercial Space Flight Industry,* IAC-12-D6.1.2, (Oct. 2012) (presented at the 63rd International Astronautical Congress in Naples, Italy), at 3 [hereinafter Quinn I].

36 14 C.F.R. § 420.19 (2012).

37 *Id.*

38 Mark Flores, *Blast Off?—Strict Liability's Potential Role in the Development of the Commercial Space Market*, 17 RICH. J.L. & TECH. 2, 30 (2010).

39 FEDERAL AVIATION ADMINISTRATION, RECOMMENDED PRACTICES FOR HUMAN SPACEFLIGHT OCCUPANT SAFETY Version 1.0 (Aug. 27, 2014), at 1.

Currently, the FAA uses a probability of risk of 10^{-6} for Expected Casualty for third parties on the ground.[40] The U.S. focuses upon the protection of the uninvolved public's persons and property, not the safety of those on board.[41] This limit represents that which has been statistically determined to ensure as high a level of public safety as practicable. However, some space safety experts in other jurisdictions consider this metric significantly lower than that deemed appropriate, preferring instead to use a factor of 10^{-4} without limitation to third parties.[42]

The limit is also applied differently for Reusable Launch Vehicles (RLVs) and Expendable Launch Vehicles (ELVS). A single limit of 30 E^{-6} E_c (expected casualty) applies to the launch/reentry of an RLV or RV (reentry vehicle) while with an ELV, separate E_c limits of 30 E^{-6} pertain to inert and explosive debris, toxic materials, and distant focusing of blast overpressure risks.[43]

The quality risk assessment (QRA) is integral to achieving the AST's overarching policy goal of public safety, and is used to identify and characterize risks using the risk-informed model used by the Nuclear Regulatory Commission (NRC) in making its regulatory decisions.[44] The risks and tolerable limits are identified to achieve specific goals. Wilde suggests that these goals should be: (1) ensuring public safety and financial responsibility; (2) understanding risk drivers and identifying prudent risk reduction measures; (3) understanding sources of uncertainty and means to reduce same; (4) helping to "fully inform" the decision-maker, ostensibly the AST, using the best available data and methods; and (5) providing transparency to facilitate commercial space transportation in an effort to create some objective certainty.[45]

The above-listed goals accord with the dual mandate given to the FAA AST, first in the Commercial Space Launch Act and continued in all of its

40 App'x C to Part 420—Risk Analysis, 14 C.F.R. § 420 (2006).

41 Quinn I, *supra* note 35, at 1.

42 *Id.*

43 Wilde I, *supra* note 33, at 6.

44 *Id.* at 2. *Cf. The NRC Risk Assessment Paradigm*, EPA.GOV, *available at* http://www.epa.gov/ttn/atw/toxsource/paradigm.html (last visited May 8, 2012). The risk to all members of the public, excluding those on waterborne vessels and aircraft, cannot exceed 3 $x10^{-6}$ casualties for each of named hazard while the risk to an individual member cannot exceed 1 x 10^{-6}. 14 C.F.R. § 417.107(b)(1) (2012). 14 C.F.R. § 417 sets forth the parameters of a safe launch. Undoubtedly, the exception for occupants of aircraft and vessels is related to the inherent risks associated with those activities.

45 Wilde I, *supra* note 33, at 2-3. Fully informing becomes quite important in the U.S. as a key test under the Federal Tort Claims Act asks whether the decision-making official was fully advised and informed of risks prior to making the subject decision. If not, liability can attach to the USG or its officials. The underlying policy is to prohibit the courts from second-guessing well-informed, authorized officials when determining acceptable operational risk.

progeny.[46] The agency must protect the public's safety (and property) while it also encourages, facilitates and promotes U.S. commercial space transportation.[47] To this end, when enacting the CSLAA, Congress restricted the FAA's ability to promulgate regulations dealing with the health and safety of crew and spaceflight participants. The intention was to provide a "learning period" to newcomers to the space transportation industry without overly burdening the development of innovative technologies with premature regulation.[48] In this way, both prongs of the mandate could be realized.

Originally, this period was to last eight years. The thought was that this would give the industry time to begin operations and to accrue a bank of data from which tailored safety regulations could flow.[49] However, the timeline for operations was longer than expected. Despite the press and public's hunger for commercial operations to commence, many operators are still in experimental permit phase. Hence, Congress extended the period several times. It now expires in October 2015.

The learning period was not without caveats. The CSLAA allowed the FAA to enact regulations prior to the expiration of the period if a flight resulted in a fatality or serious injury or in an incident that likely could. The Orbital crash, while unfortunate, did not result in fatality or serious bodily injury.[50] Nor did the company's investigation reveal conditions that likely would have. The triggering events that could set in motion FAA regulatory action were not present.

But the Virgin Galactic anomaly was another story entirely. The co-pilot died. The other pilot survived but was grievously injured. For the first time, the National Transportation Safety Board (NTSB) took the lead on the investigation,[51] finally exercising jurisdiction as per a Memorandum of Understanding between the FAA, the NTSB, and the U.S. Air Force that had

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46 Commercial Space Launch Act, PUB. LAW 98-575 §3 (Oct. 30, 1984).

47 51 U.S.C. §§ 50903 (b), (c) (2015).

48 While many refer to this part of the CSLAA as a moratorium on safety regulation, that statement is not accurate. Jeff Foust, *Industry, FAA at Odds over Extension of 'Learning Period' for Commercial Spaceflight Safety Regulations*, SPACE POLITICS (Feb. 6, 2014), *available at* http://www.spacepolitics.com/2014/02/06/industry-faa-at-odds-over-extension-of-learning-period-for-commercial-spaceflight-safety-regulations/.

49 Actually, Dr. Nield, Associate Administrator for Commercial Space Transportation, FAA, testified in 2014 that he believed the present to be the time to begin thinking about safety regulations for crew and participants as we now have 50+ years of NASA experience from which to draw information. Statement of Dr. George C. Nield, Associate Administrator for Commercial Space Transportation of the Federal Aviation Administration, before the House Committee on Science, Space, and Technology, Subcommittee on Space, on necessary updates to the Commercial Space Launch Act, Feb. 4, 2014, *available at* http://testimony.ost.dot.gov/test/nield1.pdf.

50 *Orbital-led Team to Investigate Antares Rocket Explosion*, DAILY PRESS (Nov. 5, 2014), http://www.dailypress.com/news/science/dp-nws-orbital-accident-board-20141105-story.html.

51 *NTSB Investigates Virgin Galactic Test Flight Crash*, NTSB.GOV, *available at* http://www.ntsb.gov/investigations/Pages/2014_Virgin_Galactic.aspx (last visited Feb. 14, 2015).

been in place for ten years.[52] The commercial spaceflight industry was rocked. Two tragedies struck within days of one another. The sadness was heartfelt.

Once emotion began to settle, the questions began. How would the FAA respond? What, precisely, did the language of the CSLAA require? How would this impact the industry as a whole?

The actual text of the law limits safety regulations to "restricting or prohibiting design features or operating practices that have resulted in a serious or fatal injury to crew or space flight participants during a licensed or permitted commercial human space flight."[53] This means that any resulting regulation would have to be narrowly tailored to address only those design features and operating practices that were directly implicated in causation of the death and/or injury. The NTSB concluded its investigation in late July 2015, finding probable cause in the company's (Scaled Composites) "failure to consider and protect against the possibility that a single human error could result in a catastrophic hazard" to the vehicle.[54] While the NTSB made eight recommendations to the FAA and two to the commercial spaceflight industry via the Commercial Spaceflight Federation, these deal primarily with human factors and the timing of pre-permit and pre-license consultations.[55] The ramifications for the industry will likely not be broad or onerous.

Interestingly, the two anomalies occurred a mere two months after the AST presented its Recommended Practices for Human Space Flight Occupant Safety. When announcing the documents availability at an advisory committee meeting in September, Dr. Nield explained that this was a starting point in the long and arduous rule-making process and urged industry to enter the discourse by compiling consensus industry standards.[56]

Best practices and standards are used with increasing frequency, particularly in technological sectors, such as aerospace, where more codified law is either not the goal or believed to be premature.[57] The reliance on

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52 MEMORANDUM OF UNDERSTANDING BETWEEN THE NATIONAL TRANSPORTATION SAFETY BOARD, DEPARTMENT OF THE AIR FORCE, AND FEDERAL AVIATION ADMINISTRATION REGARDING SPACE LAUNCH ACCIDENTS, (2004), *available at* https://www.faa.gov/about/office_org/headquarters_offices/ast/media/mou_space_launch_accidents.pdf (last visited Feb. 14, 2015).

53 51 U.S.C. § 50905(2)(C) (2012).

54 *Aerospace Accident Report: In-Flight Breakup During Test Flight, Scaled Composites SpaceShipTwo, N339SS Near Koehn Dry Lake, California, October 31, 2014* (adopted July 28, 2015), *available at* http://www.ntsb.gov/investigations/AccidentReports/Reports/AAR1502.pdf (last visited Sept. 6, 2015), 69-71.

55 *Id.*

56 Prior to agency rule-making action, each proposed requirement must be justified, subject to economic analysis, and put before the public for comment. Exec. Order No. 12866, 58 Fed. Reg. 51735 (Oct. 4, 1993).

57 Daniel P. Murray & Andre Weil, *The FAA's Approach to Quality Assurance in the Flight Safety Analysis of Launch and Reentry Vehicles*, in PROCEEDINGS FOURTH IAASS CONFERENCE, MAKING

standards and best practices in the absence of more positive law has been envisaged as symptomatic of emerging norms in either nascent or fast-changing areas of regulation.[58]

Presently, there are a number of space safety standards-developing initiatives in various stages of work. The Commercial Space Transportation Advisory Group (COMSTAC) is a group advising the FAA "on all matters relating to U.S. commercial space transportation industry activities," with support from the Office of Commercial Space Transportation.[59] COMSTAC itself is comprised of twenty-five representatives from industry and academia, serving for a two-year renewable term. The FAA is authorized to create working groups within COMSTAC. The most recent of these is the Standards Working Group, tasked to identify and analyze existing industry standards and to develop and prioritize a list.[60] Not a year before, the Commercial Spaceflight Federation, a consortium of U.S. member organizations working together for the common goal of democratized commercial human spaceflight, had approved the first U.S. industry standard drafted by its Technical Standards Committee.[61]

Also ongoing are international efforts. For instance, the Science and Technical Subcommittee (STSC) of the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS) established a Working Group on the Long-Term Sustainability of Outer Space Activities (LTSSA) in 2011. The Terms of Reference[62] direct the Working Group to first consider current practices and standards in use by stakeholders in Member States, then compile a report and set of proposed practices and procedures, technical standards and policies, and, finally, to produce a set of voluntary recommended guidelines in hopes that this will reduce the collective risk of space activities.[63] Participation at the Working Group level is limited to State delegations; Expert Groups were open to participation from experts nominated by delegations and invited non-governmental and

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SAFETY MATTER (May 2010).

58 Martha Finnemore & Kathryn Sikkink, *International Norm Dynamics and Political Change*, 52-4 INT'L ORG. 887, 895 (1998).

59 COMSTAC Charter, U.S. DEP'T. TRANS. Order 1110.124H (Nov. 16, 2012).

60 *Office of Commercial Space Transportation, COMSTAC Membership*, FAA.GOV, (Mar. 25, 2015, 4:51:26 PM), *available at* http://www.faa.gov/about/office_org/headquarters_offices/ast/advisory_committee/membership/.

61 ANNUAL REPORT 2013, COMMERCIAL SPACEFLIGHT FEDERATION, at 4. This first standard deals with propellant handling; apparently three more are in process.

62 "Terms of reference" is defined as "the specific limits of responsibility that determine the activities of an investigating body, etc." *Terms of Reference*, COLLINS ONLINE DICTIONARY, http://www.collinsdictionary.com/dictionary/english/terms-of-reference (last visited May 25, 2015).

63 *Terms of Reference and Methods of Work of the Working Group on the Long-term Sustainability of Outer Space Activities of the Scientific and Technical Subcommittee*, A/AC.105/C.1/L.307 (Jan. 24, 2011), *available at* http://www.unoosa.org/pdf/limited/c1/AC105_C1_L307E.pdf.

intergovernmental organizations with permanent observer status.[64]

The International Association for the Advancement of Space Safety (IAASS) is an international network/professional organization, established in 2004 in the Netherlands and "dedicated to furthering international cooperation and scientific advancement in the field of space systems safety."[65] In 2011, the IAASS formed a Technical Committee (TC) to tackle the safety issues relevant to the suborbital industry.[66] The TC's membership included individuals representing regulatory authorities, space agencies, private industry, academia, and IAASS members with expertise. Its goal was to identify best practices and standards for technical issues pertaining to safety and operations.[67] The TC drafted guidelines and presented these with a report in Germany in October 2014.[68]

The International Organization for Standardization (ISO) is a non-governmental organization (NGO) network of national standards institutes in 163 countries with a Central Secretariat in Geneva, Switzerland. There are both state and non-state elements of the ISO. Member institutes, one per country, are often part of the government structure where located, or are mandated by that government; however, other member institutes were set up by networks of industry associations.[69] The requirement is that the ISO member be the organization most representative of standardization in the home country.[70] The ISO develops far more than space standards but is active in that area.

Lastly, another international initiative recognizing both the integral importance of safety in space activities and the role that technical standards play is the International Code of Conduct for Outer Space Activities.[71] This instrument is still in draft form and key points continue to be negotiated.

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64 *Id.* at ¶¶ 18, 24. The author served as a U.S. subject matter expert and private sector advisor for Expert Group D: "Regulatory Issues" as a part of this initiative, and continues to advise the U.S. delegation as the Working Group seeks consensus on the guidelines and their format.

65 *About IAASS*, IAASS.ORG, http://www.iaass.org/About.aspx (last visited Sept. 23, 2010) http://www.iaass.org/About.aspx; Simonetta Di Pippo et al., *Pursuing the Advancement of Space Safety: the Case of ISSF & IAASS*, IAC-12-D5.1.5, at 2, Presented at IAC Naples, Italy (Oct. 2012).

66 Andy Quinn et al., *New Suborbital Safety Technical Committee for the IAASS*, *in* PROCEEDINGS 5TH IAASS CONFERENCE, A SAFER SPACE FOR A SAFER WORLD, (Oct. 17-19, 2011) (ESA SP-699, Jan. 2012). The author serves as the legal lead for the TC.

67 *Ibid.*

68 *Guidelines for the Safe Regulation, Design and Operation of Suborbital Vehicles*, IAASS SUBORBITAL SAFETY TECHNICAL COMMITTEE MANUAL (May 2014), update presented at the 7th IAASS Conference, SPACE SAFETY IS NO ACCIDENT (Oct. 2014, Germany).

69 *About ISO*, ISO.ORG, http://www.iso.org/iso/about.htm (last visited Sept. 23, 2010).

70 *ISO Code of Ethics*, ISO.ORG, http://www.iso.org/iso/codeethics_2004.pdf (last visited Sept. 23, 2010).

71 DRAFT INTERNATIONAL CODE OF CONDUCT FOR OUTER SPACE ACTIVITIES (Mar. 31, 2014), *available at* http://www.eeas.europa.eu/non-proliferation-and-disarmament/pdf/space_code_conduct_draft_vers_31-march-2014_en.pdf.

Originally proposed by the European Union and meeting with some procedural resistance at U.N. COPUOS in 2012, the latest draft was approved in March 2014.[72] Ninety-five Member States have participated in the consultative process to date.[73] The Code of Conduct is a soft-law instrument.

While these organizations all represent sincere efforts to address issues pertinent to space safety with pragmatic methodology, little has been accomplished to coordinate efforts.

V. DISPARATE METRICS AND POSSIBLE CONSEQUENCES

Safety is a shared driver of regulation, both as a social value underlying policy and a goal. The goal of safety may not be universal but it is widely acknowledged in national legislation and implicit in space treaties. However, disparate approaches in assessment indicate differences in social values (uninvolved public safety valued over participants) and may challenge interoperability of regulatory systems.

Disparate safety metrics create a hurdle to performing international activities between transportation regimes. Different thresholds for acceptable risk mean that what is considered safe and therefore legal or licensable in one jurisdiction is not in another. This is an issue even now, before commercial transportation is a regularly performed activity between jurisdictions. For instance, when presented with draft guidelines proposed by the International Association for the Advancement of Space Safety in May 2014, COMSTAC members vociferously balked at the use of the 10^{-4} metric, calling it arbitrary and onerous.[74] The U.K. CAA is exploring the possible effects this lack of alignment might have upon its plans for future space transportation.[75] Curaçao is negotiating a proposed spaceport that will fly XCor vehicles on wet lease.[76] XCor is a U.S. company, subject to U.S. licensing requirements. Curaçao is an autonomous country within the

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72 *Code of Conduct for Space Activities*, EUROPEAN UNION, *available at* http://eeas.europa.eu/non-proliferation-and-disarmament/outer-space-activities/index_en.htm (last visited Sept 6, 2015).

73 *Id.* Consultations continue on the international level. At the most recent U.N. COPUOS plenary meeting in June, 2015, the EU External Action office hosted an informal meeting in the margins. Another meeting was held at the U.N. in New York late July, 2015, with the assistance of the U.N. Disarmament office but hosted by the External Action office, *available at* http://www.spacepolicyonline.com/events/code-of-conduct-negotiations-july-2015-new-york (last visited Sept. 6, 2015). The author attended the meeting in June.

74 Jeff Foust, *International Suborbital Safety Proposal Gets Cold Shoulder in U.S.*, SPACE NEWS (May 19, 2014), http://spacenews.com/40615international-suborbital-safety-proposal-gets-cold-shoulder-in-us/.

75 U.K. GOVERNMENT REVIEW OF COMMERCIAL SPACEPLANE CERTIFICATION AND OPERATIONS: TECHNICAL REPORT 59 (July 2014).

76 *Space Experience Curaçao Announces Wet Lease of XCOR's Lynx Suborbital Spacecraft*, XCOR, *available at* http://xcor.com/press/2010/10-10-05_Space_Experience_Curacao_announces_wet_lease_of_lynx.html (last visited Feb. 14, 2015).

Kingdom of the Netherlands, a European country. How this will resolve is still unclear.

The U.S. FAA's Wilde has written extensively on improving methods of assessment.[77] He recommends four safety goals to guide decision-making regarding acceptable, or tolerable, risk and recommends quantitative safety objectives, mostly in the context of risk limits for launch and reentry activities. The first of these goals sets the chances for an individual member of the general public, uninvolved with the launch activity, at less than one percent of the average annual individual risk of becoming a casualty due to any other type of transportation accident for the uninvolved general public in the U.S.[78] The second goal limits exposure of the uninvolved public to casualty risks greater than risks associated with other comparable involuntary activities, which are defined as manmade activities that are: (1) subject to government regulation or control by government agency, (2) of vital interest to the U.S. as launching state, and (3) involuntarily expose the public to risk of serious injury, if not more.[79]

The third goal contemplates the risk for those individuals that voluntarily involve themselves with a risky activity but who are uninvolved with the commercial space activity *per se* (as in an aircraft or ship passenger) and states that this risk must be proportional to the background risk associated with that voluntary activity.[80] Lastly, the chances of an accident resulting in five or more casualties must be thoroughly mitigated.[81]

From these objectives, Wilde posits policy questions regarding the difference in treatment for RLVs, asking whether there should be separate risk limits for each phase of flight, launch and reentry, instead of treating the

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77 *See* Wilde I, *supra* note 33; Paul D. Wilde, *Public Risk Criteria and Rationale for Commercial Launch and Reentry*, *in* PROCEEDINGS 5TH IAASS CONFERENCE, A SAFER SPACE FOR A SAFER WORLD (Oct. 2011); Paul Wilde & Jim Duffy, *How Many Significant Figures are Useful for Public Risk Estimates?*, in PROCEEDINGS 6TH IAASS CONFERENCE, SAFETY IS NOT AN OPTION (21-23 May, 2013) (ESA SP-715, Sept. 2013); Paul Wilde, et. al., *Probability of Failure Analysis Standards and Guidelines for Expendable Launch Vehicles*, *in* PROCEEDINGS 6TH IAASS CONFERENCE, SAFETY IS NOT AN OPTION (21-23 May 2013) (ESA SP-715, Sept. 2013).

78 Wilde I, *supra* note 33; *see also* Joram Verstraeten & Alfred Roelen, *Safety Risk Management for the Emerging Commercial Suborbital Space Industry*, *in* PROCEEDINGS 6TH IAASS CONFERENCE, SAFETY IS NOT AN OPTION (21-23 May 2013) (ESA SP-715, Sept. 2013); Michael Brett, *Risk Hazard Analysis for Commercial Spaceflight Activities Using Range Safety Template Toolkit*, IAC-11-D6.1.2, *in* 62ND INTERNATIONAL ASTRONAUTICAL CONGRESS (Oct. 2011).

79 This definition of comparable involuntary activities is derived from the *Common Risk Criteria Standards for National Test Ranges*, Standard 321-10 at 2-2, put out by the Range Commanders Council (Dec. 2010).

80 Wilde I, *supra* note 33, at 7. *Cf.* Advisory Circular 431.35-1 US DOT FAA, *Expected Casualty Calculations for Commercial Space Launch and Reentry Missions* (Aug. 30, 2000), *available at* http://www.faa.gov/about/office_org/headquarters_offices/ast/licenses_permits/media/Ac4311fn.pdf (last visited May 9, 2012).

81 Wilde I, *supra* note 33, at 7.

entire event with one collective limit, and whether separate risk limits should be set for each source of hazard or the total risk of all hazards combined. Significantly, he asks whether the collective risk limit should include those people in the vehicle or only those on the ground. This is the place where there is divergence between the method proposed by European experts (and the current incarnation of the IAASS Suborbital Guidelines), who would include them, and the now operative U.S. expected casualty calculations, which do not. If the latter, then a separate method would be necessary to calculate and control the risks to people in the vehicle.

The risk assessments now utilized by the FAA are not completely incompatible with the methodology suggested by the IAASS and the European experts. Both could be used simultaneously. One is simply dealing with first and second parties, while the other deals with third parties. Further divergence occurs as to which metrics are considered acceptable. Despite these variables, the risk assessments are stated in the same terms (numerical), apples to apples, and do not represent an insurmountable hurdle.

VI. Emerging and Ongoing Issues in Space Safety

The different initiatives described herein concern themselves with various aspects of space safety, ranging from the handling of propellants to standardized formats for the sharing of information pertaining to space weather events. A number of key issues have emerged and continue to dominate space safety discourse at all levels. These issues include space situational awareness from the standpoint of data sharing to avoid collision, debris mitigation and possibly remediation, coordination of space traffic through national air spaces and ongoing space traffic management once beyond air space. Volumes have been written about some of these issues, debris mitigation chief among them. Space traffic coordination and management is gaining momentum as commercial space transportation operations move from the permit phase to licensed operations in the U.S., and, as more jurisdictions around the globe contemplate commercial operations and spaceports, interoperability gains in priority. Space safety is the heart of all of these.

VII. Recommendations and Conclusion

Sometimes great ideas are lost in translation. One party can view an action as very obviously for the greater good and another will see it quite differently. While this diversity of viewpoint and independent opinion can be the antidote to groupthink,[82] it can also frustrate efforts toward coalition.

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82 Sharon Allen, *The Death of Groupthink*, BLOOMBERG BUSINESS (Feb. 5, 2008), *available at* http://www.bloomberg.com/bw/stories/2008-02-05/the-death-of-groupthinkbusinessweek-business-

This appears to be the case regarding the impasse between U.S. operators and their European counterparts regarding safety standards. However, impasse does not necessarily equate with failure; it can simply mean delay.

All space stakeholders, whether they function in industry, academia, in any governmental capacity, or as regulators, prioritize safety in space activities. It is a shared value. While the details remain to be resolved, an acknowledgement of agreement on the priority of these issues is a necessary first step. The IAASS effort to create guidelines from applicant-developed criteria was simply an early initiative to begin the process of creating industry consensus standards. The U.S. operators, while invited to participate, chose not to. Perhaps this was a misunderstanding. Perhaps it was a timing issue. The fact remains that all the current initiatives described in the immediate article are voluntary, non-binding, efforts to identify existing protocols that can make space activities safer for human life. Consensus takes time. But, the ultimate pay-off is the satisfaction that all participants in building that consensus have in knowing that they contributed to a greater good.

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