HOW CATASTROPHIC INNOVATION FAILURE AFFECTS ORGANIZATIONAL AND INDUSTRY LEGITIMACY: THE 2014 VIRGIN GALACTIC TEST FLIGHT CRASH

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Abstract

We examine how catastrophic innovation failure affects organizational and industry legitimacy in nascent sectors by analyzing the interactions between Virgin Galactic and stakeholders in the space community in the aftermath of the firm's 2014 test flight crash. Our findings show that catastrophic innovation failure creates a legitimacy jolt to the firm and the nascent industry. This provides an occasion for the firm and its stakeholders to jointly reassess organizational and industry legitimacy, based on their interpretations of the failure. We trace the emergence of three competing interpretations. Each interpretation maintains the industry's legitimacy via differing interpretations of the firm's or its operating segment's legitimacy. Some detracting stakeholders blame the firm for the failure, reject the firm's legitimacy, and redraw industry boundaries to isolate the firm. Other detracting stakeholders blame the firm and its industry segment for the failure, reject the legitimacy of both, and redraw industry boundaries so as to isolate them both. Conversely, the firm and supporting stakeholders jointly argue for the legitimacy of the firm and of the innovative endeavor writ large, embed the firm within the nascent industry, and transfer ownership of the failure to the community. The firm also re-narrates its organizational identity to draw links to the industry's identity. Our findings show that catastrophic innovation failure affects the evolution of nascent industries and impacts how firms manage optimal distinctiveness: detracting stakeholders push for further distinctiveness of the firm, while supporters seek to reduce it.

Keywords: organizational innovation, innovation failure, catastrophic failure, stakeholder management, case method

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Introduction

Human progress relies on radical innovation for the development of new-to-the world products and services (Tripsas, 2009; Tushman & Anderson, 1986). Radical innovation has a significant impact on technical and economic outcomes: as it expands and alters our technological frontier, it upends existing industries while giving rise to new ones (Anderson & Tushman, 1990; Christensen & Bower, 1996). In some cases, radical innovation produces deep psychological effects by capturing public imagination and providing a glimpse of a future humanity never believed possible (Borup et al., 2006; Gartner, 2007). Prior radical innovations such as the airplane or the vaccine were introduced amidst both acclaim and skepticism (Warden III, 2011; Wolfe & Sharp, 2002); yet, each gave rise to thriving new sectors in their respective industries. Presently, advances in fields such as artificial intelligence, propulsion, and nanotechnology are likely to yield similar frontier-bending innovations such as self-driving vehicles, commercial space travel, and personalized medicine. Supported by some and criticized by others, these radical innovations—like those of the past—fuel nascent industries and sectors as they engage our imagination and redefine our aspirations for human progress and scientific and technological change.

In nascent industries that arise from radical innovations, firms frequently approach commercial development while building both industry and organizational legitimacy (Navis & Glynn, 2010). Establishing industry legitimacy is necessary because nascent industries revolve around products, markets, or models of consumption that are unfamiliar to investors, current and prospective clients, regulatory agencies, and other stakeholders. Nascent industries are also rife with ambiguity (Santos & Eisenhardt, 2009; Zuzul, 2019): they feature fuzzy market structures (Eisenhardt, 1989b; Rindova & Fombrun, 2001), uncertain market and product categories (Lounsbury & Glynn, 2001), and unclear product standards (Hargadon & Douglas, 2001). To counterbalance this ambiguity, firms' legitimacy-building efforts seek to favor the industry by portraying the innovation in the public eye as socially desirable as well as technically and economically feasible (Garud et al., 2014; Navis & Glynn, 2010). In parallel, establishing organizational legitimacy is essential, because it is often difficult for stakeholders to understand who these firms are and what they do (Lounsbury & Glynn, 2001). Innovating firms carry out

untested and incompletely understood activities (Tushman & Anderson, 1986) with unproven logics to guide their actions (Kaplan and Tripsas 2008). Firms build their own legitimacy by depicting themselves as trustworthy and knowledgeable industry players (Suchman, 1995).

Yet, given the uncertain nature of the endeavor, firms engaged in developing radical innovations often face the prospect of experiencing catastrophic innovation failure. Catastrophic innovation failure occurs in the pursuit of radical innovations during non-routine activities and is "large-scale, unusually costly, unusually public, unusually unexpected, or some combination" (Vaughan, 1990, p. 292).[4] It constitutes a "radical event" (Tripsas, 2009) that likely creates a "legitimacy jolt" (Garud et al., 2014)—a situation in which failure leads the firm and its stakeholders to redefine broad expectations. Considering the paucity of research on the nature and effects of catastrophic innovation failure, what exactly this legitimacy jolt consists of and what implications it has over the firm and the budding industry have not been explored in depth. Therefore, we ask, *how does catastrophic innovation failure affect organizational and industry legitimacy in nascent sectors*? Our paper aims to produce process theory that sheds light on how firms and stakeholders jointly reassess organizational and industry legitimacy following catastrophic innovation failure.

We answer our research question by examining a single case in depth (Siggelkow, 2007). Specifically, we study the 2014 crash of Virgin Galactic's SpaceShipTwo vehicle during a test flight, an event that caused the loss of valuable technology and killed one pilot while injuring another. Virgin Galactic (VG) is a player in the nascent commercial space industry, which encompasses for-profit firms that develop and send reusable vehicles into space. In particular, VG was engaged in the development of reusable vehicles to send individual customers near the boundary of Earth's atmosphere and outer space for recreational purposes—an activity broadly referred to as "space tourism." VG's effort was a radical innovation that marked a significant departure from the single-use propulsion technologies produced in

[4] Vaughan (1999)'s criteria were used to explain what events constituted disasters (these criteria were drawn, in turn, from Turner and Pidgeon, 1997). Hence, our definition of catastrophic innovation failure effectively focuses on innovation failures that are disastrous in nature.

the past by government agencies such as NASA to carry career astronauts to space. To build our case, we assembled an archival dataset from diverse sources where the firm and its stakeholders discussed the crash, including firm and client tweets, blog posts written by company executives, corporate website and video content, press releases, media articles, and government agency briefs.

We find that, in the aftermath of catastrophic innovation failure, the firm and its stakeholders form interpretations of *what happened* and *why it happened*, and that these interpretations inform their assessment of the failure's *implications over organizational and industry legitimacy*. Three interpretations of the failure emerge. Detracting stakeholders fall into two camps. Some detracting stakeholders view the failure as a direct result of what they consider faulty firm practices and technology. They reject the firm's legitimacy and rhetorically cast the firm out of the industry on technological grounds—a move which, from their perspective, sustains the legitimacy of the industry at large. Other detracting stakeholders view the failure as a direct result of the firm's endeavor; they see the entire product category in which the firm operates as socially unnecessary or undesirable. They reject the legitimacy of both the firm and its segment based on a perceived lack of social value, and rhetorically cast both out of the industry—a move which, from their perspective, sustains the legitimacy of the rest of the industry. Third, supporting stakeholders and the firm itself view the failure as a direct result of difficulties inherent to the industry's innovative activity. They portray the firm's activities as both technically sound and socially desirable, simultaneously upholding the worthiness of the firm and of the industry. They rhetorically embed the firm within its industry and beyond, drawing links between the firm, its industry, and high-legitimacy adjacent industries. Moreover, in order to assert its legitimacy and defend its position as a rightful player in the industry, the firm makes use of two tactics to neutralize detracting stakeholders' arguments: it leverages findings by neutral stakeholders who provide unequivocal information about the causes of the catastrophic innovation failure, and it changes its organizational identity to describe itself in similar terms as it describes the industry.

Taken together, these findings make three contributions. First, they show that catastrophic innovation failure creates occasions for firms and stakeholders to jointly reassess organizational and

industry legitimacy. The firm and its stakeholders redefine expectations surrounding what defines the industry as well as how participants operate and what they stand for. Second, with each interpretation, stakeholders and the firm rhetorically manipulate industry boundaries in ways to preserve the legitimacy of the industry. Detracting stakeholders shrink industry boundaries by carving out either the firm or both the firm and its specific industry segment, arguing one or both are illegitimate. In contrast, the firm and supporting stakeholders enhance the boundaries of the industry to encompass players in their own market and in high-legitimacy adjacent markets. Lastly, our findings shed light on higher-order dynamics that affect the evolution of nascent industries. Navis and Glynn (2010) argued that, when nascent industries first arise, firms cooperate to establish and legitimize the industry in the eyes of stakeholders. They create an industry identity that reflects attributes shared by all industry members (Mervis & Rosch, 1981; Rosa et al., 1999) and helps set stakeholders' expectations (Hannan et al., 2007; Hsu & Hannan, 2005). Firms then narrate their own organizational identities in ways that suggest strong adherence to that common concept (Glynn, 2008; Glynn & Abzug, 2002). However, as the industry evolves, firms differentiate by establishing 'optimally distinctive' identities (Brewer, 1991; Navis & Glynn, 2010, 2011), i.e., identities that are distinctive enough for stakeholders to individuate each firm through unique attributes, but not so distinctive as to make these firms unrecognizable as members of the industry. Our findings suggest that, in the wake of catastrophic innovation failure, detracting stakeholders' actions constitute efforts to vie for further differentiation. Conversely, actions of the firm and supporting stakeholders constitute efforts to revert to the original state by reducing the degree of distinctiveness of the firm's identity.

Organizational and Industry Legitimacy in Nascent Industries Amidst Catastrophic Innovation Failure

The development of radical innovations is an endeavor fraught with uncertainty and ambiguity. Innovating firms face challenges associated with the unproven nature of their product or service (Nerkar & Shane, 2007; Zahra & Nielsen, 2002), the incomplete nature of their working knowledge (Tushman & Anderson, 1986), and the unclear nature of the path to developing the necessary skills, practices, methods, and technologies to render their innovation goals attainable (Rousseau, 1997; Sitkin et al., 2011). When

radical innovation leads to the emergence of a new industry, uncertainty and ambiguity are compounded. Nascent industries are characterized by blurry boundaries (Santos & Eisenhardt, 2009), poorly defined structures (Eisenhardt, 1989b; Rindova & Fombrun, 2001), uncertain market categories (Lounsbury & Glynn, 2001), a lack of dominant designs (Anderson & Tushman, 1990), and unclear product standards (Hargadon & Douglas, 2001). As a result, stakeholders dealing with innovating firms in nascent industries have imperfect guidelines for assessing performance and "find it difficult to consistently weigh risk/reward trade-offs" (Aldrich & Fiol, 1994, p. 651).

To overcome these challenges and elicit stakeholder support, innovating firms make efforts to build legitimacy for themselves and for their budding industry (Navis & Glynn, 2010). These efforts are usually carried out in parallel, with organizational and industry legitimacy mutually strengthening one another. Efforts to build organizational legitimacy often involve portraying the firm as knowledgeable, i.e., as employing sound practices and embracing socially accepted techniques and procedures (David et al., 2013; Scott, 1977; Zimmerman & Zeitz, 2002). In the absence of clear outcome measures, sound practices "may serve to demonstrate that the organization is making a good-faith effort" to innovate in an effective way (Suchman, 1995, p. 580). Firms may also build both organizational and industry legitimacy by making key aspects of the innovation intelligible and attractive to stakeholders. The goal is to establish the innovation within a socially desirable product and market category whose existence stakeholders will come to take for granted over time (Rosa et al., 1999; Zhao et al., 2013; Zucker, 1986). To do so, firms must present credible accounts explaining what they are doing and why (Suchman, 1995). Firms lacking these credible accounts "are more vulnerable to claims that they are negligent, irrational, or unnecessary" (Meyer and Rowan, 1977, p. 50). Innovating firms frequently establish such accounts by adopting coherent narratives (Lounsbury & Glynn, 2001; Wry et al., 2011) that portray their innovative product, their organizational identity, and the emergent definition of the industry in an "optimally distinctive" way (Brewer, 1991). Optimal distinctiveness involves balancing familiarity and novelty, i.e., drawing links to well-understood preexisting categories as well as to novel ideas that elicit excitement in stakeholders' eyes (Navis & Glynn, 2010; Wry et al., 2011; Zhao et al., 2017, 2018). Hence, to build legitimacy, firms

in nascent industries adopt identities that place them within the wider industry context to strengthen the position of the collective (Mathias et al., 2018; Weber et al., 2008) while simultaneously featuring their uniqueness (Navis & Glynn, 2011). The more effective these narratives are in enabling innovating firms to build organizational and industry legitimacy, the more stakeholders will perceive them as worthy of receiving resources they own or control (Ashforth & Gibbs, 1990; Dowling & Pfeffer, 1975).

In the midst of these legitimacy-building efforts, firms involved in the development of radical innovations are highly vulnerable to innovation failure. Prior research in innovation has tended to focus on small-scale innovation failure. These kinds of failures tend to occur in the prototyping stage of the innovation process. Prototypes often progress from lower definition to higher definition and from lower cost to higher cost (Kelley & Littman, 2001). While the cause of small-scale innovation failure is initially unknown, it is usually not costly to ascertain: the small scale of the failure and the simplified nature of the prototype makes isolating the faulty components a relatively straightforward task, and firms are usually able to introduce improvements that enable them to test a new version relatively quickly. In fact, iterating is often the reason to prototype. The small scale of the failure also means that the event may not be visible to stakeholders and may consequently not threaten the firm's or the industry's legitimacy in a meaningful way. As a result, it may not even require the firm to engage with stakeholders in any capacity. In cases when small-scale innovation failure is publicly visible, it can be expected to attract little negative attention and pose mild threats (if any) to legitimacy. Oftentimes, stakeholders understand failure of this kind as an expected, valuable, and critical aspect of the innovation process (Cannon & Edmondson, 2005; Kelley & Littman, 2001; Sitkin, 1992; Thomke, 2003) that allows firms to search for and identify faulty assumptions, discover unexplored lines of inquiry, test new hypotheses and iterate toward a successful innovative outcome (Fleming, 2001; McGrath, 2011). Indeed, few studies exist on how firms engage with stakeholders when small-scale innovation failures do occur. Studies have mainly focused on firms' internal dealings following these failures, particularly on the lessons that can be learned from the failure itself (Khanna et al., 2015) and the opportunities that may follow for learning (Cannon & Edmondson, 2005) and adaptation (Sitkin, 1992).

In contrast, the innovation literature has devoted little attention to large-scale or catastrophic failures. As noted earlier, catastrophic innovation failures occur during the pursuit of non-routine activities and are characterized by their outsized scale and costs, high visibility, and sudden or unexpected nature. While the effects of catastrophic innovation failure have not yet been examined in depth, these kinds of failures can be expected to create legitimacy jolts (Garud et al., 2014) for both the firm and the industry as a whole. The jolt may be particularly acute in nascent industries because, in these contexts, the dual process of building organizational and industry legitimacy is still in progress.

The extent to which this legitimacy jolt affects organizational and industry legitimacy in nascent industries may be tied to its root causes. As a firm pursues radical innovation, some facets of the innovation process become well known while others remain poorly understood or even unknown. Hence, catastrophic innovation failure may originate in the firm's inability to obtain or adequately deploy the resources, capabilities, and management skills necessary to consistently and reliably run the facets of the innovation process it understands (Anheier, 1999; Vaughan, 1999) or in errors that arise from the 'trial-and-error' nature of the facets it has not yet understood (Thomke, 2003). In the aftermath of catastrophic innovation failure, it is not clear whether the failure occurred due to the firm's negligence in a part of the process where sufficient knowledge existed so as to prevent it or due to difficulties inherent to the innovative activity itself. In the absence of immediate unequivocal information, stakeholders tend to rely on highly subjective perceptions (Aldrich & Fiol, 1994). They may question the quality of the firm's processes and practices as being less trustworthy, the accurateness of the firm's preexisting narrative pertaining to its organizational identity, the feasibility and worthiness of the industry as a whole, and the social necessity and desirability of the innovation (Garud et al., 2014; Suchman, 1995). Yet, despite the relevance of these legitimacy threats to both the firm and the industry in the wake of catastrophic innovation failure, little research exists on how firms engage with stakeholders to address them.

The closest insights at hand come from studies of large-scale failures that occur during the course of highly routinized activities, i.e., activities that constitute the backbone of the firm's daily operations. Such catastrophic operational failures are typically associated with "action (or inaction) of organizational

agents that threatens the legitimacy of the organization and has the potential to harm the well-being of one or more of the organization's stakeholders" (Gillespie & Dietz, 2009, p. 128). The root cause of catastrophic operational failure can usually be found in negligence, oversight, error, or purposeful lack of adherence to known standards (Petriglieri, 2015; Turner, 1976, 1978). As a result, catastrophic operational failure "generates widespread, intuitive, and negative perceptions among evaluators" (Bundy & Pfarrer, 2015, p. 350) and poses an obvious threat to the firm's legitimacy—but it does not necessarily affect the legitimacy of the industry. A firm's interactions with external stakeholders in the aftermath of catastrophic operational failure often seek to align both parties' views and expectations (Fiss & Zajac, 2006). Firms usually seek to influence stakeholders' perceptions of both the firm and the event (Elsbach et al., 1998) in order to mitigate their responsibility (Bundy & Pfarrer, 2015) and repair their legitimacy. Firms may deny wrongdoing and offer excuses, present justifications in order to diminish the perceived severity of the failure, apologize and take responsibility (Elsbach, 2003), or signal willingness to learn and improve operations (Baum & Dahlin, 2007; Haunschild & Sullivan, 2002; Madsen & Desai, 2010).

While the occurrence of both catastrophic innovation and operational failures is large in scale, costly, highly visible, and unexpected, the differences between these types of failure suggest that catastrophic innovation failure may yield different firm-stakeholder interactions than those described above. In particular, the highly uncertain nature of the activities that elicit catastrophic innovation failure (vs. the routine nature of the activities at the core of catastrophic operational failure) and the potential of catastrophic innovation failure to affect both organizational and industry legitimacy (rather than organizational legitimacy alone) point to a more nuanced scenario where firms must engage with stakeholders to do more than remediate an adverse situation. Our study constitutes an early step in exploring these critical firm-stakeholder dynamics.

Methods

Research design and setting

We used inductive qualitative research methods focusing on a single in-depth case: the crash of VG's SpaceShipTwo vehicle during a test flight on October 31, 2014. These methods are well suited to

answering our research question for several reasons. Inductive methods facilitate exploration by allowing the researcher to dive deeply into the phenomenon. They are especially useful in areas where categories and processes are not yet well understood and where the researcher aims to build and elaborate, rather than test, theory (Edmondson & McManus, 2007). A case-based approach enables the researcher to be embedded in rich empirical data and to understand the phenomenon from the perspective of its protagonists (Lincoln & Guba, 1985). In particular, single cases often prove to be 'unusually revelatory' (Eisenhardt & Graebner, 2007, p. 27) because the phenomenon of interest tends to be transparently observable, affording enough richness for detailed examination (Eisenhardt, 1989a; Pettigrew, 1990; Pratt, 2009; Siggelkow, 2007). Finally, since catastrophic innovation failure is rare, its occurrence makes it a natural candidate for qualitative inductive inquiry.

Our research setting is the commercial space industry, which includes the set of activities involved in sending vehicles outside the earth's atmosphere. Segments include payload delivery (sending satellites and other deliverables into space), space tourism (transporting individuals to space for recreational purposes), and space mining (obtaining resources from space for terrestrial use). Navis and Glynn (2010) define an industry's identity as the set of attributes around which the industry is built, common to all participants. These attributes include technologies, product categories or core activities, and characteristics of firms' business models. In this vein, we define the commercial space industry's identity in terms of its technology of safe, reusable vehicles, its business activity of space conveyance and exploration, and its for-profit business model. Apart from VG, participants in this industry include SpaceX, Blue Origin, and Planetary Resources, among others. The industry is an ideal research setting because it is in the nascent stage; it contains firms engaged in radical innovation; firms in the industry face high degrees of environmental ambiguity as well as technical uncertainty; product development is risky, complex, and costly in terms of time, knowledge, and financial resources, in exchange for highly uncertain, long-term rewards; given the high stakes involved in the business and the sheer scale of the innovation effort, innovation failure carries inordinate costs as well; and much testing is carried out in the open, making large-scale failure easily observable by stakeholders.

VG is an integral player in the commercial space industry and was, at the time of the crash, the only US firm performing test flights in the space tourism segment. VG is part of Sir Richard Branson's Virgin Group, a conglomerate that operates in industries as diverse as air travel, telecommunications, finance, and energy, among others. VG was founded in 2004, when Branson licensed the technology behind SpaceShipOne, an experimental vehicle for suborbital space travel. Its designer, Burt Rutan (a high-profile aeronautical engineer), won the prestigious Ansari XPRIZE, which offered US $10 million to the first non-government organization to launch a reusable manned spacecraft into space twice within the span of two weeks. Rutan's spacecraft carried two people: a pilot and a co-pilot. VG set out to scale this design by developing a spacecraft that could transport a pilot, a co-pilot, and six passengers while withstanding repeated entry and exit to and from space. This posed a considerable technical challenge, considering the increased size and weight of the spacecraft and the need to adapt the initial technology from what was essentially a working prototype to a commercially viable vehicle. If successful, the firm would allow passengers to experience weightlessness for about 15 minutes and to see the Earth from a vantage point usually reserved for career astronauts. Branson pledged to be a passenger on VG's maiden voyage. Tickets price was initially $200,000 and later increased to $250,000. By 2014, over 700 people had signed up.

In the decade between the company's inception and the catastrophic failure, VG set up operations in various locations, including spaceports in the Californian Mojave Desert and in New Mexico. VG partnered with Rutan's company, Scaled Composites, to build a spacecraft, SpaceShipTwo, and a carrier aircraft from which the spacecraft was to be air launched, WhiteKnightTwo. Over 100 test flights were carried out under different conditions to test the technology's performance.

During a test flight at the Mojave spaceport on October 31, 2014, VG's SpaceShipTwo broke apart in mid-air shortly after being released by WhiteKnightTwo, the launch vehicle, killing co-pilot Michael Alsbury and gravely injuring pilot Peter Siebold. The crash occurred at a crucial moment in VG's relationship with key stakeholders. On the one hand, there was optimism concerning the company's maiden voyage. Earlier that year, several test flights had yielded encouraging results. Branson estimated

that the first commercial flight would happen in the first quarter of 2015; he and the first clients who signed up were already undergoing space training. On the other hand, VG was under some pressure to deliver. The maiden voyage had been announced and postponed at least eight times since the firm's inception. Hence, the crash challenged the credibility of the firm's goals and its ability to fulfill them. It also cast a shadow on the suitability and worthiness of space tourism.

Data collection

We took the 2014 crash as a focal event and collected data before and after its occurrence. We placed special emphasis on the month-long period following the crash from October 31 to November 30, 2014, as it contained the most intense engagement by VG and its stakeholders surrounding the failure.[5] This period includes several key dates. On November 12, 2014, the National Transportation Safety Board (NTSB), the federal authority in charge of investigating the crash, concluded its on-scene portion of the investigation and shed considerable light on the apparent cause of the crash. On November 21, 2014, VG published a new website capturing the firm's shift in its organizational identity.

We assembled a rich archival dataset from publicly available sources, including stakeholder and company tweets, executive blog entries, corporate website content, press releases, media articles, government publications, and multimedia. Our data provide a relatively comprehensive array of evidence of what the firm and its stakeholders said publicly leading up to and in the aftermath of the failure. Because our data contain real-time accounts of the event, they allowed us to minimize the risk of retrospective bias. Our data also reveals the diversity of individual and organizational participants: VG executives, partners, investors, and clients, space organizations, space experts (including former astronauts, commercial test pilots, and engineers), members of the press, and federal authorities. Table 1 presents information on the VG members and stakeholders represented in our data.

[Insert Table 1 about here]

[5] Data collected outside of this month-long window ranged from VG's inception until the NTSB's final report on the crash in July 2015. We used these data for context in understanding both how prior events affected the firm's and stakeholders' dispositions amidst the post-crash legitimacy reassessments as well as the official findings on the cause of the crash.

Social media sources. We performed a preliminary review to assess which social media platforms VG used most frequently to connect with stakeholders and found that Twitter was the platform of choice. We gathered all tweets published during our data collection period on seven accounts: VG's corporate account (@virgingalactic) (73 tweets), founder Sir Richard Branson's account (@richardbranson) (200 tweets), and the accounts of five clients who frequently tweeted about VG (37 tweets). They include Sir Trevor Beattie (@trevorbmbagency), Yanil Silver (@yaniksilver), Vasily Klyukin (@VKlyukin), Namira Salim (@namirasalim), and P.J. King (@pjkng).

Blog posts. Branson kept a blog on VG's parent company website (www.virgin.com) where he discussed company business at length. We gathered the full text of the two VG-related posts he published in our data collection period.

Company website. The content and structure of a firm's website provide evidence of its activities and priorities. Following a catastrophic innovation failure, website content is likely to convey the firm's preferred interpretation of the event, as well as legitimacy-sustaining statements. Using Archive.org's Wayback Machine, a tool which provides historical archives of a website on a regular basis, we gathered content (including text, photographs, videos, and site structure) on VG's website (www.virgingalactic.com) during our data collection period. On days when more than one archival version of the website was available, we collected the last version.

Company press releases. Company press releases are official statements meant to be picked up by media outlets. In the aftermath of a catastrophic innovation failure, press releases can be expected to convey the firm's preferred interpretation of the event, as well as legitimacy-sustaining statements. We gathered the five press releases published by VG during our data collection period.

Traditional media sources. We gathered online news articles and newscast transcripts on VG published during our data collection period. We restricted our data collection to content published by renowned news organizations in countries such as United Kingdom and the United States (e.g., The Washington Post, BBC News), prestigious media agencies (e.g., the Associated Press, Reuters), popular science and space publications (e.g. WIRED, space.com), and renowned news shows and channels (e.g.,

CNN, CBS). Out of the 534 articles and transcripts, 467 were sourced via LexisNexis while the rest were collected manually from sources not included in that database. We prioritized pieces in which VG managers or stakeholders offered direct quotes related to the failure event.

National Transportation Safety Board (NTSB) announcements. On November 1, 2014, the NTSB announced that it would send a team to the crash site to investigate the event. We collected all publicly available data related to their investigation, including four media briefing videos from YouTube, all 35 NTSB tweets (@NTSB), and the final official report and press conference media related to the agency's findings.

Data analysis

Our goal was to understand how VG's 2014 catastrophic test flight crash affected the firm's and the commercial space industry's legitimacy. We aimed to build process theory by identifying patterns of behavior that allowed VG and its stakeholders to engage with one another's interpretations of the event and reassess the legitimacy of the firm and its industry.

We made use of narrative analysis to map three distinct interpretations of the failure (Riessman, 1993). A narrative is "a set of events and the contextual details surrounding their occurrence" (Bartel & Garud, 2009, p. 108). Narratives evidence how actors attend to and interpret everyday experiences and communicate those experiences to others (Riessman, 1993). In the aftermath of a given event, no single individual or data source can be expected to convey all relevant aspects or to have a complete picture (Boje, 2008). Instead, each individual or data source tends to possess relevant fragments of the story that can be aggregated to produce a coherent *composite narrative* (Boje, 2001). Composite narratives therefore "summarize collective constructions of meanings" in the wake of momentous events or processes (Sonenshein, 2010, p. 483). We combined data sources to compose coherent narratives for sets of actors who appeared to share common interpretations of the event.

We first built VG's composite narrative. We immersed ourselves in VG's history and the context in which it operated at the time of the crash, and subsequently built a timeline of key company milestones. We then began our analysis by focusing on VG's Twitter account. We chose to start here because tweets

may be the most immediate, straightforward, candid messages a firm can direct at its stakeholders, and vice versa. We then moved to the company press releases and founder's blog posts, since these were often referenced in tweets via links, and found that they typically contained expanded versions of themes stated in the tweets.[6] We divided the data by day. Using these data sources, the first and third authors engaged in open coding separately, looking for emergent themes (Charmaz, 2006; Corbin & Strauss, 1990). As themes emerged, we generated in-vivo codes and frequently came together to compare and contrast our codes, building a common repository. We later worked together to aggregate these themes into higher-level categories (Corbin & Strauss, 1990). Some categories conveyed VG's interpretation of the event, and yielded codes such as 'opportunity for firm learning' and 'hinting at the cause (difficulty of activity).' Other categories spoke to the firm's views on its own legitimacy, the legitimacy of the space tourism segment, and that of the commercial space industry at large. These yielded codes such as 'asserting the morality of the endeavor,' 'forecasting customer retention,' and 'forecasting the firm's ultimate success.'

We then moved to analyzing stakeholders' interpretations of the failure and their assessment of organizational and industry legitimacy. We did line by line coding of all client tweets, all media articles and videos, and all materials provided by the NTSB, and noticed the emergence of three main narratives. We observed that some stakeholders shared VG's views: they interpreted the failure in similar ways and defended both the legitimacy of the industry and that of the firm with similar arguments. Among these stakeholders were many clients on the flight list, a host of former NASA astronauts, test pilots, and space organizations, and several space experts and analysts. We combined this data with VG's, collapsing insights from both into a single composite narrative. Among stakeholders who appeared to hold opposing views, two narratives emerged. First, some stakeholders (certain space organizations, space experts, experts in adjacent fields like propulsion, and a number of space analysts) focused on technical aspects of the failure and interpreted the event as the consequence of VG's faulty practices, design, and technology.

[6] Immediately following the crash, VG shut down its website and simply displayed press releases on a black background. Website content coincided with press release content for three weeks, at which point a new website was launched. The new website made no mention of the crash (except in archived press releases) but presented content that served to support the firm's arguments regarding organizational and industry legitimacy.

Codes such as ‘hinting at cause (technology)’ and ‘hinting at cause (managerial)’ supported this view. The categories that questioned the firm’s legitimacy yielded codes such as ‘questioning firm survival’, ‘investor reconsideration’ and ‘customer reconsideration.’ A second group of detracting stakeholders focused on the worthiness of VG’s innovation and interpreted the event as a consequence of VG’s goals, which they considered socially wasteful. This was captured by codes such as ‘hinting at cause (product category)’. The categories that questioned the firm and the segment’s legitimacy yielded codes such as ‘questioning morality of activity’ and ‘forecasting continued challenges to industry segment.’ As befitting its role, the NTSB remained impartial and only shared factual information. We treated all NTSB data as either corroborating or disputing aspects of the narratives that emerged above.

At this stage, the entire team came together to interpret unfolding findings. We engaged with literatures on legitimacy, innovation, failure, and nascent industries, moving iteratively between the literature and our data. First, we drew links between extant definitions of legitimacy in the literature and the ways in which the firm and its stakeholders interpreted legitimacy in our data. This helped strengthen the internal coherence of our composite narratives. In particular, we found that Suchman’s (1995) definition of ‘moral-procedural’ legitimacy (p. 580), which hinges on evaluations of the quality of a firm’s techniques and procedures, reflected the views of adverse stakeholders who rejected VG’s legitimacy based on technical concerns and was also present in the arguments of the firm and supporting stakeholders, who presented VG as employing sound practices. His definition of ‘moral-structural’ legitimacy (p. 581), which is tied to the degree to which a firm’s product category is considered socially acceptable, reflected the views of adverse stakeholders who rejected the legitimacy of VG and the space tourism segment by labeling both as wasteful, and was also present in the arguments of the firm and supporting stakeholders, who upheld the worthiness of the activity. Lastly, Suchman’s notion of ‘pragmatic’ legitimacy (p. 578), which hinges on expectations of the resources the firm may need and the value its activities may produce, was present across the board in all composite narratives.

Second, as we reviewed studies of legitimacy in nascent industries, we noted that the dynamics we observed in the aftermath of catastrophic innovation failure represented an understudied instance in

the evolution of nascent industries. We undertook another round of axial coding (Charmaz, 2006) to focus specifically on industry-level implications of catastrophic innovation failure within the three emergent narratives. We noticed that when a legitimacy jolt occurs, all actors aim to preserve the industry's legitimacy, albeit in different ways. We saw direct links between actors' interpretations of the failure, their arguments for/against organizational legitimacy, and their efforts to sustain the industry's legitimacy. In particular, coding revealed (1) assertions of rightful industry membership to either *isolate* VG from the industry or *embed* VG within it; (2) rhetorical manipulation of industry boundaries to either *constrain* or *enhance* them; and (3) arguments to either *increase* or *decrease* the degree of distinctiveness of the firm's organizational identity. Armed with these insights, we induced a process model of reassessing organizational and industry legitimacy in the wake of catastrophic innovation failure.

Findings: Organizational and Industry Legitimacy Following a Catastrophic Innovation Failure

On October 31, 2014, VG readied a test of its carrier aircraft, WhiteKnightTwo, and its commercial passenger spacecraft, SpaceShipTwo, with a powered flight meant to reach the boundary of the Earth's atmosphere with outer space. WhiteKnightTwo took off successfully at 16:28 UTC from the Mojave spaceport. The launch vehicle released SpaceShipTwo at 17:07 UTC. By 17:14 UTC, SpaceShipTwo was in pieces on the ground. The crash killed the co-pilot, severely injured the pilot, and led to the loss of valuable technology for VG. As soon as the catastrophe occurred, VG announced on Twitter: *"#SpaceShipTwo has experienced an in-flight anomaly. Additional info and statement forthcoming*." As the day continued, VG's tweeting remained purely descriptive:

> UPDATE: VG's partner Scaled Composites conducted a powered test flight of #SpaceShipTwo earlier today. (1 of 4)
> During the test, the vehicle suffered a serious anomaly resulting in the loss of SpaceShipTwo. [WhiteKnightTwo] landed safely. (2 of 4)
> Our first concern is the status of the pilots, which is unknown at this time. (3 of 4)
> We will work closely with relevant authorities to determine the cause of this accident and provide updates ASAP. (4 of 4)

Following VG's catastrophic innovation failure, three competing interpretations of the failure began to take shape. Two were put forth by detracting stakeholders and the third was espoused by VG and supporting stakeholders. Although divergent, all three interpretations aimed to sustain the legitimacy of

the nascent industry—albeit defining the industry in different ways. Figure 1 shows our emergent process model while Table 2 presents evidence supporting each of the categories in our model. The firm and its stakeholders formed interpretations of the catastrophic innovation failure by pondering 'what happened' and 'why it happened.' These interpretations informed how they responded to the legitimacy jolt the firm and the industry sustained in the wake of the failure (arrow 1 in Figure 1). On the one hand, the failure challenged the *moral legitimacy* of the firm and the industry on two accounts (arrow 2a): from a *procedural* standpoint, questions arose about the quality of the firm's practices and technology; and, from a *structural* standpoint, there were misgivings about the social value of space tourism (Suchman, 1995). On the other hand, the failure challenged the *pragmatic* legitimacy of the firm and the industry (arrow 2b): questions arose about the attractiveness of VG and of space tourism for both investors and customers post-failure (Suchman, 1995). Facing this legitimacy jolt, the firm and its stakeholders responded by creating arguments to sustain the industry's legitimacy while either rejecting or upholding VG's legitimacy (arrow 3). Some detracting stakeholders classified the event as an 'explosion' and interpreted it as evidence that VG's practices and technology were unsound. They ascribed responsibility for the failure to VG alone. Based on this assessment, they sought to sustain the industry's legitimacy by rhetorically shrinking industry boundaries and casting out VG as an illegitimate player. Other detracting stakeholders classified the event as a tragedy in the pursuit of a 'joyride' and declared space tourism to be a socially unnecessary and undesirable activity. They rhetorically shrunk industry boundaries so as to cast out both VG and the space tourism segment as illegitimate, while supporting other efforts in space exploration. Lastly, VG and supporting stakeholders interpreted the failure as a natural consequence of the uncertainty inherent to the development of radical innovations. They sought to maintain the legitimacy of the industry and of VG by rhetorically embedding VG within the commercial space industry and beyond, enhancing industry boundaries to include both for-profit and non-profit organizations dedicated to space exploration. Finally, VG sought to neutralize the interpretations of detracting stakeholders in two ways. First, in order to dispel the possibility of an explosion, VG leveraged unequivocal information provided by the NTSB (arrow 4a). Second, in order to suggest that its product

was more than a 'joyride', VG changed its organizational identity to bring it closer to the industry's identity, reducing its degree of distinctiveness to find a new post-failure optimum (arrow 4b).

[Insert Table 2 and Figure 1 about here]

Sustaining the Industry's Legitimacy by Isolating VG

Almost concurrently with VG's initial neutral characterization of the failure, one of the first eyewitnesses, photographer Ken Brown, who was covering the test flight, said he saw a "*midflight explosion and later came upon SpaceShipTwo debris scattered across a small area of the desert*" (Oct 31, NBC News). This interpretation of the failure as an explosion was quickly picked up by other stakeholders. For example, Joel Glenn Brenner, former Washington Post reporter familiar with the development of SpaceShipOne under Burt Rutan, said: "*The explosion came almost instantaneously, and suddenly pieces of the spaceship were raining out of the sky*" (Oct 31; CNN).

For these stakeholders, the failure brought back memories of a 2007 deadly accident when a fuel tank exploded during ground testing. This explosion was the only other large-scale failure on record for VG. On October 31, 2014, VG was testing a newly-developed hybrid fuel combination. A prior test had revealed that the firm's previous fuel combination would likely not generate enough propulsion for SpaceShipTwo to reach space. VG had not tested the spacecraft in the air since then. Hence, these stakeholders linked the cause of the catastrophe to the continual technological challenges VG had faced in connection with its engine and fuel technology since the 2007 incident. Tom Bower, Branson's biographer, noted: "*in 2007, three engineers were killed in an explosion when a rocket exploded on the ground. Ever since then it has become apparent that the science used to create this rocket is completely unreliable*" (Nov 2, Express).

Because they viewed the failure as a direct consequence of VG's technological shortcomings, these stakeholders placed ownership of the failure solely onto VG and challenged the firm's legitimacy in two ways. First, they challenged VG's moral-procedural legitimacy by negatively evaluating the quality of VG's practices and technology and its ability to learn from the previous accident. To support their views, these stakeholders brought to light deep-rooted issues connected with the firm's technological and

managerial choices. For instance, rocket scientists such as Carolynne Campbell-Knight at the International Association for the Advancement of Space Safety, said that VG had ignored warnings about the instability of their fuel:

> Based on the work we've done, including me writing a paper on the handling of nitrous oxide, we were concerned about what was going on at VG [...] I sent copies of the paper to various people at VG in 2009, and they were ignored […] I warned them ... that the rocket motor was potentially dangerous (Nov 2, The Guardian; Nov 4, Agence France Press).

Campbell-Knight also stated on her website that "*if the truth about the 2007 accident had come out*," the SpaceShipTwo crash "*would probably not have happened*" (Nov 2, LA Daily News).

Given the continuous delays VG had experienced since its founding, these stakeholders believed that the firm had been rushed and was under time pressure to perform powered tests, especially as the spacecraft had not flown for more than nine months. Brenner noted:

> The enthusiasm that's been shown outwardly by VG and by Sir Richard certainly does not match at all with the technology behind the scenes. And there is a big gap there and has been for quite some time. And I will be documenting that [...] And it's a real problem. (Oct 31; CNN)

They also maintained that VG had shown overconfidence in downplaying the risks associated with its endeavor and in diffusing issues associated with the slow pace of the testing program. For example, CNN aviation analyst Miles O'Brien that "*Richard Branson, while charming and a great PR man, has routinely downplayed the dangers and the challenges of space travel*" (Nov 3, CNN). Jeff Kluger, senior science editor of Time Magazine, stated, "*Well, this [i.e., the maiden voyage] has been around the corner for Branson every six months. We are always just half a year away from finally having these flights*" (Nov 1, Time Magazine). Hence, Brenner noted, "*they were concerned about the pace of the program*" (Nov 1, ABC News). Moreover, some also hinted that these organizational issues had caused the exits of several top executives just a few months before the crash:

> VG has reportedly lost three of its senior executives in the last year, with the vice president for safety Jon Turnipseed having left just before Christmas, and Thomas Markusic, the vice president for propulsion, having left the company in January this year. It is also understood that the chief aerodynamics engineer left the company in recent months, according to reports (Nov 2, The Independent).

Stakeholders suggested that, in the absence of sound practices, trustworthy technology, and knowledgeable staff, VG's technical viability was in question. For example, space blogger Doug Messier

tweeted, "*Ten years into #SpaceShipTwo program & they still don't seem to have reliable & safe propulsion system. Doesn't bode well*" (Nov 2, Parabolic Arc). Brenner said, "*This engine that exploded today, even if they had had a successful flight [...] they would not have ever gotten anywhere near space with this engine, OK?*" (Oct 31, CNN). She added:

> We have been talking a little bit today about setbacks and what this means for the future and now I have to tell you that I believe sincerely that this is the end for customers in space on VG—at least any time soon because they don't have a vehicle anywhere near completion. I don't see them at least being able to carry anybody into space in the next ten years. There's no way. […] So this really marks the end for what they can do (Oct 31, CNN).

Second, this interpretation of the failure severely threatened the firm's pragmatic legitimacy, particularly from a resource sustainability perspective. Not only had VG incurred the loss of its costly technology, the firm also potentially faced severe financial strain that could ultimately damage its economic viability, especially if key stakeholders such as customers, investors, and insurers stopped lending support for the endeavor. Indeed, stakeholders expected customers would reconsider going into space with VG and request refunds and suggested that the deadly crash exposed the risk of space travel to customers who may not have fully considered it initially. Brenner explained that "*customers weren't necessarily paying attention [to the risk]. I think this might have been a wake-up call to them*" (Nov 1, ABC News). Soon, news reports that several customers had indeed requested refunds began to surface, bringing empirical support to the earlier worries:

> Dozens of wealthy investors are considering pulling out of Sir Richard Branson's VG programme, in a move which could cost the entrepreneur millions [...] More than 30 people who signed up to be among the first space travellers are now said to be reconsidering whether they want to make the flight in the wake of the crash of SpaceShipTwo (Nov 3, The Independent).

In parallel, uncertainty about whether investors would continue financing VG also threatened the pragmatic legitimacy of the firm. For example, aviation expert Clive Irving said:

> There are many consequences to this failure. Not the least is what it implies for the financing of the project. After years of delays the costs have gone beyond a billion dollars. More than a third of that money has come from Aabar, an investment fund based in Abu Dhabi. […] By any measure, this accident will have set back the development program by years. Will backers want to pour ever more money into this black hole? (Nov 2, Christian Science Monitor).

This was somewhat exacerbated by the fact that VG's only external investor at the time, Aabar Investment, had a neutral rather than a positive stance with regard to its future commitment

to the project, as one of its spokespersons noted:

> As an investor, Aabar is concerned of course. It is a challenge - nothing can be decided until investigations are over. For now, it is a wait-and-watch situation. There is time to make an assessment of the future strategy (Nov 6, Arabian Business).

Based on their interpretation of the event, these stakeholders isolated VG from the rest of the industry, suggesting it was no longer a rightful industry member. On the one hand, they rhetorically shrunk the boundaries of the industry so as to cast VG out. For instance, Campbell-Knight stated that "*They [VG] should stop, give up. Go away and do something they might be good at like selling mobile phones - they should stay out of the space business*" (Nov 2, Telegraph). On the other hand, they portrayed VG's competitors, as well as the industry writ large, as still legitimate and having sound practices. For example, reporter Scott Longmuir noted:

> Several companies are vying to make their mark in the growing field of space tourism, offering a variety of services from brief sub-orbital visits (flying above a height of 100 kilometres) to spending several days or weeks on an orbiting space station. (Nov 7, ABC)

Despite these arguments, the interpretation of the failure as an explosion and stakeholders' efforts to isolate VG as an illegitimate player in an otherwise legitimate commercial space industry sharply lost momentum following advancements of the NTSB's investigation and preliminary findings. In a press conference on November 2, the NTSB cleared VG to continue performing test flights. Then, on November 3, the NTSB confirmed that SpaceShipTwo's fuel tank and engine had been recovered intact and suggested that the premature deployment of the feathering system was the likely cause of the crash. The conversation around the fuel and engine further decreased following a November 5 NTSB statement: "*We have a lot that we don't know. This [i.e., examining the fuel and engine] was one fact […] in the several links of a chain to determine the totality of what caused this mishap*."

Sustaining the Industry's Legitimacy by Isolating VG and the Space Tourism Segment

In parallel, a second group of detracting stakeholders interpreted VG's catastrophic innovation failure as a tragedy in the pursuit of a meaningless goal. They strongly objected to the firm's product category—space tourism—and branded it useless from a societal point of view. For instance, WIRED journalist Adam Rogers remarked that such a frivolous activity was not worth the loss of life:

> Space tourism is not worth dying for. […] People get rich; they spend money. Sometimes it's vulgar, but it's the system we all seem to accept. When it costs the lives of the workers building that system, we should stop accepting it. (Oct 31, WIRED)

These detracting stakeholders viewed space tourism as a superficial, expensive, and dangerous activity that consumed resources society could allocate toward worthier causes. For example, CNN commentator Sally Kohn objected to the steep price tag for space tourism by noting:

> For $9.99, you can rent Gravity [the movie]. For, like, 100 bucks, you could get a projector and watch it really big in your living room … I just saved you a lot of money, everybody. There are other things to spend $250,000 on. I'd be happy to give you a list later of like, you know, people are starving. But it's fine. People get to spend their money however they want to. I just rent Gravity instead. (Nov 1, CNN)

Consequently, these stakeholders believed that responsibility for the failure rested with VG and other high-profile firms competing in the space tourism segment. Journalist Ed Power noted:

> The accident has focused attention on the extraordinary space race between a clique of billionaires seeking to turn the heavens into their private playground. The Virgin boss is just one among many high net worth individuals who, having become masters of the universe on terra firma, have cultivated what might be considered an obsession with outer space. (Nov 8, The Independent)

These stakeholders dismissed VG's efforts due to the exorbitant cost of the trip and the limited time actually spent in space. They questioned the social value of the product category, blaming the loss of life from the catastrophic failure on insignificant and wasteful pursuits for the wealthy. Thus, they not only challenged the legitimacy of VG and its activities but also rejected that of space tourism, as they perceived the activity to lack moral-structural legitimacy. Zoe Williams, a journalist at the Washington Post, opined that "*Richard Branson's space tourism shows what today's obscene inequality looks like, the space venture did little beyond illustrating the frivolity and emptiness of the human condition*" (Nov 3, The Washington Post). Similarly, Rogers wrote that "*Virgin Galactic is building the world's most expensive roller coaster, the aerospace version of Beluga caviar. It's a thing for rich people to do: pay $250,000 to not feel the weight of the world*" (Oct 31, WIRED). Journalist Steve Connor also noted:

> But even if VG shrugs off the latest tragedy and resume its test flights, there is still the question of whether commercial space travel will ever be anything other than expensive joyriding for the super-rich. VG's passengers […] will spend only a few minutes in "space," at an altitude where the curvature of the Earth and its wispy stratosphere will be outlined by the blackness of space. And in the process of enjoying the view, they can contemplate how their cash and physical presence have contributed, just a little bit, to the further destruction of what lies below them - the atmosphere of Earth. (Nov 3, The Independent)

Besides questioning the social value of space tourism, detracting stakeholders also challenged VG's and its segment's pragmatic legitimacy by questioning their economic viability. In their minds, customers would be discouraged from signing up or maintaining their commitment to travel into space once they understood the risks associated with the endeavor. For instance, John Logsdon, a retired Space Policy Director at George Washington University who served as a member of the board that investigated the Columbia space shuttle disaster in 2003, noted that "*It [the failure] is a real setback to the idea that lots of people are going to be taking joyrides into the fringes of outer space any time soon*" (Nov 1, The Guardian). He further added:

> This will inject a note of sobriety into the enthusiasm of those who would like the spaceflight experience. There was a whole juggernaut of ground training and private spaceports that were being set up to support an emerging space tourism industry, with a collective burst of maybe unrealistic expectations. This will certainly throw cold water on that. (Nov 3, The Guardian)

Similarly, reporter Stuart Nathan doubted the economic viability of VG in these terms:

> We'll have to wait and see whether the effects of the SpaceShipTwo crash dampen the enthusiasm of the very rich to take on the freshly-emphasised risk of riding an explosion for kicks. Because ultimately, that's what'll determine whether space flight can make money for investors, and that's the sole key to the future of Virgin Galactic. (Nov 5, The Engineer Online)

Despite casting aside VG and the space tourism segment, these detracting stakeholders believed in the broad endeavor of space exploration for the advancement of humanity. They sustained the industry's moral-structural legitimacy by differentiating VG and its segment from others that, in their eyes, operated in socially valued categories. They rhetorically isolated VG and the space tourism segment away from the rest of the commercial space industry by shrinking the boundaries of the industry so as to only include segments they deemed socially valuable. For example, speaking of the difference between SpaceX's intent to enable humanity to reach, and potentially settle, on Mars and VG's, Rogers noted:

> It's a mistake to lump that kind of endeavor [SpaceX's goal of getting humanity off Planet Earth] with Virgin Galactic. Exploration and evacuation are not its value proposition. The technology SpaceShipTwo employs is not, except perhaps in its broadest description, designed to take humanity off-world. It's genius engineering, but it isn't about exploring anything except the legitimately difficult challenge of a rocket plane that can go very, very high. It is about making space tourism into a viable business. (Oct 31, WIRED)

These stakeholders also forecasted significant negative impact or even the demise of the space

tourism segment while elevating the chances of success for the rest of the industry. Specifically, they sustained the commercial space industry's pragmatic legitimacy by portraying firms in other segments as being economically sound. For example, Ann Karagozian, professor of mechanical and aeronautical engineering at UCLA, said, "*I don't think this spells doom for so-called commercial space. Many different companies are developing concepts that are experiencing a lot of success*" (Nov 1, The Christian Science Monitor). She subsequently mentioned SpaceX as one such successful company, in connection with its development of re-usable rockets to send satellites into orbit and supply the International Space Station.

This interpretation of the failure came to a natural close when the vast majority of customers reaffirmed their commitment to fly with VG, dismissing the notion that the failure would endanger space tourism as a viable activity. More importantly, as we will elaborate in the next section, customers' reaffirmation of commitment coincided with a shift in VG's organizational identity, which moved from a focus on 'tourism' to a focus on 'space exploration,' thereby defending the social value of the endeavor.

Sustaining the Industry's Legitimacy by Embedding VG within the Larger Space Community

VG and supporting stakeholders interpreted the failure as the result of difficulties inherent to the innovation process. For example, VG CEO George Whitesides said, "*Space is hard. And today was a tough day*" (Oct 31, press conference). Many industry experts echoed this sentiment, including former NASA astronaut Mike Massimino, who noted: "*It's a reminder that things can happen when you try to do bold things in space. You can have setbacks [...] It could be a rough business*" (Oct 31, CNN). Pinpointing the difficulties involved in space travel enabled VG and supporting stakeholders to remind audiences that the firm's failure, albeit catastrophic, was representative of the challenges faced by the nascent commercial space community as a whole. In doing so, the firm and supporting stakeholders symbolically transferred ownership of the failure to the industry writ large and rhetorically embedded VG within the space community, defending the firm's rightful membership. For example, NASA administrator Charles Bolden said:

> While not a NASA mission, the pain of this tragedy will be felt by all the men and women who have devoted their lives to exploration. Space flight is incredibly difficult, and we commend the passion of all in the space community who take on risk to push the boundaries of human

> achievement. (Nov 1, NASA statement)

This served to counterbalance the interpretations of the failure put forth by detracting stakeholders, who challenged VG's legitimacy based either on the quality of its technology and practices or on the worthiness of the endeavor at a social level. In response to the first set of detracting stakeholders, VG and supporting stakeholders sustained the firm's moral-procedural legitimacy by upholding its innovative capabilities and reinforcing the firm's commitment to safety. For instance, Richard Quest, CNN aviation analyst, said, "*there's no question it [i.e., the maiden voyage] will be delayed but […] when it does finally take passengers it will be as safe as it can be*" (Oct 31; CNN) Similarly, Whitesides noted that "*It was the first time the rocket had been flown using a new fuel formulation […] It had been proven and tested on the ground many times*" (Oct 31, press conference). The firm also reiterated the same message in a statement:

> At VG, we are dedicated to opening the space frontier, while keeping safety as our 'North Star.' This has guided every decision we have made over the past decade, and any suggestion to the contrary is categorically untrue. We have the privilege to work with some of the best minds in the space industry, who have dedicated their lives to the development of technologies to enable the continued exploration of space. […] This is not a mission that anyone takes lightly. (Nov 2, press release)

VG also portrayed the failure as an opportunity to learn and persevere in its goal of bringing tourists into space. Whitesides said:

> We are going to be supporting the investigation as we figure out what happened today, and we're going to get through it […] We believe we owe it to the folks who were flying these vehicles as well as the folks who have been working so hard on them, to understand this and to move forward, which is what we'll do. (Oct 31, press conference)

Similar views were espoused by supporting stakeholders. For example, client Sir Trevor Beattie tweeted "*ad astra per aspera*" ("a rough road leads to the stars") (Nov 1) while former NASA astronaut Scott Parazynski noted: "*They will look at all the data and find out what happened […] I am certain VG will persevere and get to the bottom of what's gone wrong*" (Nov 1, Sky News).

To further maintain VG's moral-procedural legitimacy, the firm and supporting stakeholders likened VG's failure to failures in nascent industries and innovations of the past. For example, Fredric Jenet, the creator/director at the Center for Advanced Radio Astronomy UT Brownsville and

STARGATE, compared VG's endeavor to early efforts in the automotive industry, commercial aviation, and non-profit space exploration. He said:

> A few failures are not going to stop private space flight, just as a few crashes are not going to stop the automobile industry. […] Where would we be if the Wright brothers decided not to pursue aviation because Otto Lilienthal, a pioneer of aviation, was killed in a glider accident? Failure is a necessary part of great success. In our efforts to travel to the moon during the golden age of space travel, there were 55 mission failures and only 41 successes. One of the most famous innovators of all times, Thomas Edison, knew that failure was intimately tied to success. When developing the electric light bulb, he reportedly failed over 10,000 times before getting it right. (Nov 6, Business Spectator)

The firm and its supporting stakeholders also responded to the first detracting interpretation that isolated VG from the rest of the commercial space industry by leveraging messages of the official voice of the NTSB. On November 3, the NTSB provided details on what had happened in a press conference. The agency's acting chairman, Christopher Hart, specifically pointed to human error in the early deployment of the spacecraft's feathering mechanism designed to be used for reentry, thus dissipating the notion that the failure was caused by an explosion: "*Shortly after the feathering occurred, the telemetry data terminated, and the video data terminated. The engine burn was normal, up until the extension of the feathers*." VG leveraged the NTSB's findings through its chairman, Sir Richard Branson, who noted:

> It was quite hurtful for the 400 engineers at VG that so many self-proclaimed experts were reeled into the Sunday newspapers to say what caused the explosion and why an explosion was inevitable to happen, when in fact there was no explosion and the fuel tanks are fine and the rocket engines are fine [...] I was grateful for the NTSB to come out very strongly last night to say the engines and fuel tanks were completely intact. It was insulting. It was the British press at its worst, and some of them should hang their heads in shame. (Nov 3, CNN)

In response to threats to VG's pragmatic legitimacy in connection with supposed technological shortcomings, VG and supporting stakeholders defended the firm's economic sustainability by making positive forward-looking statements. They acknowledged the delay as inevitable following the catastrophic failure but cast the overall endeavor in a positive light. For example, XPRIZE Foundation Chairman and Chief Executive Peter Diamandis, who had a long-standing relationship with VG and was a client on the flight list, said:

> This is what exploring is all about. We risk our lives for what we believe in. [...] I believe in [VG] and know without a doubt that they will succeed, and I will fully trust them with my safety when my turn to fly materializes. (Nov 2, The Washington Post)

Similarly, Beattie tweeted, "*We'll be back. #StillBuildingTheDream #SpaceShipThree?*" (Nov 7).

VG's pragmatic legitimacy was also questioned regarding the firm's ability to obtain and deploy the necessary resources to pursue its goal, given media reports that suggested customers were requesting refunds. VG defended its economic sustainability by confirming that "*less than three per cent of people have requested refunds*" (Nov 3, The Independent). Moreover, Branson minimized the impact of potential refunds to VG's financial health by indicating that none of the customers' money was ever used:

> Anybody who ever wants a refund would be able to get a refund. We haven't used the money. We've always decided it's best not to use the money. It just gave us the confidence to do the program knowing that these people were so committed. (Nov 1, press conference)

According to news reports, while some clients had indeed rescinded their tickets, a number of them were in fact swayed back after speaking directly with Whitesides (Nov 10, CNN) or other fellow customers (Nov 10, NBC News). For example, Craig Willan, a veteran of the aerospace industry who is 8th on VG's passenger list, managed to convince another customer not to ask for a refund. He noted:

> I told him, 'Don't' … 'Don't do it. You don't want to get into that for a couple of reasons. One is, it would be a potential run on the bank. And the second thing is, it sends the wrong signal to humankind. This is a very important phase in the gestation of something new, and we don't want to screw up this pregnancy' […] It turns out he did not ask for a refund. (Nov 10, NBC News)

Many other vocal customers reaffirmed their commitment to fly with VG and made a positive assessment of space travel in general, thus sustaining the industry's pragmatic legitimacy. Vasily Klyukin, a VG customer, tweeted on October 31 that "*Space is space. It's not like park walking. I'm planning to fly anyway,*" hence acknowledging the risks involved in the endeavor. Others also believed that the catastrophic failure did not automatically spell doom for the commercial space industry. For instance, Sten Odenwald, a NASA consultant, said that "*the commercial drivers for space travel haven't changed and I can't imagine the business community turning their backs on it now*" (Nov 2, The Independent). Ryan Bourne, the head of public policy at the Institute of Economic Affairs, concurred:

> We should therefore be very careful in implying that spacecraft technologies will never find mass markets. Similarly misguided predictions were made about aeroplanes, computers and even the electric light. Market economies have a history of innovating goods and services which meet the wants and needs of society. (Nov 4, City AM)

The second detracting interpretation aimed to isolate both VG and its segment by calling into

question the social value of space tourism, which threatened the moral-structural legitimacy of the firm and the industry as a whole. In response, VG and supporting stakeholders defended the necessity and worthiness of VG's activities and of its product category as a whole by asserting the importance of the endeavor for all of humanity. For example, on November 7, VG retweeted an article by WIRED Magazine whose title read: *"@WIRED: VG doesn't just benefit the rich – it's good for science*." VG conveyed a similar message in a press release:

> Everything we do is to pursue the vision of accessible and democratized space [...] Just like early air or sea travel, it is hard and complicated, but we believe that a thriving commercial space industry will have far reaching benefits for humanity, technology and research for generations to come. This is an important mission and we have been overwhelmed and grateful for the outpouring of support we have received from our future astronauts, friends in the industry and people all over the world who are inspired by the work our industry is doing and who are urging us to continue. (Nov 3, press release)

Supporting stakeholders also defended the moral-structural legitimacy of VG and the space tourism segment by using analogies to compare the project to all efforts in space exploration, regardless of the industry segment in which they fell. For instance, former NASA astronaut Lisa Nowak said that "*Of course, risk is part of space flight. We accept some of that to achieve greater goals in exploration and find out more about ourselves and about the universe*" (Nov 1, CNN). Similarly, Stuart Witt, CEO of the Mojave Spaceport, noted: "*My message to them [i.e., to VG] is stay the course. This business is worthy business. This is not easy. If it were easy it wouldn't be interesting to me or any of my colleagues standing with us*" (Oct 31, press conference). In the same vein, Branson said: "*We must push on. There are incredible things that can happen through mankind being able to explore space properly. […] I'm absolutely convinced VG has a great future*" (Nov 4, The Guardian).

To further counterbalance the second detracting interpretation of the failure, VG shifted its organizational identity to make it less distinctive from the industry's overall identity. This was a significant move. From its founding in 2004 until its October 2014 test flight crash, VG portrayed itself mainly as "the First Commercial Spaceline" across all its communications media. The firm referred to its clients on the flight list as "future astronauts" and portrayed them as belonging to "perhaps the world's most exclusive club." Following the catastrophe, VG's identity morphed in alignment with its response to

detracting stakeholders' interpretations. VG now described itself as "the Spaceline for Earth." Branson would later state that the new identity tagline suggested "a renewed sense of purpose" for the firm (Jan 2 2015; Branson's Blog). As the "Spaceline for Earth," VG embedded itself as part of the larger space community and highlighted its goal of contributing to mankind through space exploration. On November 21, 2014, three weeks after the crash, the firm unveiled a new website.[7] The homepage contained a tribute to the fallen pilot and displayed sections in vertical sequence, accompanied by photographs. The titles and content of many sections conveyed the firm's new identity, including "Human Spaceflight," "Why we go," "Who we are," and "Our vision for the future," suggesting different ways in which Virgin Galactic's contribution to improving life on Earth would materialize through its space exploration activities.

In turn, VG and supporting stakeholders countered detracting arguments regarding the firm's and the segment's pragmatic legitimacy by arguing that the cost of space tourism, while initially high, was meant to decrease over time. Clients on the flight list were described as pioneers who assumed the high cost of space travel to facilitate the process of diffusing the innovation into the mass market. Hence, Bob Weiss, president of the XPRIZE Foundation, said: "*Advances in commercial space flight are about more than joyrides for the superrich. The whole notion is to get the cost down. That reduction in cost is critical to ultimately being able to live and work in space*" (Nov 4, Toronto Star). Client Namira Salim noted:

> The misconception is that this is for the rich and the famous. This is going to create the gateway into space for researchers, scientists, payloads, satellites. And we are just the first to invest in the project to make it a reality for the common person, for all these other industries. (Nov 3, BBC)

Finally, VG and supporting stakeholders sought to embed the firm's activities within the industry's innovative pursuits in an attempt to sustain the firm's overall legitimacy. According to them, the industry's endeavor, and consequently VG's, were worthy and necessary for the advancement of humanity. They therefore portrayed VG's failure as representative of the challenges that the nascent commercial space industry faced as a whole. In doing so, they rhetorically enhanced the boundaries of the commercial space industry to encompass all space exploration, both for profit and non-profit, within the

[7] VG's November 21, 2014 homepage can be accessed here: https://web.archive.org/web/20141121224807/http://virgingalactic.com/

same community. For example, commenting on VG's failure, Jenet spoke of the importance of space exploration in general and symbolically transferred ownership of the failure to the community at large:

> Ultimately, we have two choices. We can play it safe, stifle creativity by being totally risk averse, and resign ourselves to being stuck on Earth for the rest of eternity. Or, we allow ourselves to dream big, take on huge challenges and claim a space for ourselves among the stars. I have no doubt that we will decide to pursue the second choice. But, be ready for more crashes, explosions and, unfortunately, fatalities. These failures signify that we are once again pursuing great things, things that are going to define who we are as a human race, and take us to a future where we explore and shape the galaxy and the universe beyond. (Nov 6, Business Spectator)

Supporting stakeholders endorsed VG and its effort to bring people into space, predicting that the firm would ultimately prevail in its mission to bring non-career astronauts into space despite this major setback. For example, former NASA astronaut Tom Jones explained:

> I think space tourism is a promising development. It is going to expose more people to the experience of space flights which I think is going broaden our interest in conducting business into space, expanding industry to space. Companies like VG are going to be important part of this. We knew that there would be accidents. Everyone knows that. (Oct 31, Fox Business)

Similarly, June Scobee Rodgers, widow of a 1986 Challenger astronaut and Founding Chair and Director of the Challenger Center, stated in a letter to VG: "*The setback is tragic, but the courage and commitment of your fellow team will soon help you all to recover, and from the energy of grief, the phoenix will arise with even more resolve and commitment*" (Nov 10, CNN).

Discussion

We examined how catastrophic innovation failure affects firm and industry legitimacy in nascent sectors by analyzing the interactions between Virgin Galactic and members of the space community in the aftermath of the firm's 2014 test flight crash. The failure brought about the devastating loss of human life and valuable technology at a time when the firm was thought to be close to launching its maiden voyage. Our findings show that catastrophic innovation failure creates a "legitimacy jolt" (Garud et al., 2014) to the firm and its nascent industry, which provides an occasion for firms and stakeholders to jointly reassess organizational and industry legitimacy. This reassessment process leads the firm and its stakeholders to sharpen their expectations surrounding what the industry is about, who gets to participate in it, as well as how participants should operate and what they stand for.

As can be expected in instances of catastrophic innovation failure, the circumstances surrounding

VG's crash were fraught with ambiguity: no single actor had perfect information about the event. To advocate for their respective views, the firm and its stakeholders engaged over time with interpretations of *what happened* and *why it happened,* which subsequently informed their discussion of the failure's *implications over organizational and industry legitimacy*, as illustrated in our process model. We traced the emergence of three interpretations of the failure that affected organizational and industry legitimacy in different ways. Concretely, while all actors sought to sustain the industry's legitimacy, they differed in their treatment of organizational legitimacy. Some detracting stakeholders viewed the failure as a consequence of VG's own technical and managerial shortcomings and argued that VG alone was responsible for the event. They isolated VG from the wider commercial space industry by rhetorically shrinking the industry's boundaries so as to exclude the firm. Other detracting stakeholders viewed the failure as a consequence of the firm's goal to bring tourists into space—an endeavor they considered socially wasteful. They believed VG and others in the space tourism segment were to blame for the event. They isolated both VG and its segment from the rest of the industry by rhetorically shrinking industry boundaries so as to encompass only those segments they viewed as socially beneficial. In contrast, VG and supporting stakeholders interpreted the failure as a consequence of difficulties inherent to the development of radical innovations. They rhetorically embedded VG within the industry, asserting the firm's rightful membership in it. Thus, they symbolically transferred ownership of the failure to the space community at large. Moreover, they enhanced industry boundaries to encompass both for-profit and non-profit players in the space community.

Our study makes contributions to the literatures on innovation failure and legitimacy building in nascent industries. First, our study situates catastrophic innovation failure as a distinct and understudied failure category. We conceptually distinguish catastrophic innovation failure from other types of failure frequently examined in the literature—particularly, small-scale innovation failure (Cannon & Edmondson, 2005; Kelley & Littman, 2001; Sitkin, 1992; Thomke, 2003) and large-scale operational failure (Bundy & Pfarrer, 2015; Gillespie & Dietz, 2009; Turner, 1976, 1976), and we provide an in-depth look into the firm-stakeholder interactions that ensue in its aftermath. In particular, previous work has

shown that catastrophic operational failure almost exclusively threatens organizational legitimacy: the consensus is that the firm is likely to blame and must take remedial action. Firms engage with stakeholders either to diminish the perceived severity of the failure or to take responsibility (Elsbach, 2003). In contrast, in the wake of catastrophic innovation failure, where ambiguity as to the cause of the failure reigns, interpretations of the failure differ and both organizational and industry legitimacy are at stake. We traced direct links between actors' interpretations of the failure, their efforts to sustain the larger industry's legitimacy across the board, and their arguments to either uphold or reject organizational legitimacy. Firm-stakeholder interactions revolved around assertions of rightful industry membership to either isolate the firm away from the industry or embed the firm within it; rhetorical manipulation of industry boundaries to either constrain or enhance them; and arguments to either increase or decrease the degree of distinctiveness of the firm's identity.

Second, our study highlights the intimate relationship that exists between organizational and industry legitimacy in nascent sectors. Prior research has established that firms in nascent sectors tend to build both types of legitimacy simultaneously, so that the construction of each strengthens the other (Navis & Glynn, 2010; Wry, Lounsbury, & Glynn, 2011). Our findings show that a jolt to one effectively threatens the other; that is, catastrophic innovation failure not only affects the legitimacy of the firm that incurred it, but can transitively affect the legitimacy of the nascent industry. When questions arise regarding the ability of the firm to deliver on its goal to produce a radical innovation, a shadow of doubt is cast on the social value, desirability, and appropriateness of the entire segment's endeavor. The firm-stakeholder dynamics that ensue redefine expectations regarding what constitutes rightful membership in the industry, how 'sound practices' are defined and deployed, and what makes a socially valuable product or segment. Our study complements recent research that explores how the success or failure of individual firms impacts the legitimacy of their product category as a whole (Soublière & Gehman, 2019), as well as work that examines how firms interact with vocal stakeholders as they construct and reconstruct their legitimacy over time (Gegenhuber & Naderer, 2019).

Third, our study illuminates higher-order dynamics that speak to the evolution of nascent

industries. Navis and Glynn (2010) demonstrate that, when an industry first arises, participants cooperate in order to establish the industry's legitimacy and narrate their own organizational identities in ways that suggest strong adherence to the industry's core attributes. However, as the industry begins to evolve, firms differentiate from one another by establishing optimally distinctive organizational identities (Navis & Glynn, 2011; Wry et al., 2011; Zhao et al., 2017), i.e., identities that highlight unique firm attributes while still identifying the firm as a rightful industry member. We observe an interesting dynamic in which the firm and supporting stakeholders seek to reduce the degree of distinctiveness of the firm's identity, appealing to organizational attributes that blend in with industry attributes, while detracting stakeholders push to increase distinctiveness, separating the firm, and possibly its segment, from the rest of the industry. In the end, the firm redefines its organizational identity by finding a post-failure equilibrium that reimagines the balance between identification with, and distinctiveness from, its industry. In our case, VG changed its organizational identity from a clearly differentiated stance (enabling clients to join 'the coolest club on Earth') to a less differentiated one (presenting a narrative centered on the personal and social benefits of space exploration, which directly speaks to industry identity attributes). Ultimately, as VG's move suggests that the process of establishing optimal distinctiveness is not unidirectional, and what may seem as an optimally distinctive identity at one point in time (pre-failure) may no longer be so at another (post-failure). In other words, our study implies that catastrophic innovation failure leads the firm to adjust its degree of distinctiveness to find a new equilibrium from which to reassert its legitimacy a rightful industry member.

Moreover, our study hints at considerations regarding the extent and timing of firms' differentiation efforts. Our findings suggest that firms pursuing radical innovations may wish to exercise caution and not rush to differentiate their organizational identities too early in the evolution of the industry, especially when the occurrence of catastrophic innovation failure is a real possibility. The firm's efforts to re-narrate its organizational identity in the aftermath of catastrophic innovation failure must prove credible in the eyes of stakeholders whose support is essential to the firm's success. If the distance between the firm's pre- and post-failure identities is considerable, stakeholders may find it difficult to buy

into the underlying narrative change (Garud et al., 2014). Still, further research is required to explore how organizational identity is affected by legitimacy jolts that stem from catastrophic innovation failure.

Lastly, our study notes the role of neutral stakeholders in moving the collective discussion forward and making aspects of what happened, why it happened, and its implications for organizational and industry legitimacy more or less salient over time. Neutral stakeholders have the ability to bring clarity to the situation because they have access to unequivocal information (Lee et al., 2017). This information may, over time, prove key in discrediting some interpretations while granting credence to others. In our case, the NTSB was instrumental in debunking the interpretation that VG's catastrophic innovation failure had occurred due to faulty technology and practices. By producing indisputable proof that an explosion had not occurred, the NTSB weakened detracting stakeholders' arguments to cast VG out of the industry and contributed to strengthening the arguments of the firm and supporting stakeholders to consider VG a rightful and knowledgeable member of the industry.

In-depth inductive qualitative case studies enable richness of data and description, but they reduce the degree to which findings generalize to other settings. For instance, detractors might not always isolate the firm and isolate the firm and its segment; rather, these represent two possible approaches. Similarly, the responses that the firm can employ to counter detractors may not be limited to the ones we identified. Our model, however, should prove useful to forecast firm-stakeholder interactions following catastrophic innovation failure in other settings. A case in point could be the fairly recent event in which a Google autonomous vehicle killed a bystander during a test drive, which raised questions about the social value of this emergent product category. Our results suggest that, regardless of context, firms pursuing radical innovations would benefit from cultivating relationships with supporting stakeholders who, in the event of catastrophic failure, are prepared to engage publicly in support of the firm. The interpretations these actors generate may effectively act as a buffer that protects the firm from detracting stakeholders' negative interpretations of the failure event.

Finally, we must also consider for a moment the nature of our data. While, our coverage of stakeholders is extensive and includes a wide array and high number of them, we found a paucity of

comments from regulators such as the Federal Aviation Administration (FAA) and from VG's competitors. We found no statements from the FAA throughout the negotiation process and only came across three messages from competitors (none at the time were in VG's space tourism segment). Furthermore, our dataset is also limited to publicly-facing pronouncements. Critical to our analysis is the idea that most (if not all) relevant arguments in support or against VG in the aftermath of the crash were, at one time or another during our period of analysis, made public. In other words, we worked under the assumption that private conversations between VG and its stakeholders resembled publicly-facing interactions. In numerous instances across our data, stakeholders such as reporters, space analysts, and clients acknowledged having spoken to VG employees and executives and gave accounts of what transpired in those conversation. In no instance did we see evidence of different arguments being employed by the firm privately that were not employed by VG and its management in the public arena as well. Still, given the proper access, future research could examine inward- and outward-facing firm and stakeholder interactions simultaneously and ascertain whether and how private discussions influence the public negotiation of the meaning of the catastrophic innovation failure event.

Conclusion

Firms that experience catastrophic failure while pursuing radical innovations must navigate the experience concurrently with stakeholders. In the wake of the aftermath, stakeholders seek their bearings and interpret the event in ways that either push the firm away from the industry or pull it toward the broader industry and community. By embedding the firm and its failure within the larger community, firms and supportive stakeholders can symbolically transfer ownership of the failure to the industry and reinforce the firm's preferred interpretation of the event as it sustains the legitimacy of not only the firm but also that of the industry. In such circumstances, how the failure is ultimately perceived is non-deterministic and requires active management by the firm and its proxies.

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Figure 1. A Process Model of Reassessing Organizational and Industry Legitimacy Following Catastrophic Innovation Failure

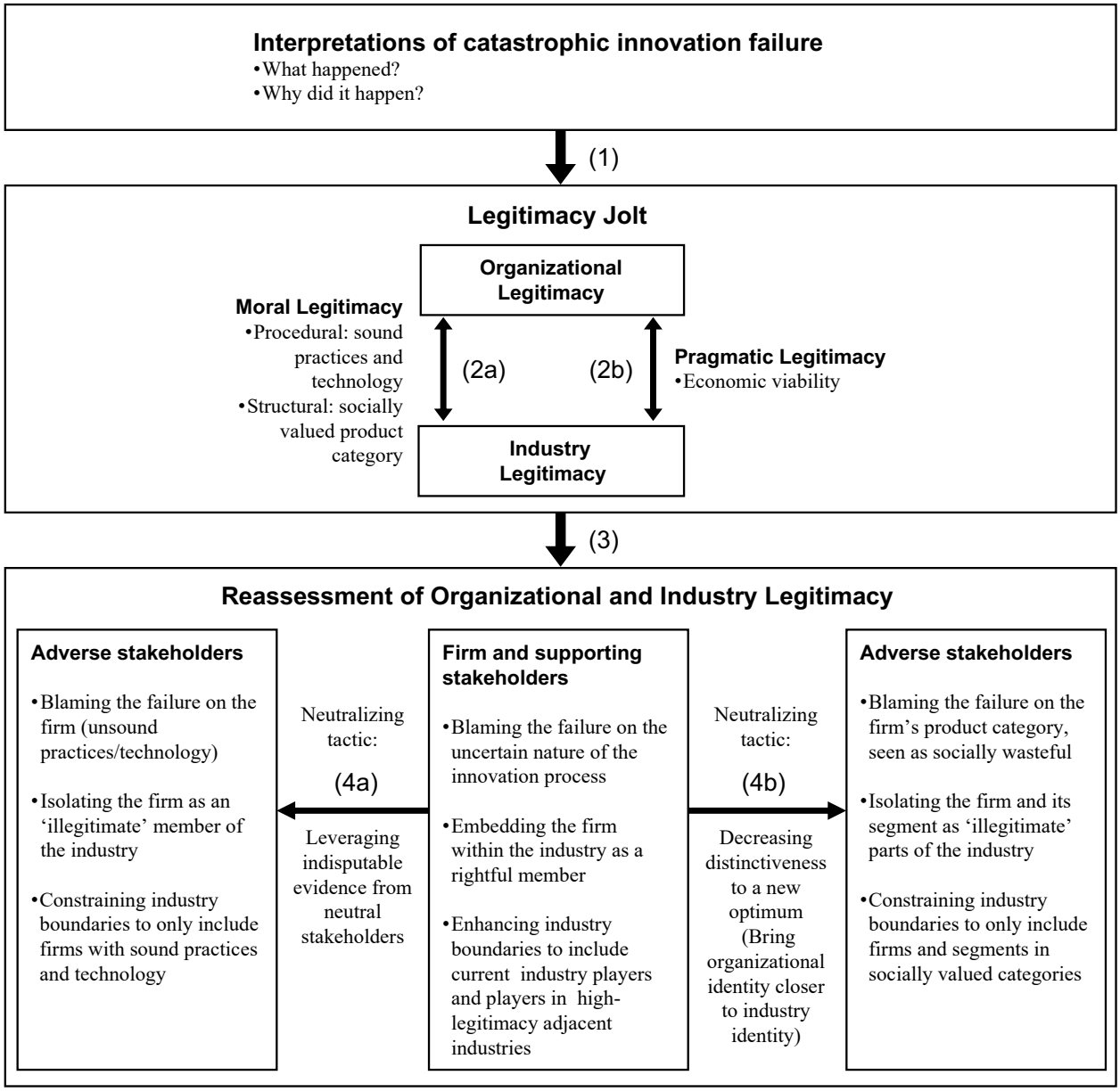

Table 1. Firm Representatives and Stakeholders Featured in the Data

Actor Type	Individuals (Firms)	Individuals' Names, Occupations, and Organizations (when relevant)	
VG and VG-related			
VG executives	5 (1)	Sir Richard Branson, Chairman George Whitesides, CEO Will Whitehorn, former CEO	Mike Moses, VP Operations Matt Stinemetze, Engineer
VG investors	0 (1)	Aabar Investments	
VG partners	4 (6)	**Aerospace partners** Scaled Composites Burt Rutan, Founder Kevin Mickey, CEO Anonymous, Employee Mojave Air and Spaceport Stuart Witt, CEO Sierra Nevada Corporation	**Other partners** Grey Goose Vodka Jardine Lloyd Thompson Land Rover
VG clients on the flight list	16	Anonymous Ken Baxter Sir Trevor Beattie Jim Clash Bill Cullen Wilson da Silva Brett Godfrey John Goodwin	P.J. King Vasily Klyukin Igor Kutsenko Namira Salim Yanil Silver Ashish Thakkar Peter Ulrich von May Craig Willan
Authorities			
Federal authorities	3 (2)	Federal Aviation Administration (FAA) National Transportation Safety Board (NTSB) Christopher Hart, Acting Chairman Eric Weiss, Spokesperson Peter Knudson, Spokesperson	
Members of the Space Community			
Space organizations	11 (9)	**Not-for-profit organizations** Challenger Center June Scobee Rodgers, Founding Chair and Director National Aeronautics and Space Administration (NASA) Charles Bolden, Administrator Wayne Hale, former Shuttle Program Manager National Aviation Hall of Fame Ron Kaplan, Enshrinement Director National Space Society (NSS) Mark Hopkins, Chairman of the Executive Committee Paul Werbos, Executive Vice President XPRIZE Foundation Peter Diamandis, Chairman and Chief Executive Bob Weiss, President Yuri's Night **For-profit organizations** Bristol Spaceplanes David Ashford, Founder SpaceX Elon Musk, Founder zero2infinity Jose Mariano Lopez-Urdiales, CEO	

Actor Type	Individuals (Firms)	Individuals' Names, Occupations, and Organizations (when relevant)	
Former NASA astronauts	11	Buzz Aldrin Leroy Chiao Chris Hadfield Jose Hernandez Tom Jones Mark Kelly	Michael Massimino Lisa Nowak John Olivas Scott Parazynski Steve Robinson
Test pilots and commercial astronauts	6	Brian Binnie Chuck Coleman Bob Hoover	David Mackay Peter Siebold Paul Tackabury
Other space experts	11	**Marco Caceres**, Senior Analyst and Director of Space Studies, the Teal Group **Thomas Gangale,** Aerospace Engineer **Diane Howard**, Assistant Professor, Commercial Spaceflight Operations Program, Embry-Riddle Aeronautical University **Fredric Jenet**, Director, Center for Advanced Radio Astronomy UT Brownsville **Marshall Kaplan**, Professor of Aerospace Engineering, University of Maryland **John Logsdon**, Retired Space Policy Director, George Washington University **Jonathan McDowell**, Astronomer, Harvard-Smithsonian Centre for Astrophysics **Tim O'Brien**, Professor, Jodrell Bank Observatory **Sten Odenwald**, Chair, National Institute of Aerospace **Tomasso Sgobba**, Executive Director, International Association for the Advancement of Space Safety **David Whitehouse**, Scientist and consultant to space agencies	
Experts in other fields	8	**Ryan Bourne**, Head of Public Policy, Institute of Economic Affairs **Carolynne Campbell-Knight**, Rocket Engineer **Geoff Daly**, Mechanical Engineer **Clive Irving**, Aviation Expert **Ann Karagozian**, Professor of Mechanical and Aeronautical Engineering, UCLA **Anthony Roman**, former Corporate Pilot **Neil Stevens**, Chief Economist, Insurance Information Institute **Steven Weisbart**, Space Insurance Expert, Satellite Finance Network Advisory Board	
Members of the Press			
Space analysts	+30	(selected) **Geoff Brumfield**, Science Correspondent, NPR **Joel Glenn Brenner**, Former Reporter, The Washington Post **Jeffrey Kluger,** Senior Science Editor, TIME Magazine **Tariq Malik**, Managing Director, space.com **Doug Messier**, Editor, parabolicarc.co **Miles O'Brien**, Aviation Analyst, CNN **Jason Perlow**, Senior Technology Editor, ZDNet **Richard Quest**, Aviation Correspondent, CNN **Adam Rogers**, Science Writer, WIRED	
Reporters	+130	+30 television news anchors and general correspondents +80 article authors +20 news organizations and publications with no byline	
Other Stakeholders			
Crash witness	1	**Ken Brown**, Photographer	

Table 2. How Catastrophic Innovation Failure Affects Firm and Industry Legitimacy – Detailed Categories

Sustaining Industry Legitimacy by Isolating VG

Proponents: adverse stakeholders

Prevalence in firm-stakeholder interactions: Interpretation begins to lose momentum on day 3, when the engine and fuel tanks (the supposed sources of the explosion) are recovered intact. It further loses momentum after day 5, when the NTSB's preliminary report officially rules out the occurrence of an explosion.

Categories	Sub-categories	Supporting evidence and sources
Interpretation of failure		
What happened?	**Failure qualified as 'explosion'**	"*All reports indicate that the explosion happened relatively soon after engine ignition*." J. Hruska (reporter); Nov 1st; media article
Why did it happen?	**VG has faulty practices**	"*They knew that three people were killed by this stuff, and yet they persisted in presenting it as safe, stable and benign*." C. Campbell-Knight (scientist, International Association for the Advancement of Space Safety); Nov 4th; media article
	VG has failed to learn from past failures	"*Based on the work we've done, including me writing a paper on the handling of nitrous oxide, we were concerned about what was going on at VG … I sent copies of the paper to various people at VG in 2009, and they were ignored*." C. Campbell-Knight (scientist, International Association for the Advancement of Space Safety); Nov 4th; media article
Who owns the failure?	**Responsibility for the failure lies exclusively with VG**	"*The tycoon [Branson] was warned by engineers and scientists last year that the rocket was an explosion waiting to happen*." T. Bower (Branson's biographer); Nov 4th; media article
Role in legitimacy jolt		
Challenging firm legitimacy	**Moral-procedural legitimacy** • Questioning VG's practices	"*It is exactly what I was expecting. It was Russian roulette which test flight blew up*." C. Campbell-Knight (scientist, International Association for the Advancement of Space Safety); Nov 2nd; media article
	• Questioning VG's ability to learn	"*Now we've got another person killed, another person seriously injured … We offered to talk, give our experience. It was either ignored or totally dismissed*." G. Daly, (scientist, International Association for the Advancement of Space Safety); Nov 2nd, media article
	Pragmatic legitimacy • Questioning VG's economic sustainability	"*After the failure of SpaceShipTwo, what will those Hollywood stars and hundreds of others this morning think about riding that rocket?*" D. Kerley (ABC transportation correspondent); Nov 1st; television newscast
Sustaining industry legitimacy	**Moral-procedural legitimacy** • Portraying other players as having sound practices	"*Other commercial space operators, such Elon Musk's SpaceX and Blue Origin from Jeff Bezos, use totally different technologies to Virgin Galactic*." S. Odenwald (chair of the National Institute of Aerospace and NASA consultant); Nov 2nd; media article
	Pragmatic legitimacy • Portraying other players as economically sustainable	"*The Virgin Galactic crash will not hinder efforts to establish Europe's first commercial spaceport in the UK*." Unnamed UK government spokesman, Nov 2nd; media article

Ultimate effects on legitimacy		
Player dynamics	**Isolating VG as an illegitimate player**	"*A fiver says Virgin Galactic will never happen … Branson will take time to abandon the project but I think even he realizes space is a step too far*." S. Calder (reporter), Nov 3rd; media article
Industry boundaries	**Constraining industry boundaries to only include players deemed to have sound practices**	"*The first jet airliners crashed with serious problems but jet travel is still with us. … It was the beginning of the end for the companies but the industries survived. Obviously it's a setback for Virgin but there are several other companies looking into the same thing*." D. Ashford (Bristol Spaceplanes founder); Nov 3rd; media article

Sustaining Industry Legitimacy by Isolating VG and the Space Tourism Segment

Proponents: adverse stakeholders

Prevalence in firm-stakeholder interactions: Weeks 1-3. Interpretation begins to lose momentum as numerous VG partners and clients, alongside high-profile space experts, uphold the value of VG's endeavors. The interpretation further loses momentum as VG brings its organizational identity closer to the identity of the industry.

Categories	Sub-categories	Supporting quotes and sources / Notes(when appropriate)
Interpretation of failure		
What happened?	**Failure qualified as an unnecessary tragedy**	"*One assumes that he [co-pilot Michael Alsbury] wouldn't have wanted his death to derail the project. Whether he would have wanted it smothered in the language of bogus communitarianism is another question*." Z. Williams (reporter); Nov 2nd; media article
Why did it happen?	**VG is pursuing a socially wasteful, unnecessary activity**	"*A brave test pilot is dead and another one critically injured—in the service of a millionaire boondoggle thrill ride."* A Rogers (reporter); Oct 31st; media article
Who owns the failure?	**Responsibility for the failure lies with VG and other high-profile firms**	"*That pilot died not for space but for a luxury service provider. His death doesn't get us closer to Mars; it keeps rich people further away from weightlessness and a beautiful view*." A Rogers (reporter); Oct 31st; media article
Role in legitimacy jolt		
Challenging firm/segment legitimacy	**Moral-structural legitimacy** • Questioning the social value of VG's/segment's product category	"*The creation of a market in space travel shows us the desperate need to reduce the gap between rich and poor … This sort of travel amounts to what the economist Thorstein Veblen once described as 'conspicuous consumption,' serving little social purpose*." Z. Williams (reporter); Nov 2nd; media article
	Pragmatic legitimacy • Questioning VG's/segment's economic sustainability	"*It is less clear … whether manned spaceflight will remain a priority investment for Abu Dhabi [sovereign fund Aabar Investments is a VG investor] in a region where prominent officials and businessmen go to great lengths to avoid any negative publicity or perception of failure*" Arabian Business via Reuters (news outlet); Nov 6th; media article
Sustaining industry legitimacy	**Moral-procedural legitimacy** • Portraying other players/ segments as operating in socially valued categories	"*In the case of Virgin Galactic … this is not space travel for the sole benefit of science. It's space travel as an adventure only the richest can afford to buy*." A. Bitton (reporter), Nov 21st; media article

	Pragmatic legitimacy • Portraying other players/ segments as technically sustainable	"*I root for SpaceX, and felt real disappointment at Orbital Sciences' Antares disaster this week.*" A Rogers (reporter); Oct 31st; media article
Ultimate effects on legitimacy		
Player dynamics	**Isolating VG/segment as illegitimate**	"*My sense, from what they [VG] themselves have described what the business is, it sounds like, if it worked, it would be an amazing ride for some very wealthy people. I am not sure I see the connection between that and space exploration*." A Rogers, Nov 2nd; radio newscast
Industry boundaries	**Constraining industry boundaries to only include players/segments deemed to be socially valuable**	"*A space program designed to get humanity off our native planet makes sense—but only a specific kind. Eventually this planet is going to be unlivable, either because of something we humans do to it or something natural. Asteroids have wiped Earth clean before, and presumably they'll do it again. It'd be good to not be here when it happens. Elon Musk has made that part of his explicit rationale for SpaceX, his rocket company. Going to space is wondrous, difficult, and a testament to the human spirit. It's also utterly, cynically practical. That's being a pioneer*." A Rogers (reporter); Oct 31st; media article

Sustaining Industry Legitimacy by Embedding VG within the Industry

Proponents: firm and supporting stakeholders

Prevalence in firm-stakeholder interactions: Weeks 1-4. Interpretation gains momentum after NTSB's preliminary report, which ruled out the occurrence of an explosion. Interpretation further gains momentum after VG's retelling of its organizational identity.

Categories	Sub-categories	Supporting quotes and sources / Notes (where appropriate)
Interpretation of failure		
What happened?	**Failure qualified as 'anomaly'; 'incident'; 'accident'**	"*At approximately 10:12, we became aware of an in-flight anomaly and implemented our preplanned response plan.*" S. Witt (CEO Mojave Spaceport); Oct 31st; press conference
Why did it happen?	**Space exploration is a difficult and uncertain endeavor**	"*Travel to the edge of space and beyond has never been without risk. In the early days of the US program, rockets blew up on the launch pad or shortly after launch*." B. Knickerbocker (reporter); Nov 2nd; media article
Who owns the failure?	**All players in the industry symbolically share the failure**	"*When we have a mishap from the test community, we find the test community is very small. And we're human. And it hurts*." S. Witt (CEO Mojave Spaceport); Oct 31st; press conference
Role in legitimacy jolt		

Sustaining firm legitimacy	***Moral-procedural legitimacy*** • *Upholding VG's capabilities* • *Portraying VG as eager to learn* ***Moral-structural legitimacy*** • *Defending the social value of VG's product category* ***Pragmatic legitimacy*** • *Defending VG's technical sustainability* • *Defending VG's economic sustainability*	"*We make sure the engineers are in charge and that's what we've done from day one. The fact that the program has taken longer is a sign we are listening to the engineers. I find it ironic that people say we are rushing when the program has taken 10 years*." G. Whitesides (VG CEO); Nov 14th; media article "*We'll now comprehensively assess the results of the crash and are determined to learn from this and move forward together as a group of friends and a company*" Sir R. Branson (VG Chairman); Nov 1st; press conference "*The risks of space tourism are similar to those during the early development of commercial aviation … You go back to 1903 and air travel was seen as a pretty silly thing by a lot of people, and it was seen as something for the rich and famous or playboys. It changed to be democratised the way it is today*." B. Godfrey (client, former Virgin Blue CEO); Nov 8th; media article "*It's possible that test flights for the next spaceship could begin within six months, before the investigation is expected to conclude*." Agence France Presse (news outlet); Nov 7th; media article "*I have no intention of … getting a refund. I'm ready to rocket to outer space*." K. Baxter (client); Nov 1st; television newscast
Sustaining industry legitimacy	**Moral-procedural legitimacy** • Likening failure in commercial space to failure in nascent industries of the past **Moral-structural legitimacy** • Portraying all efforts in space as socially valuable **Pragmatic legitimacy** • Defending the attractiveness of space exploration to consumers and investors	"*In the early days of aviation there were incidents and then aviation became very safe. In the early days of commercial space travel there have been incidents and then, we hope, that one day the tests pilots will enable people to go into space safely*." Sir R. Branson (VG Chairman); Nov 2nd; media article "*Taming space for the benefit of all, unmasking its truths and using the boundless resources available to us [...] Taking a chance allows us to seek new horizons — and we all benefit from being horizon hunters*." B. Aldrin (former astronaut); Nov 8th; media article "*I desperately want to try space. I think that Vasco da Gama, if he was around today, would be exploring space. This is really exciting, to be able to push humanity beyond the boundaries of the Earth*." W. da Silva (client); Nov 6th; media article
Ultimate effects on legitimacy		
Player dynamics	**Embedding VG within the industry**	"*Virgin Galactic and Scaled Composites are engaged in one of the great efforts of our time: opening space for all humanity. That is a noble pursuit*." National Space Society (NSS); Oct 31st; press release
Industry boundaries	**Enhancing industry boundaries to encompass all space exploration (for profit and non-profit)**	"*Space is important to all of our futures. At the end of the day, one of the things that I think is most powerful is that we'll be able to get a new perspective on our planet as hundreds and eventually millions of people are able to go into space*." G. Whitesides (VG CEO); Nov 10th; media article