THE SAFETY OF THE FLYING PUBLIC: THE BOEING COMPANY AND THE FEDERAL AVIATION ADMINISTRATION VERSUS THE NATIONAL TRANSPORTATION SAFETY BOARD

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In July 2016, a traveler in New York was preparing to begin a journey that would take him back to his native Iran, after decades of living in the United States. This was going to be a month-long visit, and he was excited to take along his young US-born son. The lowest fares were offered by Azerbaijan Airlines, with a connection in Baku. Even though he knew little about Azerbaijan and its airline, he had not hesitated to purchase the tickets. On the day of departure at Kennedy airport, however, feelings of doubt and anxiety started to gnaw at him as he watched his restless ten-year old push the luggage cart toward the check-in counter. He had just discovered that the aircraft they were about to get into was a spanking new Boeing 787. He remembered the news headlines about the numerous incidents of battery fires on this type of aircraft as he held firmly his son's hand and reluctantly lurched forward toward the boarding gate.

Three years earlier, in January 2013, the Federal Aviation Administration (FAA) had ordered all Boeing 787 Dreamliner planes operating in the United States to be grounded immediately. Japanese and other foreign regulators followed suit. These drastic measures followed several incidents involving fires in the electrical systems of Boeing 787 Dreamliners, raising serious concerns about their safety. The problems that led to these mishaps could be traced to the lithium-ion battery technology used for the first time in these new planes. The 787-aircraft model represented a departure from past practice at Boeing in terms of the materials used to build the aircraft as well as the organization of the manufacturing process.

Faced with increased competition in the airline industry and the need to produce a fuel efficient long-range aircraft, Boeing, in the early 2000s, adopted a number of new and innovative technologies and components (Kotha, 2005). The new 787 was built with composite materials, including graphite, making it lighter and more fuel efficient. Boeing also changed the aircraft's electrical systems, selecting a no-bleed architecture powered by lithium-ion batteries. That is, power was not diverted from the main engines to charge its electrical system as had been done in

[1] This case has been written solely on the basis of published. Consequently, the interpretation and perspectives presented in this case are not necessarily those of the companies mentioned in the case, or of their employees.

previous models but was instead supplied directly from its batteries. This set-up improved fuel consumption and increased efficiency and reliability (Sinnett, 2007). [1]
However, in October of 2007, Boeing announced that it was pushing back the anticipated delivery of the first aircraft by six months and that development costs would increase by at least $700 million (Gates, 2007). After another series of delays, the aircraft which had originally had its first flight scheduled for 2007, finally had its first test flight in 2009 (Elahi et al., 2014). Initial delivery did not occur until 2011, approximately three years behind the original schedule (Gates, 2011). Initial development cost estimates of approximately $5.8 billion ballooned to over $15 billion by 2011.

Boeing also adopted a new approach to the manufacturing process for the 787 Dreamliner. Boeing's traditional approach to airplane production for all previous models was that its engineers would develop the design of the planes and suppliers would build the parts to their specification. In a novel approach developed for the 787, Boeing instead provided only the performance specifications to its suppliers (Kotha, 2005). Suppliers were then tasked with the actual design and manufacture of the several million pieces needed to build the plane.

The reconfiguration of the supply chain relied on approximately fifty tier-1 suppliers that assumed a leading role in organizing and integrating manufacturing and assembly operations. Companies such as Rolls Royce, GE, Mitsubishi and Thales belonged to this group. These suppliers in turn worked with their own suppliers. Thales of France, a tier-1 supplier, was the supplier of the electrical power systems. GS Yuasa of Japan, a manufacturer of lithium-ion batteries, and Securaplane, an Arizona-based producer of battery charging systems, were in turn suppliers to Thales.

Boeing's delegation of responsibility to tier-1 suppliers elevated them to the status of risk-sharing partners. These firms were now empowered to fund and conduct research to develop new technologies and systems. In taking this approach, Boeing copied the Toyota Production System which had a long history of success in the automotive industry (Cizmeci, 2005). The imitation of successful procedures or approaches in another industry, known formally as institutional isomorphism, was not unprecedented. Although this approach may have seemed financially attractive, it carried its share of risks, especially when applied on a very large scale.

The grounding of the 787's lasted 123 days. Significantly, the cause of the malfunction of the batteries remained unknown. "We may never get to a single root cause" said Michael Sinnett, Boeing's chief engineer (Tabuchi, 2013). In order to prevent further fire related problems in the future, Boeing and its suppliers redesigned the battery set-up. They also included a steel box enclosure to prevent any fire from spreading, as well as a new ventilation system to direct fumes outside the plane (Lebeau, 2013).

The passengers on the flight to Baku boarded the aircraft. Among them, the father and son located their row and the boy quickly laid claim to the window seat, leaving his father to settle uneasily in the middle seat. His unease had little to do with the constrained space to which he

would be confined for the next ten hours. He wondered how many passengers were aware of the checkered history of the Boeing 787. Was he overreacting? Can a parent be overly prudent when it comes to the safety of his child? What is the point of being remorseful now? These thoughts crossed his mind in rapid succession. He looked at the boy who was already immersed in video games provided by the in-flight entertainment system. Under normal circumstances, he would have objected, warning of electronic addiction and perhaps suggesting a book or simple conversation. On this occasion, however, he kept silent, as the plane roared down the runway and began is ascent into the blue sky, leaving the bustling JFK airport behind.

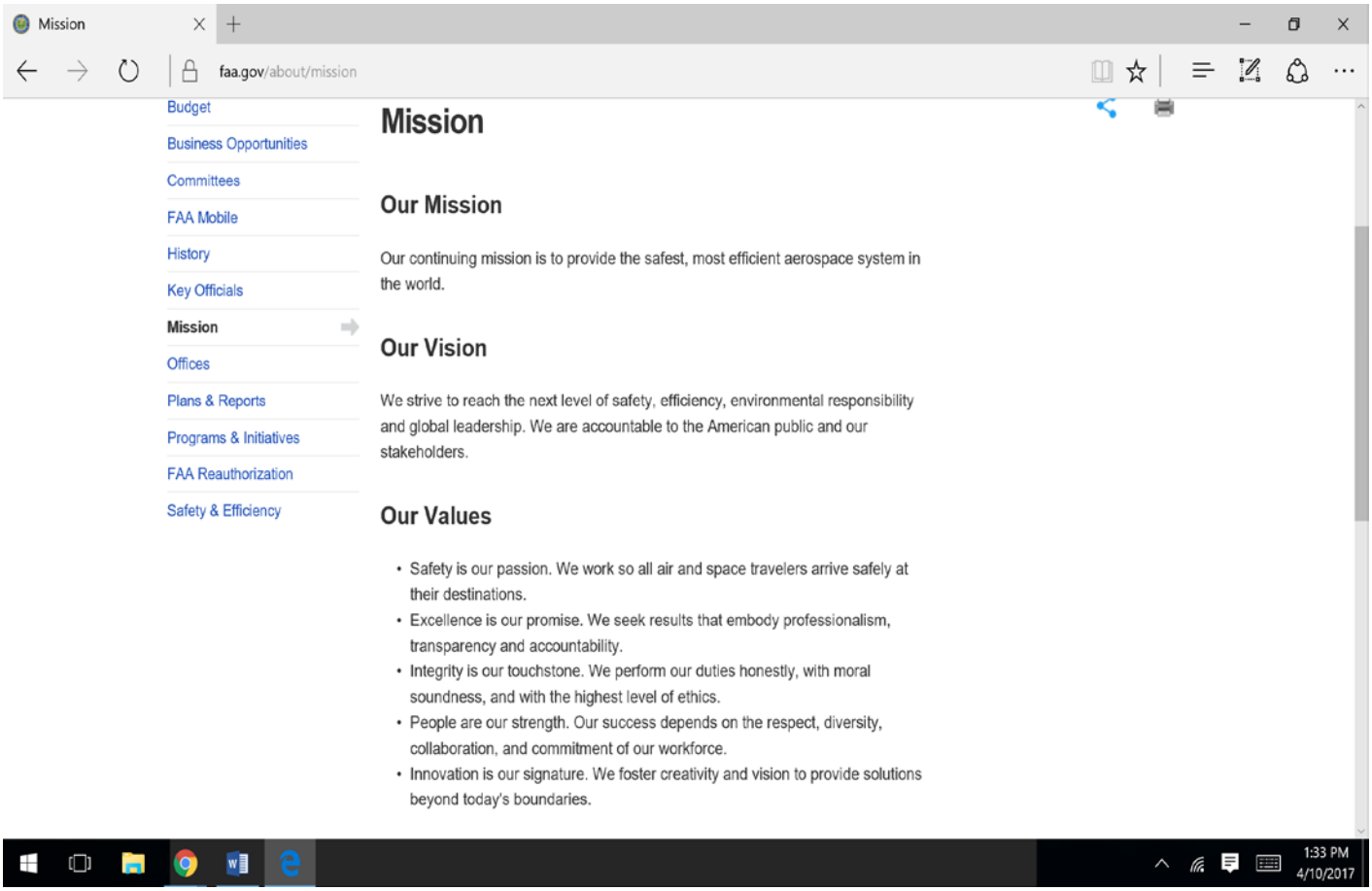
The development of air transportation and the need for oversight: the FAA and the NTSB

Known as New York International Airport or Idlewild when it opened in 1948, JFK airport is a node in the infrastructure needed to support air travel. The airline industry grew from a fledgling into a giant in a relatively brief span of time in the early and mid-twentieth century. As a consequence, the federal authorities charged with overseeing both airlines and plane builders also had to adapt quickly to this burgeoning industry. The lack of commercial experience with this form of transportation meant that the long-term growth potential was difficult to predict. The first regulations over navigable airspace took the form of the Air Commerce Act of 1926 (Kelly, 2000). It placed regulatory authority in the hands of a number of elements of the executive branch, including the President and the Departments of Commerce and Defense as well as the states.

The Civil Aeronautics Act in 1938 consolidated the preceding diffuse regulatory authority in one agency, the Civil Aeronautics Authority. In 1940, regulation of the differing, if not competing interests of the industry, commercial success on the one hand and flight safety on the other, were divided between the Civil Aeronautics Board- commerce (CAB) and the Civil Aeronautics Administration- safety (CAA) (Niles, 2002). Subsequently, in (1958) the CAB was reorganized into an independent regulatory agency, the Federal Aviation Agency.

Finally, in (1966), the FAA was transferred to the US Department of Transportation (DOT). However, in this final move a critical addition was made to its existing authority of regulating the safety of civil air travel. The FAA (now called the Federal Aviation Administration) was charged with the additional responsibility of fostering air commerce. The addition of this latter imperative has since created a dual mandate for the FAA. Many commentators, including former Secretary of Transportation, Federico Pena, have called for its re-examination (Niles, 2002). The FAA defines its mission as providing “the safest, most efficient aerospace system in the world” (Exhibit 1). To fulfill this mission, the FAA regulates civil aviation, promotes aviation technology and mitigates negative environmental impacts of the industry, among other roles.

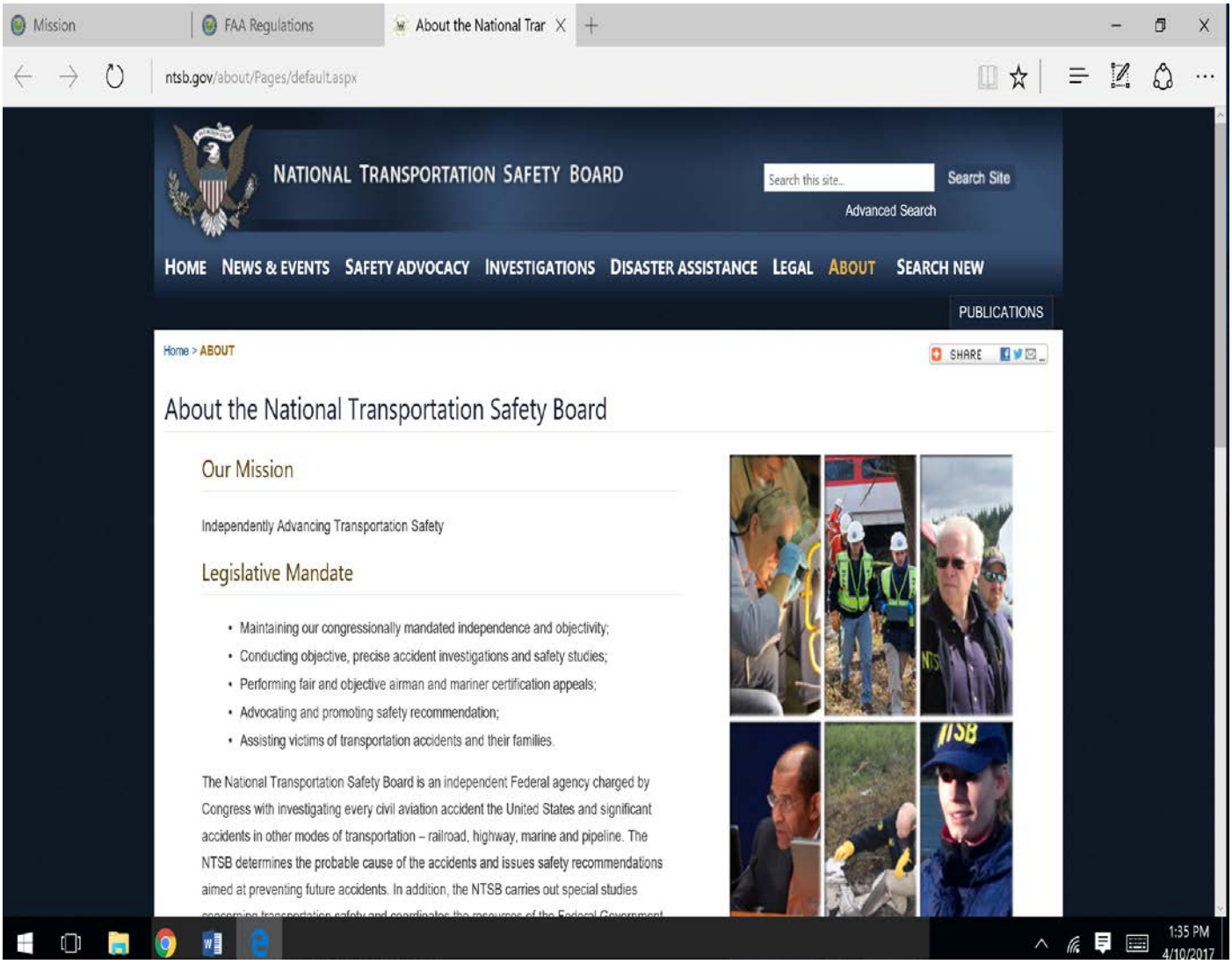
Figure 1- Mission, Vision and Values of the Federal Aviation Administration



FAA Website. Screenshot downloaded April 10, 2017 from https://www.faa.gov/about/mission/

In contrast to the FAA, the National Transportation Safety Board (NTSB) has no regulatory authority. Since its inception in 1926, the NTSB has been charged with investigating aircraft accidents and since 1967, accidents in all modes of transportation. Although the agency operated for a time as an independent entity within the DOT, in 1974 it became administratively independent. The change was deemed necessary to ensure the total objectivity of the investigative mission of the NTSB and to avoid any potential conflict of interest with the DOT. The DOT's activities to foster air commerce could potentially impact the safety or adequacy of transportation systems. These are areas that could come under scrutiny and criticism in the course of an investigation by the NTSB (Exhibit 2).

Figure 2- Mission and Legislative Mandate of the National Transportation Safety Board



NTSB Website. Screenshot downloaded on April 10, 2017 from https://www.ntsb.gov/about/Pages/default.aspx

Based on the results of its investigations, the NTSB makes recommendations to various transportation regulatory agencies including the FAA (Irving, May 28, 2014). It also conducts transportation related safety studies, issues safety reports and coordinates emergency responses in major transportation accidents. The NTSB considers its effectiveness to be dependent on a "reputation for conducting thorough, accurate and independent investigations and for producing timely, well-considered recommendations to enhance transportation safety" (Exhibit 2). As part of its mission, then, the NTSB investigated the string of incidents that had resulted in the temporary grounding of the Boeing 787 planes by the FAA.

As has been noted earlier, the NTSB has no power beyond investigation and recommendation, whereas the FAA has the power of regulation and certification (Exhibit 3). The FAA can be compared in this respect with other government agencies, such as the Food and Drug Administration (FDA) or the Environmental Protection Agency (EPA). All of these agencies are purveyors of regulations in their specific areas. It is clear that the regulations generated by these agencies to serve the public interest directly impact the fortunes of private business entities (Boddewyn & Brewer, 1994).

Table 1

Comparison of the Missions of the FAA and the NTSB

National Transportation Safety Board (NTSB)	**Federal Aviation Administration (FAA)**
The mission of the NTSB is • To investigate accidents in aviation, highway, marine, pipeline and railroad roads as well as accidents related to the transportation of hazardous materials • To coordinate Federal assistance of families of aviation accident victims (since 1996). This responsibility has been expanded to include all modes of transportation on a case by case basis Through its investigations and recommendations the aim of the NTSB is to enhance transportation safety.	The overall mission of the FAA is to provide the safest and most efficient aerospace system in the world. To support its mission the FAA: • Certifies commercial and general aviation aircraft • Ensures the safe, efficient and environmentally responsible operation of airports • Provides air traffic services • Conducts research to ensure the safety of aviation • Issues licenses and certificates to pilots, aircraft and airports • Develops regulations and policies • Provides training and testing

Source: www.faa.gov
www.ntsb.gov

The FAA deems the Boeing 787 safe to fly

On Monday May 20th, 2013, a United Airlines flight from Houston to Chicago ended the long hiatus during which the Dreamliner was grounded in the United States. To mark the occasion, two important business leaders were on board: the CEO of Boeing, James McNerney and the chief executive of United Continental Holdings, Jeff Smirsek (Drew, 2013). The two had reason to celebrate: the four-month grounding had been very costly in more ways than one. For United,

operating other types of aircraft on long-haul routes was expensive. The company had put 777's in service out of necessity, for flights like the one linking Shanghai and Los Angeles. In a quarterly earnings call, United CFO John Raimey said that the airline lost approximately $11 million due to the grounding (Gates, April 25, 2013) Moreover, the opportunity cost of having idle planes was high. In addition, United was the first US airline to operate the Dreamliner and the marketing advantage of this distinction was largely lost (Lebeau, 2013).

As for Boeing, various commentators in the business press advanced differing amounts and degrees of financial responsibility for the grounding. The FAA estimated a cost of approximately $465,000 per plane to fix the batteries. The total bill for new batteries for the fifty affected planes would have been over $23 million that outsiders thought Boeing would pay directly (Gates, April 25, 2013). In addition, a substantially greater amount was estimated to have been lost in revenue by the airline companies which could not fly the 787 during the 123-day grounding.

Mizuho Securities estimated that ANA by itself could have incurred approximately $1.1 million in additional costs for every day that the grounding lasted (Topham, Jan. 17, 2013). The other airlines flying the 787, including United Airlines and Japan Airlines, lost substantial revenue and incurred additional cost in substituting other planes to fly the routes designated for the 787. Boeing CEO Jim McNerney said that "there were no contractual obligations" to compensate airlines for lost revenues (Gates, April 2013). However, Clifford Irving, writing in The Daily Beast in June of 2014 opined that the grounding cost Boeing hundreds of millions of dollars (Irving, 2014) owed in undisclosed compensation to its customers.

The estimated total deferred cost of the aircraft reached over $26 billion in early 2014 (Basu, 2015). As a consequence, Boeing faced a very sizeable financial issue that demanded a quick fix to the Dreamliner's problems.

Boeing worked hard to convince regulators to approve its plans to address the safety concerns over the batteries' malfunction issue and allow the planes to fly again. In parallel with the efforts focused on the battery issue, a team charged with a broader review of the Boeing 787-8 critical systems, made up of FAA as well as Boeing employees, was formed. Such reliance on the manufacturer is not unusual in the certification process, as the regulator had neither the financial resources nor the technical expertise to conduct testing on its own (Pasztor & Ostrower, 2013).

Indeed, regulators in many industries work closely with manufacturers and the aerospace industry is no exception. The team's report had been prepared for the Director of Aircraft Certification Service at the FAA, Dorenda Baker and for the Vice President of Boeing's Design Center, Daniel Mooney. In a letter addressed to Ms. Baker and Mr. Mooney, the two co-chairs of the Critical Systems Review Team (CSRT), Michael Kaszycki of the FAA and Richard Ptacin of Boeing, jointly stated that over six months starting from January 31, 2013, their team members "used their expertise and exercised independent judgment to validate the work conducted during the Boeing 787-8 certification process" (FAA Report, p. VI, 2014). The CSRT concluded that the 787 met its safety requirements, since the aircraft's design was sound and adequate processes had been developed to address problems that had arisen during and after certification.

The CSRT did recommend improvements in the communication of design requirements to the Tier 1 and relevant Tier 2 suppliers. Many observers had noted that the drastic departure from past practice both in terms of technology and in terms of outsourcing may have been the cause of the battery malfunctions. The CSRT, however, determined the primary cause of the various issues facing the Dreamliner "was not the novelty of the technologies" (FAA Report, p. IX, 2014). The CSRT acknowledged some deficiencies in suppliers' relations, but it added that Boeing had taken measures to address those deficiencies. Some difficulties were attributed to the learning curve experienced by suppliers, implying that there were temporary bumps in the road that was nevertheless fundamentally sound.

In sum, after a review of engineering and manufacturing processes for the 787 Dreamliner, the review team found "existing processes for problem reporting, product improvement, manufacturing quality assurance and continuous operations safety to be effective in addressing the issues investigated" (FAA Report, p. XII, 2014). The report, completed a few months after the 787 was deemed safe to fly again, did not address the issue of the battery fires directly.

The National Transportation Safety Board (NTSB) disagrees

The approval of the FAA and its reassurances about the safety of the Boeing 787's did not put to rest the serious concerns about the safety of the planes among other stakeholders. Some experts raised alarms about the FAA certification process itself, which although satisfactory in the past, may not have been sufficiently rigorous now to deal with the new approaches introduced by Boeing with this model (Pasztor & Ostrower, 2013). During the thousands of hours of testing the 787 in the summer of 2011 before the FAA certified it to fly, battery safety issues did not prompt re-evaluation by senior FAA officials (Pasztor & Ostrower, 2013). Kitty Higgins, a former member of the National Transportation Safety Board (NTSB) asked whether the FAA's certification systems and processes were "where they needed to be" given the technological advances of the aircraft (Pasztor & Ostrower, 2013).

The NTSB seemed to have serious reservations about the safety of the 787 Dreamliner airplanes. In a letter addressed to the FAA dated May 22, 2014, the Acting Chairman of the NTSB, Christopher Hart, urged the FAA to take swift action following the battery malfunction incidents that marred the commercial debut of the Boeing 787 (Hart, 2014). The NTSB noted that neither the tests of the lithium-ion battery conducted by GS Yuasa, the manufacturer, nor those conducted by the Board's own experts were entirely satisfactory because "design and environmental factors, such as installation interfaces and/or ambient temperature conditions to which the battery was exposed, could affect test results" (Hart, 2014). The NTSB concluded that to ensure safety tests of the batteries were valid, the batteries must be configured in the same manner as they had been installed on the plane in order to know conclusively how they would react under various conditions.

In addition, the NTSB expressed concerns about the reliability and repeatability of tests conducted so far. In other words, the test methods used could be questionable. The NTSB recognized that reliance on the manufacturer's expertise is an unavoidable part of the

certification process. However, the NTSB recommended reaching out to independent experts outside the industry for the certification of airplanes that incorporate so much new technology.

To conclude its letter, the acting chairman of the NTSB made five specific recommendations. These were: 1) develop an appropriate test of the battery that replicates the actual aircraft interface and subject the battery to conditions producing the worst damage 2) mandate manufacturers' testing the batteries that have been permanently installed 3) reach to outside experts to design tests that simulate the battery malfunction 4) review certification procedures and perform additional tests, if needed and, last but not least, 5) create a panel of independent experts as an advising board to make recommendations on testing and safety of new technology and develop best practices in the area.

The popular press picked up immediately on this difference in approach between the FAA and NTSB stressing the significance of the five safety recommendations made by the NTSB concerning the lithium-ion battery (Jansen, 2014). Clive Irving of The Daily Beast (Irving, 2014) devoted a considerable article to this disagreement describing the NTSB as "plainly unhappy" with the steps taken to that date by the FAA to understand the risks posed by the Lithium-ion batteries. He went on further to indicate that the FAA "immediately swatted away" a recommendation to create a panel of independent experts to advise it on testing new technology (Irving, 2014).

Indeed, the FAA reacted quickly to this recommendation by declaring that it was "already working closely with domestic and international battery experts…" In fact, there was such a body charged with establishing appropriate protocols for testing lithium-ion batteries to ensure that they could be approved as being safe for use by the aviation industry. This body was known as the Special Committee of the Radio Technical Commission for Aeronautics (RTCA), based in Washington, DC and created in 2011 (Irving, 2014). The standards developed by this Special Committee were used by the FAA in its certification process. However, despite their expertise, members of this committee may have had difficulty keeping up with the rapidly changing technology.

Perhaps of greater significance, many members of the Committee were representatives of manufacturers of lithium-ion batteries. This situation was quite understandable but also troubling. The Committee had to rely on technical expertise from the industry that it was tasked with overseeing. In addition, two Boeing employees were members of the Committee and a third, was its Chair. These individuals possessed, doubtlessly, valuable and much needed technical knowledge (Irving, 2014) but their presence created a perceptual issue.

On December 1, 2014, the NTSB issued its final report on the Japan Airlines Boeing 787 fire at Boston Logan Airport on Jan. 7, 2013 (NTSB/AIR-1/-01). The NTSB's report mirrored positions previously communicated in its letter of May 22, 2014. Among other points made concerning safety issues were the following: 1) Cell manufacturing defects (for the Lithium-Ion battery) and oversight of the cell manufacturing processes by GS Yuasa were of concern and the chain of oversight responsibilities, FAA of Boeing, Boeing of Thales and Thales of Yuasa did not ensure that the cell manufacturing process was consistent with established industry practices

and 2) the FAA certification engineers did not possess FAA certification orders that clearly indicated the manner in which individual special conditions should be traced to test procedures or test reports in a certification plan.

The NTSB determined that "the probable cause of the Boston fire was an internal short circuit within a cell of the APU (auxiliary power unit) lithium-ion battery which led to a thermal runaway that cascaded to adjacent cells resulting in the release of smoke and fire." (NTSB/AIR-14/01). The NTSB made safety recommendations to the FAA, Boeing and GS Yuasa in order to prevent further fires in the future.

On board Azerbaijan Airlines flight 102 to Baku, the passenger in the middle seat next to a now sleeping child, was restless after more than ten hours that had seemed like an eternity. He reached for the window and raised the blind. It was early morning in the Caucasus and the plane had started its descent. He leaned forward and looked down at the gleaming waters of the Caspian Sea. He remembered his own childhood summers spent on the south coast of the inland sea. These were fond memories and for the first time, the dark thoughts that had tormented him throughout the journey receded. As the airline public address system announced the imminent landing and the young boy stirred and opened his eyes, he pointed out to him the boats that crisscrossed the blue waters. He promised to take him to the beach for a few days. The Boeing 787 landed and soon after, the relieved passenger and his son were waiting at the gate for the Embraer regional jet aircraft that would take them to their final destination.

Oversight challenges under a new paradigm

As stated earlier, the manufacturing approach of the 787 represented a radical departure from past practice at Boeing. The implementation of new technologies as well as the increased reliance on suppliers made the task of oversight critical for Boeing. However, the devolution of responsibilities to the supplier network and the loss of in-house expertise made it more challenging for Boeing to exercise that oversight effectively. The Federal Aviation Administration provided a second line of defense as far as safety was concerned. According to the NTSB, however, that defense was compromised by the modus operandi of the FAA regulators, i.e. the process through which they gathered information and issued their certifications. Although Kenneth Quinn, the attorney for GS Yuasa indicated that this was the most investigated battery incident ever, it remained that the cause of the short circuits and fires were never determined.

In fact, the Critical System Review Team did not address that issue at all. Instead, the seven Boeing employees and six FAA representatives that made up the team validated Boeing's corrective actions and the processes in place, in particular, inspection delegation to suppliers. Their joint report simply formulated recommendations to strengthen the existing procedures, in particular vis-à-vis the suppliers' network.

Specialized expertise about state-of-the-art technologies was not widely distributed and experts were likely linked to the industry. The decentralization of the production process meant that suppliers tested components prior to installation and use. Parts that had been installed and were in use may, however, have reacted differently to the conditions in their new environment, as the example of the lithium-ion batteries demonstrated. The FAA procedures may have been adequate for the traditional plane assembly management at Boeing, where a fundamental premise of suppliers' relations was strong central control. The new paradigm, however, uprooted old certitudes and may call for a review of the FAA's procedures and processes.

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