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THE NATIONAL TRANSPORTATION SAFETY BOARD: A MODEL FOR SYSTEMIC RISK MANAGEMENT

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We propose the National Transportation Safety Board (NTSB) as a model organization for addressing systemic risk in industries and contexts other than transportation. When adopted by regulatory agencies and the transportation industry, the safety recommendations of the NTSB have been remarkably effective in reducing the number of fatalities in various modes of transportation since the NTSB's inception in 1967 as an independent agency. The NTSB has no regulatory authority and is solely focused on conducting forensic investigations of transportation accidents and proposing safety recommendations. With only 400 full-time employees, the NTSB has a much larger network of experts drawn from other government agencies and the private sector who are on call to assist in accident investigations on an as-needed basis. By allowing the participation in its investigations of all interested parties who can provide technical assistance to the investigations, the NTSB produces definitive analyses of even the most complex accidents and provides actionable measures for reducing the chances of future accidents. It is possible to create more efficient and effective systemic-risk management processes in many other industries, including financial services, by studying the organizational structure and functions of the NTSB.

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1 Introduction

The National Transportation Safety Board (NTSB) is an independent federal agency with a mandate to investigate accidents and promote safety in the transportation industry. With its reputation for independence and objectivity, the NTSB is widely regarded as an authoritative voice in transportation safety, and one of the most admired agencies in the federal

government. Through its detailed accident investigations, direct and unequivocal recommendations for safety improvements, and plainspoken real-time communication with the public at the start of a major accident's media barrage, the NTSB has earned the public's trust and confidence in ways that few other government agencies can match. The objective of this study is to understand the key factors underlying the effectiveness of the NTSB so as to derive lessons that may be profitably applied to other industries.

Of course, we acknowledge at the outset that certain unique features of the transportation industry contribute to the NTSB's success. Transportation accidents are almost always limited in scope and time, which makes it possible to conduct in-depth forensic[1] investigations that result in concrete conclusions and actionable remedies. Such accidents are also typically well-defined, with causes that are usually identifiable upon detailed examination, allowing the NTSB to be largely reactive yet still highly effective. Finally, and perhaps most significantly, no one benefits immediately from a transportation accident. Therefore, all stakeholders are united in their desire to improve safety. As Jeff Marcus, an NTSB safety specialist, put it, "You can trust people to be honest and moral about not killing themselves." This last point may seem obvious, but in other industries, certain parties may profit handsomely from crises that inflict enormous pain on others.

Despite these features of transportation, the NTSB's enviable record of success deserves further study to determine which of its methods are applicable to other technology-based industries such as financial services, healthcare, and energy, all industries in which "accidents" arise from the failure of complex systems, i.e., systemic risk. This is the challenge we undertake in this article.

By examining the structure and functions of the NTSB, and studying a specific accident investigation in detail, we observe five major factors that seem to characterize the agency's success: (1) the governance structures that give rise to the agency's impartiality and singular focus; (2) the investigative "Go Team" as a cohesive unit; (3) the collective intelligence of the NTSB's "party system"; (4) effective media relations; and (5) employee satisfaction. While some of the NTSB's practices are indeed specific to the transportation industry, we believe that the most important drivers of its success can be adapted to other industries and contexts.

We begin in Section 2 by providing a brief organizational overview of the NTSB. In Section 3, we focus on the most important aspect of the NTSB: its accident-investigation process. To illustrate how this process works, we present a case study of the NTSB's investigation of the Minnesota I-35W highway bridge collapse in Section 4. Based on this example and other observations, we summarize the organizational factors that contribute the most to the success of the NTSB in Section 5. In Section 6, we consider some of the current challenges facing the NTSB, and we conclude in Section 7.

2 The NTSB organization

The NTSB can be traced back to the Air Commerce Act of 1926, which eventually led to the establishment of the Civil Aeronautics Board's Bureau of Safety in 1940. Beginning in 1967, the NTSB emerged as an independent agency within the Department of Transportation (DOT), and was later reestablished as a completely independent entity outside of DOT by Congress through the Independent Safety Board Act of 1974 (see Appendix A.1 for key facts and figures of the NTSB). A lean organization of about 400 employees, the NTSB is charged with investigating every civil aviation accident and all significant highway, marine, railroad, pipeline, and

hazardous-materials accidents. From these investigations, the NTSB first identifies the cause of the accidents and, thereafter, develops safety recommendations for preventing similar accidents in the future.

Significantly, the NTSB has no regulatory authority; the Federal Aviation Administration regulates the airline industry, the National Highway Traffic Safety Administration and the Federal Motor Carrier Safety Administration regulate motor vehicle transportation, the United States Coast Guard regulates civil waterborne transportation, and the Pipeline and Hazardous Materials Safety Administration regulates pipelines and hazardous materials. The NTSB is primarily responsible for conducting investigations to determine the causes of accidents and making safety recommendations.[2] This lack of regulatory powers may seem to be a disadvantage; after all, how can an agency have impact without the authority to carry out its recommended courses of action? In fact, the absence of rule-making responsibilities preserves the NTSB's objectivity in its investigations, allowing it to identify regulatory gaps and failings as well as engineering flaws, and can therefore issue the most objective recommendations to improve safety. This important feature is described explicitly in the NTSB's strategic plan (*NTSB Strategic Plan 2010–2015*, pages 6, 7):

> In 1974, Congress reestablished the NTSB as a completely separate entity, outside the DOT, reasoning that '… No federal agency can properly perform such (investigatory) functions unless it is totally separate and independent from any other … agency of the United States.' Because the DOT has broad operational and regulatory responsibilities that affect the safety, adequacy, and efficiency of the transportation system, and transportation accidents may suggest deficiencies in that system, the NTSB's independence was deemed necessary for proper oversight.
>
> The NTSB, which has no authority to regulate, fund, or be directly involved in the operation of any mode of transportation, conducts investigations and makes recommendations from an objective viewpoint.

This paradox of less regulatory authority yielding greater influence is one of the most striking characteristics of the NTSB, and in this section we shall attempt to deconstruct and explicate the mechanisms by which this small agency has been able to achieve so much.

2.1 The NTSB board

The NTSB is governed by a five-member board, with each member nominated by the President and confirmed by the Senate to serve a five-year term. One of the board members is designated by the President as the Chairman and another as Vice Chairman, each for a two-year term, with separate Senate confirmation required of the Chairman. The Chairman oversees the entire organization as its "Chief Executive Officer." The Managing Director, reporting directly to the Chairman, is, in effect, the "Chief Operating Officer" of the organization, running the day-to-day operations of the NTSB and providing ongoing management to the civilian workforce (see Figure 1 for the NTSB's current organizational chart).

The NTSB's board members do not report to the Chairman of the Board and, except for the Chairman, they are not involved in the day-to-day management of agency operations. Therefore, once nominated by the President and confirmed by the Senate, each board member is free to focus solely on the mission of transportation safety. This structure maximizes the independence and objectivity of each board member, one of the most important factors in producing impartial investigations and safety recommendations. Moreover, the NTSB staff does not report to the board members (with the exception of the reporting relationship to the Chairman through the Managing Director), which imbues the investigative staff—whose technical expertise and judgment form the very foundation of the NTSB—with the same sense of impartiality and purpose.

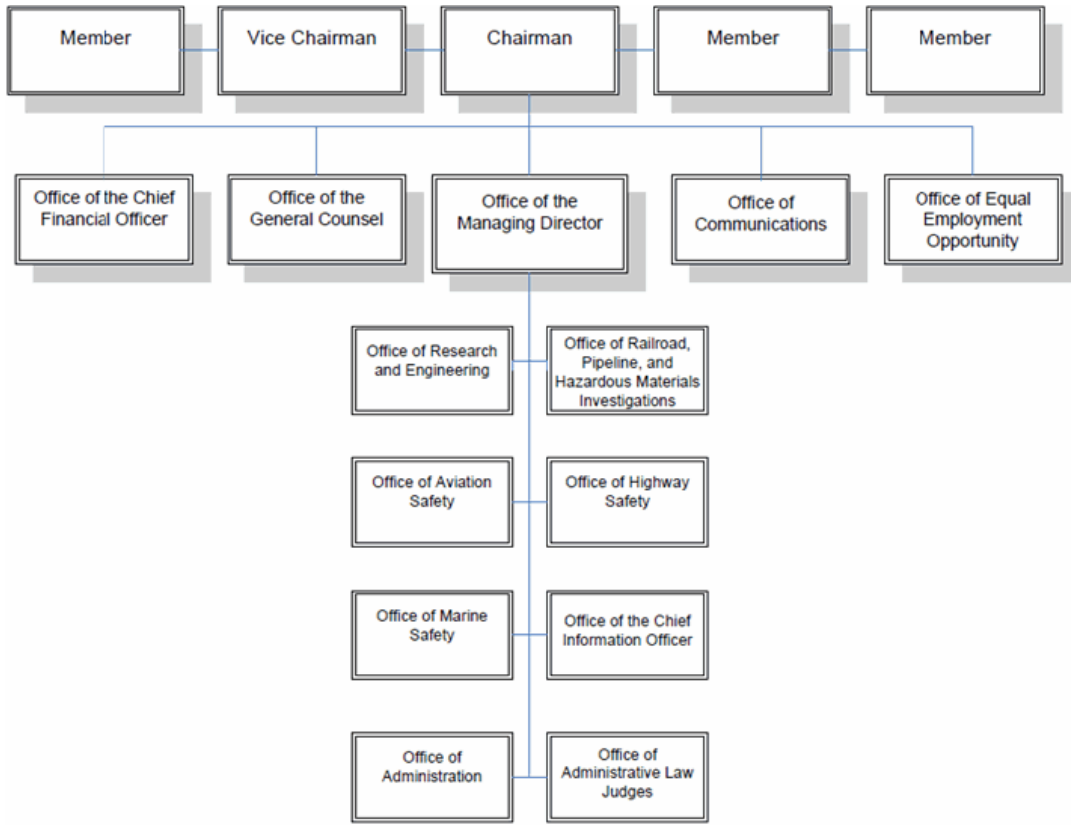


Figure 1 Organizational chart of the NTSB. Source: NTSB website http://ntsb.gov/Abt_NTSB/orgchart/org.htm.

The primary focus of the board members is to promote transportation safety by determining the probable causes of accidents and issuing safety recommendations, which take center stage at board meetings where each board member holds equal voting power and the majority prevails. In addition, one board member is always on the scene of each major accident investigation and serves as the NTSB's spokesperson for that investigation. For example, Chairman Hersman has been the "Member on-scene" for 19 major investigations during her tenure at the NTSB (as of October 27, 2010; see http://ntsb.gov/Abt_NTSB/member.htm).

Given the responsibilities of the board, members must have the necessary expertise to render informed judgments in accident investigations; hence, it is mandated that at least three out of the five board members be technical experts. By these standards, all five current board members qualify: Chairman Hersman had extensive transportation legislative experience prior to the NTSB; Vice Chairman Hart is a pilot with a Master's Degree in aerospace engineering; Dr. Rosekind is an internationally recognized expert in human fatigue; Dr. Weener is a long-time chief engineer in aerospace engineering; and Mr. Sumwalt served as a commercial airline pilot for 32 years (see Appendix A.2 for biographies of all the current board members). Each of the current board members came to the NTSB with extensive experience with or in the transportation industry, and during their tenure at the NTSB, they develop a comprehensive understanding of all aspects and modes of the industry, which is evident from board-meeting discussions.

To further ensure the objectivity of the board, it is mandated that no more than three members belong to the same political party. Last, but not least, the members are appointed for fixed terms, as opposed to serving at the pleasure of the President, so they cannot be removed for political reasons or unpopular views and decisions.

The purpose of these safeguards is to help assure that NTSB decisions are made as much as possible on the basis of the evidence, and as little as possible on the basis of the politics.

The board meetings of the NTSB are where accident investigations are discussed and conclusions and recommendations are finalized (see Appendix A.3 for a summary of a typical board meeting). Staff members present their findings and proposed recommendations in the form of an accident report, and board members vote on the probable cause of the accident as well as safety recommendations stemming from that accident. The independence of each board member and the staff, and the culture of openness at the NTSB, can make these meetings intense events with a great deal of discussion and debate, often accompanied by arcane technical details gleaned from the investigation.

Under the Government in the Sunshine Act, all NTSB board meetings are open to the public and, under current practice, are available via webcast. Moreover, while board members are allowed to consult with each other individually in private, three members legally constitute a quorum for a meeting, and a quorum can meet to discuss official Board business only if the public notice and other process requirements of the Sunshine Act have been satisfied.[3] The opening and closing comments, as well as presentations, are also available at an NTSB website (http://www.ntsb.gov/events/Boardmeeting.htm).

2.2 The party system and public hearings

Given the resource constraints of the agency, it is impossible for NTSB investigators to know all the details of every aircraft, vehicle, or transportation mode involved in an accident, all of the operational policies and procedures of the carriers involved, all the nuances of air traffic control, and all of the applicable regulatory guidance. To leverage its limited resources, the NTSB designates other organizations and external parties to participate in its investigations,[4] creating a much more nimble, intelligent, and dynamic organization. This "party system" has become integral to NTSB accident investigations as transportation systems have become more complex, knowledge more specialized, and organizations more interconnected. The party system allows the NTSB to focus on its core competencies of managing complex investigations and developing theories from myriad facts and data sources, and is one of the primary sources of the NTSB's reputation and pride.

This unique party system is "by invitation only"; as described by the NTSB (http://www.ntsb.gov/abt_ntsb/invest.htm):

> Other than the FAA, which is by law automatically designated a party, the NTSB has complete discretion over which organizations it designates as parties to the investigation. Only those organizations and corporations that can provide expertise to the investigation are granted party status and only those persons who can provide the Board with needed technical or specialized expertise are permitted to serve on the investigation; persons in legal or litigation positions are not allowed to be assigned to the investigation. All party members report to the NTSB during the investigation.

The parties are responsible for the accuracy of the facts summarized by the NTSB in its factual reports (called "group factual reports" in major accident investigations undertaken by multiple parties).

By using outside experts and interested parties who can provide technical assistance to accident investigations, the NTSB also creates a much more inclusive atmosphere for all stakeholders involved. This cooperative approach to accident investigation is largely responsible for transforming a naturally adversarial finger-pointing exercise into a collaborative effort to uncover the truth. Most parties are more than willing to participate since it provides them with initially privileged and timely access to information from the ongoing investigation, as well as an opportunity to provide the investigators with additional information that may affect the course of the investigation.[5] However, even parties who are reluctant to participate because of potential liabilities usually do so since the relevant information is likely to emerge eventually (in particular, the NTSB has the authority to issue subpoenas to obtain the information they need).

However, while parties are used in the fact-gathering phase of an investigation, they are not permitted to participate or be involved in the formal analysis, which is performed by internal NTSB staff only and is not disclosed to the public until the board meeting.[6] This limitation allows the NTSB to maintain full control of the investigation despite the active involvement of external participants. Parties are, however, allowed to submit analyses—their "side of the story"—to the NTSB for consideration. Any analysis the parties choose to offer is limited to a "submission" under NTSB rules: the submission must be served to the other parties involved in the investigation, and the results are put in a public docket item that displays the offerings made by the party under this limited role in NTSB analysis. After this public submission, the parties have no further role in the NTSB's deliberations.

Another method used by the NTSB for gathering information, and for providing transparency and accountability to the public and the media with respect to its investigation, is the public hearing. As described by the NTSB (http://www.ntsb.gov/abt_ntsb/invest.htm):

> The Board may hold a public hearing as part of a major transportation accident investigation. The purpose of the hearing is two-fold; first, to gather sworn testimony from subpoenaed witnesses on issues identified by the Board during the course of the investigation, and, second, to allow the public to observe the progress of the investigation. Hearings are usually held within six months of an accident, but may be delayed for complex investigations.

Hearings are focused on information-gathering rather than fault-finding, hence they tend to be highly technical and less like legal or congressional hearings. During these proceedings, board members, assisted by a Technical Panel consisting of the NTSB staff, will question the witnesses, who have been selected because of their ability to shed light on the accident under investigation.[7]

The NTSB has a preferred practice of releasing some factual information through open public dockets before a board meeting is held to support formal hearings or to provide the public greater information about the ongoing investigation. This practice minimizes interference with or intrusions into the analytical process by external parties due to discovery needs in litigation, public or congressional calls for information, or regulatory oversight.

2.3 Conflicts of interest

While conflicts of interest inevitably arise and must be addressed by the appropriate policies and procedures, the integrity of the board members and NTSB employees is the ultimate gatekeeper of such conflicts. Each of the board members and employees undergoes a rigorous ethical review process and is subject to ongoing restrictions such as not having any financial interests in transportation-related companies so

as to minimize actual and potential conflicts (see Appendix A.4 for details on the ethical review process for board members and employees).

The NTSB pays special attention to the potential conflict of interest when its employees and board members come from or return to the private sector. For example, an NTSB employee who is newly hired from Boeing will not be permitted to serve as a lead investigator on an accident involving a Boeing aircraft during the first year of her employment (a "cooling off" period), and may never be allowed to participate in NTSB investigations of aircraft components she was directly responsible for during her tenure at Boeing. Other restrictions apply to departing NTSB staff. The general principles upon which the restrictions are based are outlined in the "14 Principles of Ethical Conduct for Government Officers and Employees," and the NTSB has a team of ethics officials to ensure compliance and address more complex conflicts on a case-by-case basis.

To further reduce the potential for conflicting agendas, stakeholders' attorneys, and insurance companies are excluded from the NTSB party system so as to help keep the investigation process from becoming adversarial and to insulate the NTSB's deliberations from the legal and financial considerations that might be associated with an accident.

3 The investigative process

While the independence of the NTSB gives it a unique vantage point, the lack of regulatory authority over any transportation sector poses an interesting challenge to the organization, and yet it has yielded some remarkable results. As noted in its strategic plan (*NTSB Strategic Plan 2010–2015*, page 7), "Because the NTSB has no formal authority to regulate the transportation industry, the effectiveness of the NTSB depends on its reputation for conducting thorough, accurate, and independent investigations and for producing timely, well-considered recommendations." In the absence of regulatory powers, the only means for the NTSB to maintain its relevance is the quality of its analysis, which is manifested in its accident investigations.

Although major transportation accidents are rare events, they capture tremendous media attention and public interest when they occur. If not managed properly, they can become fertile ground for speculation, rumor, and panic, which explains the NTSB's congressional mandate to investigate all aviation accidents as well as significant accidents in other modes of transportation.[8] Given the limited resources of the NTSB, judgment must be exercised in deciding which accidents should be investigated, and which accidents are chosen is still more of an art than a science. For all transportation modes except aviation, the agency uses formal risk criteria to ensure a number of issues are considered before making a final determination. Over the years, and partly in response to recommendations from the U.S. Government Accountability Office (GAO), the NTSB's selection process for its accident investigations have become more transparent, objective, and systematic. The clarity and openness of the investigative process are crucial not only to the mission of the NTSB, but also to its credibility.

3.1 The NTSB "Go Team"

Once an accident investigation is launched, an Investigator-in-Charge (IIC)—typically a senior investigator with considerable technical and management experience—is appointed to lead and oversee the entire investigation. For larger accidents, the IIC will assemble a "Go Team" of several forensic engineers who will accompany the IIC to the accident scene as quickly as possible. For example, the Go Team for the accident on February 12, 2009 involving Colgan Air, Inc.

Figure 2 Colgan Air, Inc., operating as Continental Connection Flight 3407, crashed into a house near Buffalo, NY at 22:17 EST on February 12, 2009, causing a post-crash fire, and killing all 49 on board and 1 person in the house. The NTSB was notified immediately, and the NTSB Go Team, headed by IIC Lorenda Ward, arrived at the scene early the next morning. Former board member Steven Chealander was the spokesperson accompanying the Go Team on the scene. See Appendix A.5 for details about the accident and the investigation. Source: NTSB Annual Report (2009, page 31).

operating as Continental Connection Flight 3407 (Figure 2) was led by IIC Lorenda Ward, and staffed with 14 investigators having expertise in the areas of operations, human performance, air traffic control, and meteorology among others. Each specialist in the Go Team heads a working group or "subcommittee" in his or her domain of expertise, and each subcommittee is staffed by the representatives of the parties involved, providing an unusual level of employee empowerment (see Section 2.2 for details of the party system). In addition to these technical experts, other parties to the Colgan Air accident investigation were the FAA, Colgan Air, the Air Line Pilots Association (ALPA), the National Air Traffic Controllers Association, and the United Steelworkers Union (flight attendants). Bombardier, the manufacturer of the aircraft, participated as the technical advisor to the Accredited Representative from Canada. A public hearing for Colgan Air Flight 3407 was also held from May 12 to May 14, 2009.

IICs and investigators are assigned to Go Teams on a rotational basis, and during their duty rotation, they are on-call 24 hours a day with the tools of their trade—flashlights, tape recorders, cameras, personal protective equipment, etc.—ready to be deployed at a moment's notice. This rotational arrangement fosters cross-pollination and prevents information silos by giving investigators opportunities to work with different colleagues, through which they develop broad expertise and a wide network of valuable contacts.

3.2 Communicating with the media

Communicating with the media and the public is a critical component of the NTSB's responsibilities, especially at the early stages of a major

accident investigation. This is an often underappreciated aspect of crisis management in which rumors, fear, and panic are counteracted with hard facts and deep expertise. The NTSB actively engages in informing the public through the following mechanisms:

- **Board Member Spokesperson.** Upon launching a major investigation, one of the members of the board accompanies the Go Team and serves as the NTSB spokesperson, holding media briefings at least once a day. The Member on-scene is supported by an NTSB public affairs officer who serves as full-time liaison to the press throughout the duration of the on-scene accident investigation.
- **Press Releases.** The NTSB offers regular press releases and email alerts to inform those who sign up of the latest happenings at the NTSB.
- **Transparency.** Thanks to the 1976 Government in the Sunshine Act, much of the Board's business is conducted in the public domain, with Board meetings and public hearings open to the public and available via webcast. A public docket is published during the investigation to support the factual findings and analytical work of the NTSB.
- **Web-Based Archive.** The NTSB maintains an extensive web-searchable public docket which includes all factual information from accidents, the analyses from party members, and the final accident reports. The NTSB also offers public access to its extensive safety recommendation database.

Only factual information is released during the on-scene investigation; conjectures, conclusions, and editorial remarks are strictly prohibited. Over time, the NTSB has discovered—as any emergency room doctor can attest—that timely, clear, and honest communication of the facts has a calming effect on the general public, building credibility and creating trust in the NTSB investigation process.

3.3 The accident report and safety recommendations

The culmination of an NTSB Go Team's accident investigation is the accident report, a public document that outlines the probable cause of the accident and lists specific safety recommendations based on the data gathered from the investigation and subsequent analysis conducted by internal NTSB staff investigators. Accident reports make clear distinctions between facts and analysis, and typically contain four major sections starting with factual information, followed by analysis, then conclusions and, finally, recommendations. As described in Section 2.2, external parties who may have been involved in the fact-gathering phase of the investigation are not part of analysis and report writing, but are allowed to submit their own analyses and proposals for probable causes and safety recommendations, which become part of the public docket.

Significantly, while there are no restrictions regarding the use of the facts that the NTSB places in the public docket, the NTSB's accident report is inadmissible as evidence in lawsuits for civil damages, which prevents the NTSB from playing any judicial role and allows it to focus solely on its primary mandate of information-gathering, analysis, and safety recommendations.[9] Moreover, the NTSB's regulations provide that its employees cannot be subpoenaed to testify as witnesses in suits for civil damages, otherwise its staff would likely be mired in endless legal entanglements from criminal and civil proceedings associated with transportation accidents. However, it does, in accordance with its rules, permit extremely limited depositions on factual matters only in civil lawsuits. The NTSB receives numerous requests for such depositions, which are typically held during the discovery phase of litigation and attended

by a court reporter and attorneys from both sides, during which factual information is reviewed, but no analysis is provided.[10]

Safety recommendations are, of course, the most important product of the NTSB, and need not be limited to direct causes of the accident.[11] Sometimes the investigation reveals recurring issues that have been reflected in safety recommendations from previous accident reports, and the Board may reiterate certain recommendations to speed up the adoption process. If, in the course of an accident investigation, the NTSB discovers potential safety concerns that warrant immediate attention, it will issue recommendations immediately regarding those potential concerns rather than awaiting the completion of the final accident report.[12]

A draft accident report is prepared by career (i.e., not politically appointed) NTSB investigative staff, and before being submitted to the board for approval, it must also be approved by the NTSB's Office of Research and Engineering (RE), a separate group that serves as a general resource for all the NTSB modal offices. RE provides technical support for investigations, conducts separate safety studies, and serves as a repository for broad-ranging expertise, especially in the area of emerging safety issues. RE staff tend to be specialists, but with experience in all modes of transportation and with many forensic techniques, their expertise is applied generally across the NTSB. RE is considered the scientific core of the NTSB, providing yet another layer of independence and analytic oversight for the organization.

Once approved, the accident report is submitted to the five NTSB board members, and each board member can meet with staff to discuss the report. The draft report conclusions and recommendations are finalized during a public board meeting where board members meet with NTSB staff to resolve any outstanding issues, and this public meeting is the first time that the board reviews and considers the report as a full board.

3.4 What the investigations reveal

The direct causes of transportation accidents are often technical at first glance, e.g., birds striking an airplane's engines, unusual winds, or icing conditions. However, the invention and adoption of technology are uniquely human endeavors, and more often than not, human factors are the root cause. Some accidents are due to limitations in individual skills or organizational capacities, which is understandable given the complexity of modern transportation systems and the level of coordination required. One example of such limitations is the case of Continental Airlines Flight 1404, which veered off the runway during take-off from Denver International Airport on December 20, 2008, resulting in a post-crash fire that seriously injured the captain and five passengers. On July 13, 2010, the NTSB issued a press release following its board meeting in which it reported the following conclusions:

> The National Transportation Safety Board today determined that the probable cause of the … accident was the captain's cessation of rudder input, which was needed … when the plane encountered a strong and gusty crosswind that exceeded the captain's training and experience.
> Contributing to the accident was the air traffic control system that didn't require or facilitate the dissemination of key available wind information to air traffic controllers and pilots, and inadequate crosswind training in the airline industry…

This example illustrates surprisingly basic deficiencies in individual skills and organizational capacity that pilots and air traffic controllers were unaware of as recently as in 2008. Clearly, transportation safety is an ongoing challenge.

Accident investigations sometimes reveal chronic shortcomings in operations, either as a result

of "unintentional" mismanagement or intentional shortcuts. For example, the Colgan Air accident is the latest in a string of accidents involving "code-sharing", a marketing arrangement in which regional airlines operate flights for major airlines.[13] A growing trend in the industry, code-sharing is used by the major airlines as a way to cut costs. However, the safety implications are not well understood and regulations have not yet caught up with this practice. The NTSB hosted a two-day symposium, "Airline Code-Sharing Arrangements and Their Role in Aviation Safety," in October 2010, taking a leadership role in bringing parties together to publicly discuss the issues surrounding code-sharing and potentially shape the industry and regulatory views of this practice.

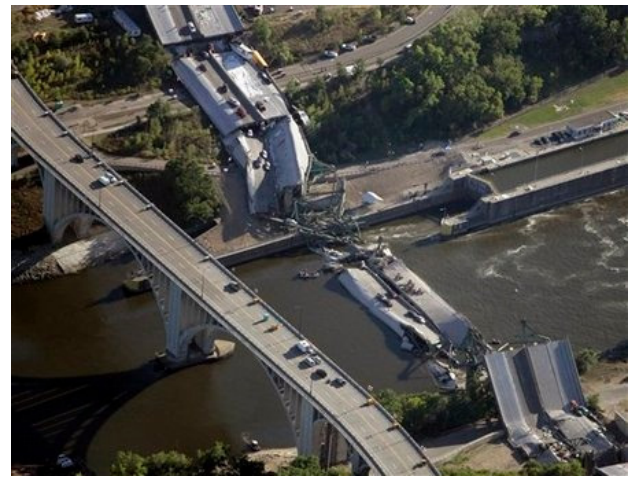


Figure 3 The Minnesota I-35W highway bridge collapsed on August 1, 2007 (photo credit unknown). The NTSB Go Team was headed by Investigator-in-Charge (IIC) Mark Bagnard. Mark Rosenker, Chairman at the time, was the spokesperson accompanying the Go Team on the scene. Source: NTSB Annual Report (2008, page 54). See Appendix A.6 for details on the accident and investigation.

4 Minnesota I-35W highway bridge collapse: A case study

On August 1, 2007, the eight-lane I-35W highway bridge over the Mississippi River in Minneapolis collapsed, falling 108 feet into the 15-foot-deep river. This tragedy instantly captured national attention. Since the safety of bridges and other public infrastructure is taken for granted, catastrophic failures like this directly threaten the credibility of the government, and can easily turn into widespread panic and public outrage. In this section, we consider in some detail the NTSB's response to this extraordinary and politically charged accident.

4.1 Taking the initiative

While the NTSB has primacy in the investigation of all aviation accidents, it does not enjoy the same level of authority for other modes of transportation such as highways, where state and local authorities are not even obligated to inform the NTSB that a major accident has occurred. In such cases, the NTSB must take the initiative in establishing itself as a participant in the accident investigation process. This was the case for the Minneapolis I-35W highway bridge collapse, in which the NTSB defined its own role among all the other federal and local authorities involved, including the Minnesota Department of Transportation (MN DOT), the state police, and the FBI. In such circumstances, the NTSB is usually a welcome participant because its focus complements that of the police, who are primarily concerned with which parties are at fault and whether any laws were broken, while the NTSB's interest is in promoting long-term safety by determining the underlying causes of the accident.

The NTSB's Office of Highway Safety—a relatively small division with only 24 people—quickly assembled a Go Team across its regional offices with experts in structural engineering, bridge design, construction oversight, and survival factors. Because of the inevitable public

outcry for bringing the responsible parties to justice, Tim Pawlenty, then-governor of Minnesota, and the MN DOT hired the engineering firm, Wiss, Janney, Elstner Associates, within hours of the collapse to provide analysis that would parallel the NTSB investigation.[14] As the investigation progressed, the NTSB quickly established itself as the authority, with the engineering firm collaborating in its area of expertise on behalf of the MN DOT, a party to the investigation. Through the Federal Highway Administration, another party to the investigation, the NTSB was able to locate and collaborate with an engineer who wrote his Ph.D. thesis on possible failure scenarios for this particular bridge, an example of the kind of expertise the NTSB can leverage. Once again, the NTSB's reputation for impartiality and technical expertise was instrumental in establishing its legitimacy in this accident investigation.

4.2 Time constraints

However, the NTSB's lack of primacy did hamper its efforts significantly. For example, unlike aviation accident investigations, the NTSB was unable to dictate the pace of the investigation, hence its normal investigative process had to be adjusted to take into account the constraints imposed by the other stakeholders, including law enforcement agencies and politicians. Participating in this particular investigation were representatives from the Federal Highway Administration, the MN DOT, the state and local police, and the bridge maintenance contractor, Progressive Contractors, Inc. (PCI). The bridge design company, Jacobs Engineering, which had acquired the original designer of the bridge (Sverdrup & Parcel and Associates), became a party to the investigation five months into the investigation as the focus shifted to the bridge design. While the NTSB is well-known for its party system (see Section 2.2), one consequence of the constraints imposed by other parties in this case was the NTSB's decision to forgo a public hearing so as to make faster progress on the investigation itself.[15] This decision drew heavy criticism from Congressman James Oberstar, the representative of Minnesota's eighth Congressional district, and Chairman of the House Transportation and Infrastructure Committee (Veracifier, 2008).

Cooperation and competition among the parties can be both challenging and productive. For example, an interesting exchange occurred between two parties to the investigation: MN DOT and PCI, the contractor repaving the bridge at the time of the collapse. Because construction equipment and materials were stockpiled on the bridge at the time of the accident, this excess weight was a source of contention and one of the primary focuses of the investigation early on. MN DOT claimed that PCI did not get approval for stockpiling materials on the bridge, while PCI claimed that its requests for an additional lane closure (which would have spread the load) and permission to stockpile its materials at another location were denied (NTSB HAR-08/03, page 13). While each party might have chosen to reveal facts selectively at the start of the investigation, competition between these two parties eventually led to a number of important revelations regarding the accident.

4.3 Faulty gusset plate

With technical support from Dr. Carl Schultheisz, a materials research engineer, and others in the NTSB's Office of Research and Engineering, the investigation ultimately concluded that the probable cause of the accident was the concentrated construction weight placed directly on the weakest link of the bridge, a faulty gusset plate (a $4' \times 8'$ metal plate used to connect and secure multiple beams, see Figure 4). This plate was half as thick as it should have been, the result of an error in the original design by Sverdrup & Parcel and Associates in 1961 that somehow made its way through

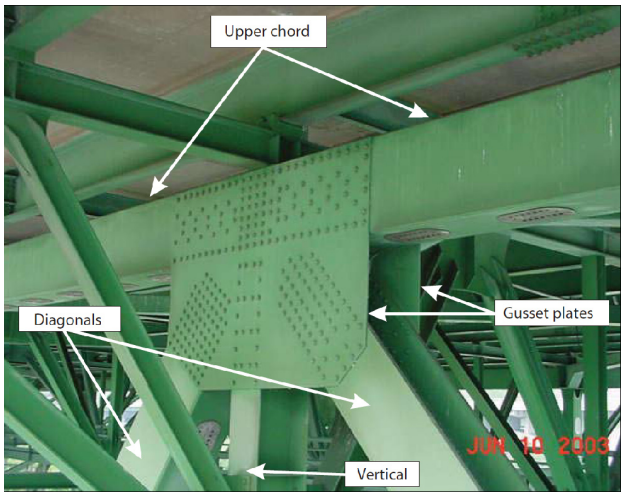


Figure 4 Gusset plate for typical five-member node on the Minnesota I-35W highway bridge. Source: NTSB/HAR-08/03 Report (2008, Figure 6).

the quality control process within the firm, and the many rounds of design reviews by federal and state transportation officials.

To make this conclusion irrefutable from all stakeholders' perspectives, the NTSB team had to rule out several other possible explanations, which is one of the main reasons for the length of NTSB investigations. According to the accident report (NTSB/HAR-08/03):

> Before determining that the collapse of the I-35W bridge initiated with failure of the gusset plates at the U10 nodes, the Safety Board considered a number of potential explanations. The following factors were considered, but excluded, as being causal to the collapse: corrosion damage in gusset plates at the L11 nodes, fracture of a floor truss, preexisting cracking, temperature effects, and pier movement.

Some parties welcomed this conclusion, e.g., URS Corporation, the bridge inspection company that was sued by the families of the victims,[16] while others were disappointed because a bridge-design flaw did not provide as much support for their efforts to raise taxes to fund bridge repairs and related infrastructure projects.[17] However, the NTSB managed to rise above political and economic considerations and withstood pressures from all sides. NTSB officials recognize that its most valuable asset is its reputation for objectivity and thoroughness, which can easily be damaged or destroyed if there were even an appearance of bias, favoritism, or acquiescence to political pressure.

4.4 Unanswered questions

On September 18, 2008, only one year after the collapse, the replacement I-35W St. Anthony Falls Bridge was opened to the public. While the NTSB report was conclusive, it also raised new questions that have yet to be answered. Are there other problems lurking in the gusset plates of the thousands of similar bridges across the United States? A key fact about the failure of the I-35W highway bridge was the lack of load redundancy in its design; are the many other bridges with the same single-point-of-failure designs also in jeopardy of collapsing, and how do we determine which are safe and which should be closed immediately? Finally, the load on the I-35W highway bridge increased by 20% during the two prior renovations, a significant change for which the implications for the collapse is still unclear; how do we assess the impact of future load changes on structural integrity and how often should re-assessments be done?

As with all good scientific research, the investigatory process often raises more questions than it answers, but all stakeholders agree that these are important questions that must be asked, even if the answers may not be immediately forthcoming.

5 Organizational effectiveness

Having described and illustrated the basic organizational structure and functions of the NTSB in Sections 2–4, in this section we attempt to distill the most important factors for the organization's effectiveness. Our observations suggest at

least five distinct factors: impartiality and singular focus, the Go Team, the collective intelligence of the party system, effective media relations, and employee satisfaction. We describe each of these factors in more detail in Sections 5.1–5.5.

5.1 Impartiality and singular focus

Given the overriding importance of impartiality and trust to the NTSB's mission, maintaining independence and managing real and perceived conflicts of interest are critical to the organization's success. Perhaps the most significant factor contributing to this impartiality is the independent and non-regulatory status conferred to the NTSB by Congress through the Independent Safety Board Act of 1974, which rendered the NTSB a separate entity from DOT. With the primary focus on accident investigation, determination of probable cause, and formulation of safety recommendations, the NTSB is relatively free of ongoing economic and political influences, which, in turn, reduces its profile among industry lobbyists and special interest groups. Also, without regulatory authority, the NTSB has no stake in past or current regulations and is free to identify, analyze, and critique regulatory deficiencies and failures, and has done so on numerous occasions.[18] Because the NTSB is not expected to promote the transportation industry, its focus is narrower and less conflicted. In contrast, regulators do have a vested interest in the economic health of the industries they regulate (by design), which can lead to conflicts and compromises as they attempt to satisfy multiple constituents.[19]

A closely related source of the NTSB's independence is its subpoena power, without which accident investigations would be considerably less informative and conclusive. The NTSB has the ability to subpoena practically any entity—whether it is a party participant in the investigation or not—to obtain information vital to an accident investigation.

The NTSB's impartiality is, of course, a product of its independence and singular focus on accident prevention and safety. However, one of the most important ways it preserves its objectivity is by separating the fact-gathering function of an accident investigation from the analysis of the accident. While there may be genuine differences of opinion in analyzing an accident, all parties should be basing their analyses on the same set of facts, otherwise it may be impossible to reach any definitive conclusions. This separation is achieved in many ways (see Sections 2 and 3):

- **Member On-Scene.** During the daily media briefings at on-scene accident investigations, the Member on-scene provides only factual information, and will not speculate on possible explanations as to why or how the accident occurred.
- **Party System.** The party system is used solely during the fact-gathering phase, not for the analysis phase, which is done by internal NTSB staff only, and is not disclosed to the public until the board meeting.
- **Separation of Facts and Analysis.** The accident reports make clear distinctions between facts and analysis.

Another contributing factor to the NTSB's impartiality is the fact that five board members—often of different perspectives, political affiliations, and backgrounds—must vote on the reports, including probable causes and safety recommendations, hence their integrity and judgment are at stake each time they file a report.

5.2 The Go Team as a cohesive unit

Making teams, not individuals, the cornerstone of organizational design and performance is

an important feature of the NTSB's relatively flat organization (see the organizational chart in Figure 1). Small to medium size teams as cohesive units yield many advantages:

- **Accountability.** A clearly identifiable group of individuals is accountable for the investigation, while within the team, the responsibilities of each individual are clearly delineated.
- **Collaboration.** Because the team is accountable for the investigation, the members are "in it together" and cooperation and camaraderie arise naturally.
- **Empowerment.** The Go Team is in some part made up of leaders, with each team member leading his or her own workgroup in a specific area of expertise, and staffed by party members. Given that party members are often some of the brightest experts in their organizations, handpicked to participate in the investigation, each Go Team investigator heads an impressive group of high-caliber professionals.
- **Sense of Accomplishment and Pride.** The objective of an investigation is clearly defined, and so is "mission complete," often a lengthy and challenging process of putting the pieces together. As a result, the sense of accomplishment and pride is tremendous.

Moreover, having team assignments on a rotational basis fosters an atmosphere of fairness and equality, promoting knowledge sharing and collaboration while de-emphasizing individual status in the organization.

5.3 The collective intelligence of the party system

The NTSB's party system is a unique approach to analyzing complex systems that no single individual or group has the expertise to do. At first blush, allowing external parties to participate in an accident investigation—especially parties that may ultimately be found to be responsible—seems rife with bias and conflicted interests. However, the clean separation between an investigation's fact-gathering and analysis phases is an ingenious organizational structure to address these conflicts. The party system yields several notable advantages over other approaches to accident investigation:

- **Leverage.** With about 400 employees in an organization that investigated 13 major accidents, 10 international accidents, and 195 other accidents in fiscal year 2009 (*NTSB 2009 Annual Report*, page 4), the NTSB is able to accomplish this feat by temporarily seconding experts from other organizations for their Go Teams.
- **Expertise.** The party system allows the NTSB to draw on a much larger pool of expertise, which is essential to gathering the most relevant and accurate facts about a complex system over a short-time frame.
- **Influence.** One of the best ways to expand the influence of an organization is to invite others in. By working alongside NTSB investigators, parties become temporary insiders to an accident investigation and are exposed to the NTSB culture and philosophy, and this perspective is brought back to the party's home organization after the investigation is completed.
- **Competition.** Each party is eager to clear itself from blame, and will compete with other parties to provide as much information and party analysis as possible to that end. This healthy competition greatly benefits the NTSB's efforts to gather facts quickly and thoroughly, but does not compromise the NTSB's independence in conducting its own analysis of those facts.
- **Adoption.** It is a lengthy and often frustrating process to get safety recommendations adopted by regulators and the industry. Party members, while not directly involved in developing safety recommendations, are intimately familiar with

the accident and the investigation (at least from a factual perspective). These individuals often serve as informal advocates for the NTSB's recommendations, and may be among the first to embrace the recommendations and their implications for improved safety. An interesting development in recent years, particularly in light of new communications technologies, is the growing role of victims and victims' families in organizing to advocate for certain safety improvements, oftentimes those recommended by the NTSB.

The team of experts involved in any given NTSB accident investigation, and the social value they create, are among the most compelling examples of "collective intelligence" available.

5.4 Effective media relations

At the very start of each accident investigation, the NTSB establishes itself as the clearing house for all information related to the accident, communicating regularly with the press and television media. By taking such an active role in providing the media with factual information, the NTSB reduces the likelihood of panic, the perception of self-serving statements by various parties, and the development among the public of a mistrust in the validity of the investigation and the reliability of the results. The importance of this single feature of the NTSB's accident investigation protocol cannot be overemphasized.

For industries that rely on public confidence, e.g., banking and finance, insurance, public health, and transportation, widespread fear and hysteria can have disastrous economic and social consequences that can take years to recover from. Misinformation, or simply the lack of information, is one of the primary causes of such herd behavior. This is particularly true in recent years as media coverage has become ubiquitous and relentless thanks to new technologies such as Internet-based communication, text-messaging, and other forms of technology-leveraged social networking. The NTSB has learned over time that news agencies will file reports whether or not information is available, hence forthright and frequent communication with the media is the most effective way of reducing panic and ensuring an accurate portrayal of an accident investigation.

5.5 Employee satisfaction

In a knowledge-based organization like the NTSB, the level of dedication and motivation of the employees directly affects the quality and quantity of its work product. While financial compensation is an important element to any workforce, highly knowledgeable employees are likely to put more emphasis on autonomy and being able to do meaningful and/or challenging work. In fact, because of the flat and lean organizational structure of the NTSB, managers often engage in hands-on work in addition to managing their team, and Board members provide clear role models of top management being deeply engaged in accident investigations.

One of the predominant characteristics of the NTSB staff is the "mission driven" ethos—they take great pride in the NTSB and appreciate the agency's reputation in the transportation industry. For example, Erin Gormley, an aerospace engineer in the NTSB's Office of Research and Engineering, said, "When I travel in an airplane, I know what I have done to make it safer." Julie Perrot, a safety recommendation specialist, said, "I know the woman whose hand you see on the pedestrian signals. We recommended using a hand to make the signal more intuitive." Many individuals in the industry make it their career goal to work for the NTSB; the average tenure of employees at the agency is 17 years.

In fact, according to the 2009 rankings of best-placestowork.org, the most comprehensive rating

of employee satisfaction in the federal government, the NTSB ranked 7th out of 32 under the category "Best Places to Work in the Federal Government" for small agencies. One of the component criteria in this ranking is "employee skills/mission match," in which the NTSB is ranked 3rd in the small agencies category. For professionals who have studied and worked hard for many years to build their skills, nothing appears more fulfilling than being able to use those skills in a meaningful way.[20]

In short, the typical NTSB employee's position—particularly for technical experts—is the capstone to a successful career, not a stepping stone to a better job elsewhere.

6 Current challenges facing the NTSB

Although the NTSB has enjoyed an enviable record of success in improving safety in the transportation industry, its leadership has long recognized a number of challenges that need to be addressed. The Rand Corporation, a well-known think tank, conducted a comprehensive review of the NTSB in 2000 with the support of then NTSB Chairman Jim Hall and Managing Director Peter Goltz, and highlighted a number of issues that the organization could improve upon, which the NTSB has sought to address since the report's publication (see Sarsfield *et al.*, 2000). In this section, we highlight four current challenges to the NTSB's mission and continuing relevance. The sometimes lengthy delay between an accident and the NTSB report, and the even longer delays before certain safety recommendations are adopted, often frustrate politicians and the public who seek immediate and decisive action. We discuss these challenges in Sections 6.1 and 6.2, respectively. In Section 6.3, we consider the tension between the NTSB's mandated role of producing safety recommendations reactively and a more proactive role of attempting to reduce the likelihood of accidents yet to occur. Finally, as with any government agency, the NTSB faces stiff competition from the private sector in recruiting and retaining new talent, which we describe in more detail in Section 6.4.

6.1 Duration of investigations

Due to the complex nature of major accident investigations and resource constraints, producing timely accident reports has been an ongoing challenge for the NTSB. The 2006 Government Accountability Office (GAO) report indicated that it routinely took longer than two years to complete major investigations (GAO-06-801T, cover page). The NTSB has made significant progress in improving the process; in 2009, the average time for completing aviation investigations was reduced to 13 months (NTSB FY2010 Operating Plan, page 13). Table 1 summarizes key factors contributing to these delays and how the NTSB has addressed them.

The NTSB recognizes the importance of timely safety recommendations. As a partial remedy, it may issue safety recommendations during the investigation, before the final report is published.[21]

6.2 Adoption of safety recommendations

Issuing safety recommendations is only the first step of the NTSB's accident investigation process; its mission is not complete until its recommendations have been accepted and become standard practice in the industry either voluntarily or through new regulation. For example, flight data recorders or "black boxes"—now standard equipment for all commercial aircraft—started out as safety recommendations issued in the mid-1950s and early 1960s by the Civil Aeronautics Board (CAB), the predecessor to the NTSB. This kind of success does not come easily; the adoption

Table 1 Key factors, challenges, and NTSB responses in producing timely accident-investigation reports.

Key factor	Challenges	Actions
Investigation Scope	The NTSB does not limit itself to the direct cause of an accident to maximize lessons learned. But the temptation of making the most comprehensive and in-depth accident reports often lead to "scope creep".	The NTSB will evaluate and refine its capability to establish appropriate scope of its investigative activities and accident reports (NTSB FY2010 Operating Plan, page 12)*.
Eliminating Negatives	It is often not enough to prove the probable causes. In order to convince all parties, the NTSB has to take on additional burden to rule out other possibilities†, which is resource intensive.	This feature of accident reports cannot be eliminated. While it may seem to be a waste of time, such thoroughness is what makes NTSB accident investigations so irrefutably conclusive for all stakeholders.
Human Resources	The NTSB is a small agency; investigators are often pulled away from ongoing investigations when new accidents occur.	Process improvements allow the NTSB to partially compensate for the impact of staff reductions in recent years (NTSB FY2010 Operating Plan, page 13).
Report Approval Process	Paper-based report production process is labor intensive.	The NTSB is in the process of deploying an electronic information system to streamline this process.

*One example is the practice of code-sharing, which was listed as a factor in the Colgan Air accident on February 12, 2009 (NTSB AAR-10/01) (see Section 3.4). The NTSB decided to refrain from extensive study of code-sharing during this investigation and, instead, hosted a symposium on this topic in October 2010 (see http://www.ntsb.gov/events/symp_code-sharing/agenda.htm).

†For example, as part of the investigation of the Minnesota I-35W highway bridge collapse in 2007, the following alternate explanations had to be ruled out before the NTSB concluded that an incorrectly designed gusset plate was responsible: corrosion damage in gusset plates at the L11 nodes, fracture of a floor truss, preexisting cracking, temperature effects, and pier movement. See Section 4.3 for further details.

process is usually a lengthy and often frustrating process.

When the NTSB issues a safety recommendation to, for example, the FAA, the FAA has a mandate from Congress to acknowledge it within 90 days. Afterward, each safety recommendation takes on a life of its own, and it is not unusual for the regulator to take a year or substantially longer to report back with an expected adoption status.[22] Unlike the NTSB, whose sole focus is on safety, the regulators have other mandates including cost and benefit analysis as well as addressing feedback from the industry.[23]

In addition, the introduction of any new regulations has to go through a lengthy formal process. If the FAA decides to proceed with a new regulation after its own due diligence, it will then send it to the Office of the Secretary in the DOT for review, where it is subject to a cost-benefit analysis by its own economists as well as industry lobbying. Once it is approved by the DOT's Office of the Secretary, the regulation is sent to the Office of Management and Budget, a White House agency, for review, where it is once again subject to a rigorous cost-benefit analysis, and potentially, to the influence of industry and industry groups.

The communications trail of a typical safety recommendation is described in Appendix A.7—nine-month turnaround times are not conducive to quick resolutions. From time to time, the NTSB may request meetings with the FAA to discuss the progress of high-priority items. However, many of the non-priority items are often open for years at a time, waiting for status updates from the FAA.

Perhaps the clearest indication of the challenges in getting safety recommendations adopted is the lack of satisfactory progress on the NTSB's "Most Wanted" list of recommendations. Out of 16 items listed in the NTSB 2009 Annual Report (pages 8 and 9), 10 are color-coded red, indicating unacceptably slow responses. None of them is color-coded green, indicating timely progress.

6.3 Reactive accident investigations versus proactive safety studies

Most of the work at the NTSB is reactive in nature, responses to accidents as they occur. As a result, the vast majority of its safety recommendations are lessons learned from actual accidents instead of proactive measures for prevention. Moreover, since the NTSB cannot investigate every accident due to resource constraints, it has developed accident launch criteria to determine which accidents to investigate (largely related to the number of fatalities or other risk factors). Technological innovations also pose great challenges for the NTSB because the staff has limited time to keep pace with these innovations, which is necessary for identifying emerging issues before they cause accidents. To that end, the NTSB develops and publishes an emerging issues list each year, and emerging issues are often the focus of hearings, forums, and other NTSB-sponsored symposia.

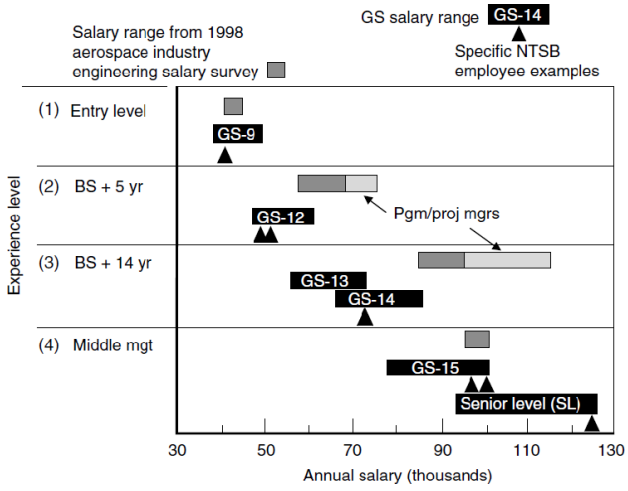
The NTSB has long realized the need for a less reactive approach to identifying safety issues, and safety studies have been used for this purpose, but only on a limited scale. In fact, in 2006 the GAO recommended increasing the use of safety studies (GAO 07-118, page 58), and the NTSB has made significant progress, but according to the 2009 GAO report, there is more to be done on this front (GAO 10-183T, pages 12 and 13):

> NTSB has also made significant progress in implementing our recommendation to increase its use of safety studies, which are multiyear efforts that result in recommendations. … Although NTSB has not completed any safety studies since we made our recommendation in 2006, it has three studies in progress, one of which is in final draft, and it has established a goal of developing two safety study proposals and submitting them to its board for approval each year. … NTSB officials told us they would like to broaden the term 'safety studies' to include not only the current studies of multiple accidents, but the research done for the other smaller safety-related reports and data inquiries. Such a term, they said, would better characterize the scope of their efforts to report safety information to the public.

On March 9, 2010, the NTSB issued a safety study on the glass cockpit (the electronic flight display) in light aircraft to determine how the transition to this new technology has affected the safety of such aircraft. Safety studies like these help to shape the industry and the regulatory landscape in anticipation of further technological innovation. The expanded use of safety studies has the potential to further establish the leadership of the NTSB in the transportation industry.

6.4 Challenges in human capital management

Like all other organizations, the NTSB faces challenges in recruiting and retaining its work force. One of the biggest challenges—common to most government agencies—is competition from the private sector for the best talent. The compensation in the private sector tends to be higher for highly trained professionals. The salaries for mid-career NTSB professionals in particular appear to lag behind typical aerospace industry salaries (Sarsfield *et al*., 2000, pages 142, 143).[24] Figure 5 shows the discrepancies for various levels of experience, which can be substantial in some



Source: "Despite Consolidation, Aerospace Offers Attractive Employment Opportunities and Salaries," *Aviation Week & Space Technology*, February 8, 1999, page 83; Personal communications with NTSB administrative officers, Spring 1999; U.S. Office of Personnel Management, 1998.

Figure 5 Comparison of NTSB and Aerospace Industry Salaries. Source: Sarsfield *et al.* (2000, Figure 5.4).

cases. However, this gap is not nearly as large as it may be in other industries such as financial services, in which mid-career and senior personnel can earn multiples of a GS-15 government salary.

In addition, companies typically offer relocation packages while the NTSB typically does not, which can be a major factor in recruiting new talent. Also, while a flat organizational structure may be efficient from a workflow perspective, it provides limited opportunities for promotion, making career advancement more difficult. Finally, anticipated retirements may have a significant impact on the NTSB's management ranks during the next few years *((NTSB Strategic Plan 2010–2015*, page 37), making recruitment and employee development even more important in maintaining the continuity of leadership as well as the level of technical and management expertise.

7 Conclusion

As inevitable as accidents seem to be, how one responds to them can lead to profound differences in the likelihood of reoccurrence. Dismissing them as rare and isolated events does little to prevent them from happening again, and pointing fingers without any evidence or analysis only creates more obstacles to genuine progress. Through the NTSB, the transportation industry has developed a different approach to dealing with accidents. The independence, objectivity, and credibility that this small but powerful agency exemplifies are essential elements worth considering in other industries that hope to improve their safety records.

While there may be certain aspects of the transportation industry that allow the NTSB to be so effective, we believe that the practice of independently and systematically reviewing failures—sifting through the wreckage and analyzing every step of an accident to determine its proximate and ultimate causes—can benefit every technology-based industry. Accident investigations do occur in other industries already, e.g., mortality and morbidity review committees in medicine, but few industries have institutionalized this important aspect of process improvement as systematically as the transportation industry, and in most of the industries that have an investigative process for mishaps, the investigation is undertaken by the regulator rather than by an independent entity.

A case in point is the financial services industry, which is as highly regulated as the transportation industry but has no organization like the NTSB. One reason may be the trauma and public outrage associated with transportation accidents involving the deaths of innocent victims—the 50 lives lost in the Colgan Air accident of February 12, 2009 create a sense of urgency that outweighs most other priorities, including financial loss. A conclusive accident investigation yields safety

recommendations that may save future lives, but also provides some form of closure to victims' families. While the recent financial crisis may not be directly linked to loss of life, the consequences of systemic shocks to the financial system may be far broader, devastating in its own right, and on a much larger scale considering the size of the financial industry.[25] Moreover, in some cases, the sudden loss of wealth and employment may force individuals into adverse lifestyle and healthcare choices, which do have implications for life expectancy and mortality rates. And to the extent that a dollar value may be placed on a human life—which is an inescapable aspect of many public policy decisions—the most recent estimate of the cost of the government's Troubled Asset Relief Program of $50 billion is equivalent to 7,761 lives lost.[26] This figure does not include the impact of unemployment, home foreclosures, lost retirement savings, and other consequences of the financial crisis.

Of course, the transportation and financial industries differ in a number of ways. Perhaps the most significant difference is the definition of an "accident," which is clear in transportation but not in finance. For example, was the bursting of the "Internet Bubble" that began on March 13, 2000 an "accident" deserving of investigation? Unlike an airplane crash—which no one would argue is a necessary and unavoidable consequence of air travel—financial loss is indeed a necessary and unavoidable corollary of risk, financial innovation, and economic growth ("nothing ventured, nothing gained"). Therefore, the first order of business for a financial NTSB is to define the scope of its investigations. One possible starting point is to define a "systemic event" as a set of circumstances that has the potential to disrupt the stability or proper functioning of the financial system or any critical subcomponent. While this notion is still ambiguous when compared to a transportation accident, nevertheless, it does serve the purpose of narrowing the investigative purview of a financial NTSB to a more manageable subset of incidents. Of course, some judgment and discretion will need to be exercised at the outset of such an organization's activities, but over time and after a number of investigations, a clear and practical definition of a financial accident should emerge.

The second difference between transportation and financial services is the role of intellectual property and client confidentiality. In the transportation industry, intellectual property is typically protected by patents, and client confidentiality is not often threatened by any single NTSB investigation. However, in the financial industry, intellectual property is typically protected by trade secrecy, and client confidentiality can be a significant concern even for one investigation. These differences suggest that a financial NTSB investigation must be conducted in a different manner, with greater protections for proprietary information, e.g., anonymizing client data and limiting the disclosure of unrelated trade secrets.

Finally, the breadth of financial services implies a broader investigative mandate for a financial NTSB, requiring greater use of external parties which, in turn, implies a more complex web of potential conflicts of interest. A closely related issue is the much larger gap between government pay scales and those of the financial industry; in some cases, the differences may be two or three orders of magnitude. These challenges can be overcome with greater use of the party system, perhaps with more involved ethical guidelines that must be actively managed. Contrary to the stereotypical view of Wall Street denizens as self-interested profit-maximizers who have no interest in government service, the recent financial crisis has drawn many highly compensated individuals into government service because they wish to have a positive impact during this critical

period. Moreover, as with the NTSB's party system, there is an even larger pool of industry professionals who would gladly take a three- to six-month leave of absence—with the support of their employers—to assist in an official government investigation requiring their unique financial expertise.

The complexity of the financial system now rivals that of the most technologically sophisticated industries, and truly systemic "accidents" are an unfortunate consequence. This state of affairs is part of a much broader trend in which technological innovation is a double-edged sword that is responsible for great prosperity, but has also created unintended consequences and systemic vulnerabilities. The most sophisticated technologies often require equally sophisticated coordination among individuals with highly specialized skills, but the institutional and organizational structures needed to support that level of coordination have not always kept pace, especially during periods of rapid growth and innovation. As systems become more complex, the number of points of failure inevitably also increases, and even the most experienced and intelligent individual cannot comprehend all possible failure scenarios with proactive risk analysis. Accordingly, in-depth investigation of failures and collaboration on systemic remedies are essential to reducing the chances of catastrophe. As the sociologist Charles Perrow argued over two decades ago, all complex and tightly coupled systems are prone to "normal accidents" (Perrow, 1984); systemic failure is not only possible, but should be expected to occur under such conditions. The financial system may well be the largest and most important tightly coupled complex system today.

Accidents happen in virtually every technologically advanced endeavor, and while this may indeed be normal, we need not compound our mistakes by failing to learn from them. The NTSB's example provides a compelling alternative.

A Appendix

In this appendix, we provide more detailed information about the NTSB. In Appendix A.1, we present some basic facts and statistics for the organization, and include the biographies of current board members in Appendix A.2. We provide an example of a typical NTSB board meeting in Appendix A.3, and in Appendix A.4 we describe the NTSB's ethical review process. Excepted summaries from the NTSB accident reports of the Colgan Air crash and the Minneapolis I-35W Highway Bridge collapse are included in Appendixes A.5 and A.6, respectively. And in Appendix A.7, we present the NTSB/FAA communication trail for a typical NTSB safety recommendation.

A.1 Facts and Statistics of the NTSB

Source: NTSB website (http://ntsb.gov/Abt_NTSB/history.htm).

The NTSB originated in the Air Commerce Act of 1926, in which the U.S. Congress charged the U.S. Department of Commerce with investigating the causes of aircraft accidents. Later, that responsibility was given to the Civil Aeronautics Board's Bureau of Aviation Safety, when it was created in 1940.

In 1967, Congress consolidated all transportation agencies into a new U.S. Department of Transportation (DOT) and established the NTSB as an independent agency placed within the DOT for administrative purposes. In so doing, Congress expanded the NTSB's purview to include all transportation modes, not just aviation.

In 1974, Congress reestablished the NTSB as a completely separate entity, outside the DOT. In 1996, Congress assigned the NTSB the additional

responsibility of coordinating Federal assistance to the families of aviation accident victims.

In 2000, the agency embarked on a major initiative to increase employee technical skills and make their investigative expertise more widely available to the transportation community by establishing the NTSB Academy, which was renamed to NTSB Training Center in 2006.

Since its inception, the NTSB has investigated more than 132,000 aviation accidents and thousands of surface transportation accidents. On call 24 hours a day, 365 days a year, NTSB investigators travel throughout the country and to every corner of the world to investigate significant accidents and develop factual records and safety recommendations with one aim— to ensure that such accidents never happen again.

To date, the NTSB has issued over 12,900 safety recommendations to more than 2,500 recipients. In 2008, the NTSB continued to push for safety improvements as 67 recommendations (for all recipients) were officially closed with one of the following classifications: "exceeds recommended action," "acceptable action," or "acceptable alternate action." The average acceptance rate for safety recommendations remained at just over 82 percent for 2008.

The NTSB publishes the Most Wanted List of Transportation Safety Improvements each year. The brochure highlights important safety actions that the Department of Transportation, the U.S. Coast Guard, and States need to take to prevent accidents and save lives.

In addition to its central role as accident investigators, the NTSB provides a fair and impartial adjudicatory process for appeal of FAA certificate actions and denials, and some civil penalty actions through proceedings before its administrative law judges and appellate review of the judges' decisions. The five-member Board also reviews Coast Guard certificate actions.

A.2 Biographies of current NTSB board members

Source: http://www.ntsb.gov/abt_ntsb/member.htm.

Deborah A. P. Hersman, Chairman. Deborah A. P. Hersman was sworn in as the 12th Chairman of the National Transportation Safety Board on July 28, 2009, following her nomination to the post by President Barack Obama and confirmation by the United States Senate. Her two-year term as Chairman runs until July 2011. She is also serving a second five-year term as a Board Member, which expires on December 31, 2013.

Chairman Hersman has been a Member of the NTSB since June 21, 2004. Since then, she has chaired a number of public events hosted by the Board including public forums and public hearings. During her tenure at the Board, she has been the Member on the scene of 19 major transportation accidents.

Before joining the Board, Chairman Hersman was a Senior Professional Staff Member of the U.S. Senate Committee on Commerce, Science and Transportation from 1999 to 2004 where she was responsible for a number of transportation issues, and earlier served as Staff Director and Senior Legislative Aide to Congressman Bob Wise of West Virginia.

Chairman Hersman earned Bachelor of Arts degrees in Political Science and International Studies from Virginia Tech University in Blacksburg, Virginia, and a Master of Science degree in Conflict Analysis and Resolution from George Mason University in Fairfax, Virginia.

Christopher A. Hart, Vice Chairman. Christopher A. Hart was sworn in as a Member of the

National Transportation Safety Board on August 12, 2009 and designated by the President for a two-year term as Vice Chairman of the Board on August 18.

Member Hart joined the Board after a long career in transportation safety, including a previous term as a Member of the NTSB. Immediately before returning to the Board, Member Hart was Deputy Director for Air Traffic Safety Oversight at the Federal Aviation Administration. He was previously the FAA Assistant Administrator for the Office of System Safety.

He served as a Member of the NTSB from 1990 to 1993. After leaving the Board, he served as Deputy Administrator of the National Highway Traffic Safety Administration, before moving to the FAA in 1995.

From 1973 until joining the Board in 1990, Member Hart held a series of legal positions, mostly in the private sector. He holds a law degree from Harvard University and Master's and Bachelor's degrees in Aerospace Engineering from Princeton University. He is a member of the District of Columbia Bar and the Lawyer-Pilots Bar Association.

Member Hart is a licensed pilot with commercial, multi-engine and instrument ratings. His term expires December 31, 2012.

Robert L. Sumwalt. Robert L. Sumwalt was sworn in as the 37th Member of the National Transportation Safety Board on August 21, 2006, whereupon President Bush designated him as Vice Chairman of the Board for a two-year term, ending August 2008. His term of office as a Board Member will run until December 31, 2011.

Prior to coming to the Board, Mr. Sumwalt was Manager of Aviation for the SCANA Corporation, a Fortune 500 energy-based company.

Mr. Sumwalt was a pilot for 32 years with extensive experience as an airline captain, airline check airman, instructor pilot, and air safety representative. Mr. Sumwalt worked on special assignment to the U.S. Airways Flight Safety Department from 1997 to 2004. He also served as a member of the Air Line Pilots Association's (ALPA) Accident Investigation Board, and he chaired ALPA's Human Factors and Training Group. A trained accident investigator, Mr. Sumwalt participated in several NTSB investigations prior to joining the Safety Board.

Mr. Sumwalt co-authored a book on aircraft accidents and published over 85 articles and papers in aviation trade publications. In 2003, Mr. Sumwalt joined the faculty of the University of Southern California's Aviation Safety and Security Program, where he was the primary human factors instructor.

In recognition of his contributions to the aviation industry, Mr. Sumwalt received the Flight Safety Foundation's Laura Taber Barbour Award in 2003 and ALPA's Air Safety Award in 2005. He is a 2009 inductee into the South Carolina Aviation Hall of Fame.

Since joining the Board, Member Sumwalt has served as the Chairman of the Board of Inquiry for several NTSB public hearings. He has served as the Member on-scene for a number of NTSB accident investigations.

Mr. Sumwalt is a graduate of the University of South Carolina.

Mark R. Rosekind. Mark R. Rosekind, Ph.D. was sworn in as a Member of the National Transportation Safety Board on June 30, 2010. He was nominated by President Obama and confirmed by the United States Senate for a term that expires on December 31, 2014.

Prior to joining the Board, Dr. Rosekind was the President and Chief Scientist of Alertness Solutions, a scientific consulting firm that specializes in fatigue management. Before founding Alertness Solutions, Dr. Rosekind directed the Fatigue Countermeasures Program and was Chief of the Aviation Operations Branch in the Flight Management and Human Factors Division at the NASA Ames Research Center. Prior to his work at NASA, Dr. Rosekind was the Director of the Center for Human Sleep Research at the Stanford University Sleep Disorders and Research Center.

Member Rosekind is an internationally recognized fatigue expert who has conducted research and implemented programs in diverse settings, including all modes of transportation. He has published 150 scientific, technical, and industry papers and provided hundreds of presentations to operational, general, and scientific audiences. His contributions have been acknowledged through numerous honors and awards, including the NASA Exceptional Service Medal, six other NASA Group/Team Awards, two Flight Safety Foundation honors (Presidential Citation for Outstanding Safety Leadership, Business Aviation Meritorious Award), and as a Fellow of the World Economic Forum in Davos, Switzerland.

Member Rosekind earned his B.A. with Honors at Stanford University, his M.S., M.Phil., and Ph.D. at Yale University, and completed a postdoctoral fellowship at the Brown University Medical School.

Earl F. Weener. Earl F. Weener, Ph.D., took the oath of office as a Member of the National Transportation Safety Board on June 30, 2010.

Dr. Weener is a licensed pilot who has dedicated his entire career to the field of aviation safety. Most recently, he has been a consultant and fellow for the Flight Safety Foundation, where he worked to reduce accidents through coordinated industry programs.

From 1975 to 1999, Dr. Weener held a series of positions with The Boeing Company, including three Chief Engineer positions, in Airworthiness, Reliability and Maintainability, and Safety; in System Engineering; and in Safety Technology Development. He also served four years as Boeing's Manager of Government Affairs.

He has served as a general aviation flight instructor and Part 135 pilot.

Dr. Weener earned all three of his academic degrees in Aerospace Engineering at the University of Michigan—his bachelor's, master's, and doctorate. Among his awards are a 1994 Laurel Award from Aviation Week and Space Technology magazine and, in 2005, the Honeywell Bendix Trophy for Aviation Safety.

Dr. Weener's term as a Member of the NTSB expires on December 31, 2015.

A.3 Example of a typical NTSB board meeting

Source: http://ntsb.gov/events/2010/Washington-DC-Metro/presentations.htm.

On July 27, 2010, the National Transportation Safety Board held a board meeting to deliberate the draft accident report for the Metrorail train collision which occurred on June 22, 2009 in Washington D.C. The board meeting was chaired by Chairman Debbie Hersman and joined by Vice Chairman Christopher Hart, Member Robert Sumwalt, Member Mark Rosekind, and Member Earl Weener.

Chairman Hersman's opening statement gave the background and laid out the structure of the meeting:

This morning, the Board meets in open session as required by the Government in the Sunshine Act. While this is a

public meeting, only the Board members and NTSB staff may participate in today's discussions. Three weeks ago, the staff presented to the Board the draft report we are considering today: the collision of two Metrorail trains on the Red Line near the Fort Totten station on June 22, 2009. While the individual Board members have had the opportunity to read the accident report and to meet with the staff individually, today is the first time that all five Board members are meeting together to discuss it. Staff has prepared five presentations, which will be followed by a round of questions from the Board members. We will then consider the report's conclusions, probable cause determination, and proposed safety recommendations.

The five presentations from the NTSB staff were as follows:

- James A. Southworth, Chief, Railroad Division: Overview with animation of the accident.
- Ruben Payan, Electrical Engineer, Signal and Train Control Investigation: Two technical presentations on automatic train control system and false signals.
- Loren Groff, Safety Research Division: Safety Culture of the WMATA.
- Stephen Klejst, Railroad Division: Safety Oversight of the WMATA.

After four hours of discussion which resulted in modifications to the draft report, the board voted on the probable causes of the accident and safety recommendations. Chairman Hersman concluded the meeting with closing remarks.

After the board meeting, that same day, the NTSB issued a press release and synopsis of the NTSB accident report, including the probable cause, conclusions, and safety recommendations on its website. The full report was made available on its website a few weeks later.

Because the investigation uncovered potential safety concerns that warranted immediate attention, the NTSB also issued several recommendations on July 13, 2009, and on September 22, 2009, well before the July 27, 2010 Board meeting. These recommendations were approved by vote of the members individually, without a meeting.

A.4 Ethical review process

Source: Designated Agency Ethics Official, NTSB Office of the General Counsel.

Ethical Review Process for Board Members

New Board Members (Nominees): For individuals that the President wishes to nominate for a Board Member position, the Office of White House Counsel simultaneously provides to the Designated Agency Ethics Official (DAEO) of the NTSB and the Office of Government Ethics (OGE), copies of the individual's Public Financial Disclosure Report (SF 278).

- The DAEO and OGE review the draft financial disclosure report, as well as the potential nominee's resume concerning his or her past employment and professional relationships. In consultation with the potential nominee, the DAEO and OGE ensure that the financial disclosure report, which includes information about prior employment and employers, is accurate and complete and then identifies financial holdings that would present a conflict of interest and other relationships that could create issues with regard to the potential nominee's impartiality.
- The DAEO and OGE identify financial interests that the potential nominee must divest (to avoid a conflict of interest) and assist him or her in creating an Ethics Agreement that specifies what issues exist and what the potential nominee will do to manage and/or avoid the conflicts and questions of the nominee's impartiality.
- Upon completing this review, and after the President announces his intent to nominate the individual for a position as Board Member, the DAEO forwards the nominee's financial

disclosure report (SF 278) and ethics agreement to the Director of OGE, along with a letter articulating whether the individual may serve without conflicts and questions as to his or her impartiality.

New Board Members (who have been confirmed by the Senate and sworn in): Within 30 days of a Board Member assuming his or her office, the DAEO provides a complete, face to face briefing in accordance with the requirements of the Standards of Conduct and the Ethics in Government Statute. The briefing is required to last for at least one hour and typically extends for one to two hours.

Continuing Ethics Review/Training: After the initial financial disclosure report and training, each Member must file a public financial disclosure report on an annual basis, which is reviewed and certified by the DAEO and forwarded to the Director of OGE for final certification. The financial disclosure report, with its sections concerning gifts, payments from outside sources, and outside positions provides the opportunity for periodic ethics review and counseling throughout a Member's tenure. Additionally, each year each Board Member must also have face to face ethics training of at least one hour with the DAEO or another ethics official.

As a final matter, when a Board Member leaves the government and his or her appointed position, he or she must, within 30 days of separating from the NTSB, file a termination financial disclosure report, which is reviewed and certified by the DAEO and forwarded to the Director of OGE for final certification.

Ethical Review Process for NTSB Employees

Initial Ethics Review/Screening: A member of the NTSB ethics staff conducts an interview and briefing with each potential employee (an individual that has received a preliminary offer of employment) as part of the final screening/clearance process—before a final job offer is made. The interview/briefing, which is conducted in-person or telephonically, typically lasts from 30 minutes to an hour (or more, depending on the complexity of the employee's background) and follows the format in the ethics interview checklist focusing on financial interest and relationship. The NTSB is required to provide each new employee with a copy of the "14 Principles of Ethical Conduct for Government Officers and Employees" as well as contact information of the NTSB ethics staff.

Upon completing the briefing/interview, the ethics staff creates a report that goes to the hiring authority. The report identifies ethics issues and specifies methods for handling issues, if they exist.

Additional Review/Training: With regard to continuing review for compliance with ethics guidelines, if the individual is identified, because of position or duties, as a being required to file a financial disclosure report (Public—SF 278; or Confidential—OGE Form 450), he or she must file his initial report within 30 days of reporting for duty. The report is reviewed by ethics officials. The employee must, thereafter, file annual financial disclosure reports which are reviewed by agency ethics officials each year.

Additionally, the employee must complete online ethics training within 30 days of reporting to duty and must, thereafter, complete it, as do all employees, on an annual basis.

A.5 Continental connection flight 3407 (Colgan Air) crash

Source: NTSB accident report (NTSB AAR-10/01).

On February 12, 2009, about 22:17 EST, a Colgan Air, Inc., Bombardier DHC-8-400, N200WQ,

operating as Continental Connection flight 3407, was on an instrument approach to Buffalo-Niagara International Airport, Buffalo, New York, when it crashed into a residence in Clarence Center, New York, about 5 nautical miles northeast of the airport. The two pilots, two flight attendants, and 45 passengers aboard the airplane were killed, one person on the ground was killed, and the airplane was destroyed by impact forces and a post-crash fire.

The National Transportation Safety Board was notified of this accident about 22:30 on February 12, 2009. A Go Team launched early the next morning. Accompanying the team to Buffalo was former Board Member Steven Chealander. The following investigative teams were formed: Operations, Human Performance, Structures, Systems, Power plants, Air Traffic Control, Meteorology, Aircraft Performance, Maintenance Records, and Pipeline. Also, specialists were assigned to conduct the readout of the flight data recorder and transcribe the cockpit voice recorder at the NTSB's laboratory in Washington, D.C.

Parties to the investigation were the Federal Aviation Administration (FAA), Colgan Air, Air Line Pilots Association (ALPA), National Air Traffic Controllers Association, and United Steelworkers Union (Flight Attendants). In accordance with the Convention on International Civil Aviation, the Transportation Safety Board of Canada (TSB) participated in the investigations among others. Bombardier, the manufacturer of the aircraft, was the technical advisors to the TSB.

A public hearing was held from May 12 to 14, 2009, in Washington, D.C. Former Acting Chairman Mark Rosenker presided over the hearing; Board Member and current Chairman Deborah Hersman, former Board Member Kathryn Higgins, and Board Member Robert Sumwalt also participated in the hearing. The issues presented at the hearing were the effect of icing on airplane performance, cold weather operations, sterile cockpit rules, flight crew experience, fatigue management, and stall recovery training. The technical panel comprised investigators from the NTSB and the TSB. Parties to the public hearing were the FAA, Colgan Air, ALPA, and Bombardier.

The National Transportation Safety Board determines that the probable cause of this accident was the captain's inappropriate response to the activation of the stick shaker, which led to an aerodynamic stall from which the airplane did not recover. Contributing to the accident were (1) the flight crew's failure to monitor airspeed in relation to the rising position of the low speed cue, (2) the flight crew's failure to adhere to sterile cockpit procedures, (3) the captain's failure to effectively manage the flight, and (4) Colgan Air's inadequate procedures during approaches in icing conditions.

The safety issues discussed in this report focus on strategies to prevent flight crew monitoring failures, pilot professionalism, fatigue, remedial training, pilot training records, airspeed selection procedures, stall training, Federal Aviation Administration (FAA) oversight, flight operational quality assurance programs, use of personal portable electronic devices on the flight deck, the FAA's use of safety alerts for operators to transmit safety-critical information, and weather information provided to pilots. Safety recommendations concerning these issues are addressed to the FAA.

A.6 Minnesota I-35W highway bridge collapse

Source: NTSB accident report (NTSB HAR-08/03).

About 6:05 p.m. on August 1, 2007, the eight-lane, 1,907-foot long I-35W highway bridge over the Mississippi River in Minneapolis collapsed, resulting in 13 fatalities and 145 injuries.

On the day of the collapse, roadway work was underway on the I-35W bridge. In the early afternoon, construction equipments and construction materials (sand and gravel for making concrete) were delivered and positioned in the two closed inside southbound lanes.

The National Transportation Safety Board was notified of the Minneapolis, Minnesota, bridge collapse on August 1, 2007. Investigative teams were dispatched from the Safety Board's Washington, D.C.; Atlanta, Georgia; Arlington, Texas; and Gardena, California, offices. Separate groups were established to investigate structural engineering, bridge design, construction oversight, and survival factors issues. Other groups were formed to facilitate evidence documentation, structural modeling, and witness identification. Chairman Mark Rosenker at the time was the Board Member on scene.

Participating in the on-scene investigation were representatives of the Federal Highway Administration, the Minnesota Department of Transportation, the Minnesota State Police, the Minneapolis Police Department, the Hennepin County Sheriff's Office, and the maintenance contractor, Progressive Contractors, Inc. Jacobs Engineering (the company that had acquired the firm responsible for original design of the bridge) initially provided design plans and other related documents and later, on January 17, 2008, was included as an official party to the investigation.

The on-scene investigation, including documentation and analysis of the recovered bridge structure, required Safety Board investigators and other support staff to remain at the accident site from August 2 to November 10, 2007.

The National Transportation Safety Board determines that the probable cause of the collapse of the I-35W bridge in Minneapolis, Minnesota, was the inadequate load capacity, due to a design error by Sverdrup & Parcel and Associates, Inc., of the gusset plates at the U10 nodes, which failed under a combination of (1) substantial increases in the weight of the bridge, which resulted from previous bridge modifications, and (2) the traffic and concentrated construction loads on the bridge on the day of the collapse. Contributing to the design error was the failure of Sverdrup & Parcel's quality control procedures to ensure that the appropriate main truss gusset plate calculations were performed for the I-35W bridge and the inadequate design review by Federal and State transportation officials.

Contributing to the accident was the generally accepted practice among Federal and State transportation officials of giving inadequate attention to gusset plates during inspections for conditions of distortion, such as bowing, and of excluding gusset plates in load rating analyses.

A.7 NTSB/FAA communication trail of a typical safety recommendation

Source: NTSB Safety Recommendation Information System (SRIS) http://www.ntsb.gov/safetyrecs/private/QueryPage.aspx.

Accident Background:

According to NTSB accident report (NTSB AAR-04/04), American Airline Flight 587 crash on November 12, 2001 killing 260 on board and five on the ground, caused by excessive rudder input from the first officer when the plane flew into a larger jet's wake. The NTSB issued safety recommendation A-02-01 to FAA regarding the issue of excessive rudder input.

Timeline:

Nov 12, 2001—Accident occurred and investigation was launched.
Feb 08, 2002—Safety recommendation A-02-01 issued.
Status (as of 8/11/2010)—Open acceptable.

Response Date: 4/15/2002
From: Addressee
Response:

Letter Mail Controlled 05/07/2002 10:58:22 AM MC# 2020458. The Federal Aviation Administration (FAA) agrees with the intent of these safety recommendations and has taken the following action based on the results of the accident investigation to date.

Response Date: 7/22/2002
From: NTSB
Response:

The Safety Board thanks the FAA for the actions it has taken in response to these recommendations. The Board notes that the FAA's review of training programs was limited to the programs of operators of Airbus airplanes. The Board believes that the training programs of operators of other manufacturers' airplanes should also be reviewed. The FAA's plan to use non-regulatory means to meet the intent of Safety Recommendation A-02-01 may represent an acceptable alternative; however, the FAA also indicates that it may ultimately make a regulatory change. The Board will assume, until the FAA indicates otherwise, that the FAA will develop some regulatory changes in pilot training programs in response to Safety Recommendation A-02-01. Pending completion of changes to pilot training programs in response to the recommendations, the determination of whether these revisions will be implemented through the procedures in HBAT 99-07 or through regulatory changes, and the FAA's consideration of reviewing the training programs of operators of other manufacturers' airplanes, Safety Recommendations A-02-01 and A-02-02 are classified "Open–Acceptable Response."

This is the last communication in the database between the NTSB and the FAA on this safety recommendation as of August 15, 2010.

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Notes

[1] Our use of the term "forensic" here and throughout this article refers to the scientific methods with which the NTSB investigates matters of public safety, and is not meant in the legal sense; in fact, the NTSB's investigations are not admissible evidence in court (see Section 5.1).

[2] The NTSB also serves as the appellate authority for airmen, aviation mechanic, and mariner certificate actions (e.g., to reinstate a suspended certificate) taken, respectively, by the FAA Administrator, and the Commandant of the U.S. Coast Guard. It also provides transportation disaster assistance functions, which involves guiding carriers in the development of plans to assist accident victims and families of accident victims.

[3] Of course, individual board members, in accordance with the NTSB's preference for openness and accessibility, often hold separate meetings with others, including advocacy groups and family members of the victims of accidents under investigation.

[4] Parties are named as participants in the investigatory process based upon their ability to provide needed information, skills, and assistance. The parties typically will

include a DOT modal administration (i.e., the FAA, the FRA, FHWA, etc.), as well as non-Federal entities, including carriers, manufacturers, and a variety of experts.

[5] Many of the participants who can provide technical assistance are also likely to be defendants in the ensuing litigation. For that reason, families of the victims, i.e., potential litigation plaintiffs, complain that this privileged access to information by those prospective defendants gives those defendants an unfair litigation advantage.

[6] Party members are not permitted to reveal to their employers any aspect of the investigation that is not public information. However, party members may face pressure from their superiors to divulge information in an effort to limit the liabilities of their companies.

[7] Whether or not a public hearing is held can sometimes be a point of contention between the NTSB, Congress, and other stakeholders. For example, the NTSB's decision not to hold a hearing for the Minneapolis bridge collapse was quite controversial (see http://www.youtube.com/watch?v=ZgCqh1OLcG0).

[8] In some cases, an accident investigation may involve criminal activities, e.g., the four airplane crashes on September 11, 2001, and in these situations, the NTSB no longer plays the lead investigative role but, instead, provides support for the law enforcement agencies involved. As described on the NTSB website (http://ntsb.gov): "In cases of suspected criminal activity, other agencies may participate in the investigation. The Safety Board does not investigate criminal activity; in the past, once it has been established that a transportation tragedy is, in fact, a criminal act, the FBI becomes the lead federal investigative body, with the NTSB providing any requested support. …As the result of recent legislation, the NTSB will surrender lead status on a transportation accident only if the Attorney General, in consultation with the Chairman of the Safety Board, notifies the Board that circumstances reasonably indicate that the accident may have been caused by an intentional criminal act."

[9] Because NTSB investigations are focused on determining probable causes of accidents, not legal liability, the accident reports are not meant to serve as evidence in legal proceedings, and certain conclusions and recommendations may be considered prejudicial—and therefore, inadmissible—under certain local and federal rules of evidence. The inadmissibility of NTSB accident reports also allows parties engaged in legal proceedings to conduct their own investigations in ways that are most effective in supporting their cases.

[10] While NTSB accident reports are inadmissible as evidence in legal proceedings, they provide important underlying information on which lawsuits are based, and not surprisingly, make NTSB investigators attractive to litigants as potential sources of valuable information that can influence litigation strategies. See 49 U.S.C 1154(b) and 49 CFR Part 835 for more details.

[11] For example, on March 4, 2008, a Cessna 500 corporate jet crashed in Oklahoma City, killing all five people on board. At first glance this accident was caused by pelicans hitting the airplane, but the investigation soon revealed numerous alarming inadequacies in charter operations. The NTSB proposed four safety recommendations regarding wildlife strikes and six safety recommendations on the operations of chartered flights [NTSB AAR-09/05].

[12] For example, during the investigation of the crash of TWA flight 800 in 1996, the NTSB issued an urgent safety recommendation regarding the plane's center fuel tank, four years before the investigation was completed.

[13] In addition to the crash of the Colgan Air flight, which was operating as Continental Connection, there was a 2007 accident in Traverse City, Michigan, in which a Pinnacle Airlines flight was operated as Northwest Airlink; a 2007 accident in Cleveland, Ohio, in which a Shuttle America flight was operated as Delta Connection; and a 2006 accident in Lexington, Kentucky, in which a Comair flight was operated as Delta Connection. (NTSB Advisory, August 16, 2010).

[14] This action was later criticized by some as politically motivated (see Kaszuba, 2007).

[15] The time commitment required to prepare for an NTSB public hearing is typically three months or more of full-time preparatory work for most of the investigative team, which effectively brings the investigation to a full stop during this period.

[16] According to a statement issued by URS Corporation to its investors on August 23, 2010, it settled the litigation for a sum of $52.4 million, denying any wrong-doing, and citing the NTSB investigation (see http://www.urscorp.com).

[17] For example, this explanation was not particularly supportive of Congressman Oberstar's initiative to raise state and federal gasoline taxes to fund bridge repairs and road reconstruction. As reported in the Minneapolis Star Tribune on August 22, 2007 (see Kersten,

2007):

> …Minnesota Rep. Jim Oberstar—the powerful chairman of the House Transportation and Infrastructure Committee—has called for a 'temporary' 5-cent increase in the federal gas tax to raise what he says is a critically needed $25 billion over three years for a national bridge-repair trust fund. "If you're not prepared to invest another five cents in bridge reconstruction and road reconstruction, then God help you," he said after the bridge collapse.

[18] During the investigation of the Colgan Air accident (see Section 3.1), the NTSB pointed out deficiencies in FAA oversight and surveillance. According to the accident report (NTSB AAR-10/01, page 154), "The current Federal Aviation Administration surveillance standards for oversight at air carriers undergoing rapid growth and increased complexity of operations do not guarantee that any challenges encountered by the carriers as a result of these changes will be appropriately mitigated."

[19] For example, "To ensure aviation's future viability, FAA is now working with its federal and industry partners to develop a flexible aerospace system that fully responds to the changing needs of businesses and customers in the 21st Century." (http://www.faa.gov/about/history/brief_history/). A more direct illustration is the FAA's 2004 "Customer Service Initiative" in which the airliners were considered its "customers" instead of the traveling public. This initiative has since been appropriately modified, but it provides a sobering illustration of the sometimes unavoidable conflicts faced by regulators.

[20] The NTSB also ranked 6th in "pay and benefits," 10th in "team work," 10th in "performance based rewards and advancement," and 6th in "family friendly culture."

[21] According to the NTSB accident report for the American Airline Flight 587 crash on November 12, 2001 in Belle Harbor, New York, which killed 260 aboard and 5 on the ground (NTSB AAR-04/04), the first safety recommendation was issued on February 8, 2002, while the final accident report was adopted on Oct 26, 2004.

[22] For example, the NTSB determined that the probable cause of the explosion of TWA Flight 800 shortly after take-off on July 17, 1996 was the ignition of flammable fuel vapors in the plane's center wing fuel tank, and issued safety recommendation A-96-174 on December 13, 1996 requiring airplanes to be fitted with some form of "fuel inerting system." In July 1998, an FAA study concluded that the cost to the industry would be $20 billion and very difficult to retrofit into existing airplanes. Subsequent FAA studies produced a cheaper and effective alternative, and on November 23, 2005 the FAA published a Notice of Proposed Rule Making in the *Federal Register* (Vol. 70, No. 225, pages 70921–70962) regarding its proposal to require the installation of flammability reduction systems in all commercial aircraft. The new FAA rule was issued on July 21, 2008 *(Federal Register* Vol. 73, No. 140, pages 42444–42504), 12 years after the NTSB safety recommendation. See the NTSB article: http://www.ntsb.gov/recs/mostwanted/explosive_tanks.htm for further details.

[23] Some have argued that this dual perspective can sometimes lead to "regulatory capture," in which regulators become overly influenced by industry they are supposed to regulate. For example, *The New York Times* published a story on June 4, 2009, about four months after the Colgan Air accident, of an FAA inspector who raised issues with Colgan Air more than a year prior to the crash, but was overruled by his supervisor in an effort to help Colgan Air maintain its flight schedule (see Wald, 2009). However, it is clear that most regulators do have multiple competing objectives by charter, hence such conflicts are inevitable and must be managed carefully by the regulatory body.

[24] The salary data is from 1998 and 1999.

[25] For example, in 2008, the value-added contribution of the financial services industry to gross domestic product was $1,882.4 billion (the sum of: finance and insurance; Federal Reserve banks, credit intermediation, and related activities; and securities, commodity contracts, and investments), which is over seven times the value-added of $252.3 billion of the transportation industry (the sum of: air, rail, water, truck, transit and ground-passenger transportation). See the Bureau of Economic Analysis's "Gross-Domestic-Product-by-Industry Accounts," May 25, 2010 Release for further details.

[26] See Office of Financial Stability (2010, page 1) for the $50 billion estimate of the economic impact of TARP. A recent estimate of the economic value of a life is provided by Viscusi (2004), who incorporates worker fatality risk, and arrives at an estimate of $5.0 million in 2000 dollars. With the Consumer Price Index at 169.30 in January 2000 and 218.15 in August 2010 (see http://www.bls.gov/cpi/), this implies a current value of $6,442,705.26 which, when divided into $50 billion, yields 7,761 lives.

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