# SAFETY in the SKIES

Institute for Civil Justice • RAND

## Personnel and Parties in NTSB Aviation Accident Investigations

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# PREFACE

The daily movement of millions of passengers over distances thought impossible merely a century ago is emblematic of the modern transportation era—an era characterized by speed and personal convenience. The commerce of aviation, both the operation of commercial aircraft for profit and the development of aeronautical systems, is also an important symbol of national prestige and a powerful economic force. Safety in air transportation is, therefore, a matter of profound national importance.

The National Transportation Safety Board (NTSB) plays a central role in the overall equation of aviation safety. The agency enjoys the reputation of being the most important independent safety investigative authority in the world; the caliber of its investigations has become the international standard. The NTSB is considered to be the best in the business and has served as a model for independent investigative authorities in many countries. However, recent major commercial aviation accidents, such as TWA Flight 800 and USAir Flight 427, have stretched the resources of the NTSB to the limit and have challenged the ability of the technical staff to unravel the kinds of complex failures that led to such horrific tragedies.

Preserving and enhancing the NTSB's ability to fulfill its crucial safety mission were the central motivations for this research and are the guiding principles behind the recommendations that are proposed. Recognizing the strain now being placed upon the limited resources of the safety board and its technical staff, NTSB Chairman Jim Hall sought a self-critical examination of the agency's capability to carry out one of its most important and visible assignments: the investigation of major commercial aviation accidents. Chairman Hall

requested that the inquiry substantially pertain to this subject, with application where appropriate to the other transportation modes under the NTSB's jurisdiction. Although the NTSB investigates thousands of general aviation, marine, rail, highway, and other transportation accidents every year, the public reputation and credibility of the safety board substantially rest on its ability to determine the cause of major commercial aviation accidents. It is also in this area that the NTSB's independence has been most vigorously challenged by the many stakeholders whose interests may be affected by the outcome of an investigation.

In undertaking this research, RAND was able to involve personnel with expertise in several disciplines from three RAND programs: the Institute for Civil Justice, the Science and Technology Policy Institute, and Project AIR FORCE. This multidisciplinary approach enabled the researchers to use a variety of quantitative and qualitative research techniques to examine the inner workings of the NTSB closely. This research provides the most comprehensive examination of NTSB operations that has ever been undertaken in the 30-year history of the agency.

We commend this report to serious consideration by the NTSB and all the affected interest groups and stakeholders involved with the investigation of major commercial aviation and other transportation accidents. The report offers significant insights into the existing investigative process and, at the same time, sets forth important recommendations aimed at strengthening the safety board's ability to carry out its essential safety mission. We believe the report makes a significant contribution to assuring the safety of the traveling public and to the advancement of public policymaking in this most important field.

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# SUMMARY

The NTSB bears a significant share of the responsibility for ensuring the safety of domestic and international air travel. Although it is not a regulatory agency, the NTSB's influence weighs heavily when matters of transportation safety are at issue. The NTSB is independent from every other Executive Branch department or agency, and its mission is simple and straightforward: to investigate and establish the facts, circumstances, and the cause or probable cause of various kinds of major transportation accidents. The safety board is also charged with making safety recommendations to federal, state, and local agencies to prevent similar accidents from happening in the future.[1] This responsibility is fundamental to ensuring that unsafe conditions are identified and that appropriate corrective action is taken as soon as possible. However, the safety board has no enforcement authority other than the persuasive power of its investigations and the immediacy of its recommendations. In the scheme of government, the agency's clout is unique but is contingent on the independence, timeliness, and accuracy of its factual findings and analytical conclusions.

Increasingly, the NTSB has no choice but to conduct its investigations in the glare of intense media attention and public scrutiny. As commercial air travel has become routine for millions of passengers, major accidents have come to be viewed as nothing short of national catastrophes. At the same time, an NTSB statement of cause may

[1]The term *safety board* is used throughout as a short form for the NTSB. RAND uses *board members* to refer to the five politically appointed Members of the Board of the NTSB.

also be nothing short of catastrophic for the airline, aircraft manufacturer, or other entity that may be deemed responsible for a mishap. A very real, albeit unintended, consequence of the NTSB's safety investigation is the assignment of fault or blame for the accident by both the courts and the media. Hundreds of millions of dollars in liability payments, as well as the international competitiveness of some of America's most influential corporations, rest on the NTSB's conclusions about the cause of a major accident. This was not the system that was intended by those who supported the creation of an independent investigative authority more than 30 years ago, but it is the environment in which the investigative work of the agency is performed today.

The NTSB relies on teamwork to resolve accidents, naming "parties" to participate in the investigation that include manufacturers; operators; and, by law, the Federal Aviation Administration (FAA). This collaborative arrangement works well under most circumstances, leveraging NTSB resources and providing critical information relevant to the safety-related purpose of the NTSB investigation. However, the reliability of the party process has always had the potential to be compromised by the fact that the parties most likely to be named to assist in the investigation are also likely to be named defendants in related civil litigation. This inherent conflict of interest may jeopardize, or be perceived to jeopardize, the integrity of the NTSB investigation. Concern about the party process has grown as the potential losses resulting from a major crash, in terms of both liability and corporate reputation, have escalated, along with the importance of NTSB findings to the litigation of air crash cases. While parties will continue to play an important role in any major accident investigation, the NTSB must augment the party process by tapping additional sources of outside expertise needed to resolve the complex circumstances of a major airplane crash. The NTSB's own resources and facilities must also be enhanced if the agency's independence is to be assured.

The NTSB's ability to lead investigations and to form expert teams is also seriously threatened by a lack of training, equipment, and facilities and by poor control of information. The NTSB's standards in these areas must be enhanced to ensure the continued integrity and credibility of the safety board's investigations. Additionally, the need to modernize investigative practices and procedures is particularly

acute. Given modern aircraft design, manufacture, and operation, the NTSB's investigative techniques are in some respects archaic, raising doubts that complex accidents will be expeditiously, or even conclusively, resolved.

Clearly the NTSB needs additional resources, but management reform is no less vital. Ensuring effective use of resources first requires adequate means of monitoring expenditures. A lack of even rudimentary project-type financial accounting prevents the NTSB from monitoring such important parameters as staff workload. Reinvigorating the NTSB must start here.

In this report, RAND outlines a comprehensive set of recommendations aimed at helping to ensure that the NTSB can meet the demands of the future. The recommendations are formed around a model of the NTSB that is less insular in how it operates and more proactive in the realm of national and international aviation safety. The recommendations aim to accomplish the following eight objectives:

- strengthen the party process
- create a more expansive statement of causation
- modernize investigative procedures
- streamline internal operating procedures
- better manage resources
- maintain a strategic view of staffing
- streamline training practices
- improve facilities for engineering and training.

While the tenets upon which the NTSB was originally created remain sound, new approaches outlined in the recommendations are necessary to meet the demands of a more complex aviation system.

# ACKNOWLEDGMENTS

The authors would like to thank NTSB Chairman Jim Hall and NTSB Managing Director Peter Goelz for their support and assistance with this project and for their appreciation of the benefits to be gained from independent research. Special thanks also go to Bernard Loeb, Vernon Ellingstad, Barry Sweedler, Dan Campbell, and Craig Keller, senior staff at the NTSB, for their advice, counsel, and expertise about the aviation accident investigation process. The authors would also like to specially thank a former NTSB staff member, Matthew M. Furman, who as Special Counsel, helped to devise the notion of this project and to formulate the initial research agenda. Last, but certainly not least, NTSB Board Members Robert T. Francis II; John Goglia; George W. Black, Jr.; and John Hammerschmidt spent many hours in open and frank discussions of safety board procedures and operations.

A central element of this study was obtaining access to NTSB data sources and information about the accidents selected for review. The authors wish to thank the staffs of the NTSB's Offices of the Chief Financial Officer, Human Resources, Government, Public and Family Affairs, Aviation Safety, Research and Engineering, and Safety Recommendations and Accomplishments for their cooperation, patience, and support. Personnel in all of these offices provided rapid response to our inquiries and were available to assist us in obtaining the information we requested. A special thanks also to Henry Hughes, a senior investigator at the NTSB, who went to extraordinary lengths to provide special insights into safety board operations. The authors would also like to thank C. O. Miller, who, although long retired from the NTSB, continues to offer valuable

insights and institutional memory that proved to be of great assistance in our research.

FAA Administrator Jane Garvey and David Thomas, then the FAA's Director of Accident Investigation, provided a fundamental understanding of the relationship between the NTSB and the FAA. RAND is very appreciative of the insights of Mary Connors and Irving Statler of the NASA Ames Research Center, who provided information on the Aviation Safety Reporting System and the important topic of monitoring aviation safety incidents.

The study benefited greatly from the assistance and information that many companies and individuals involved with aviation safety and the aviation accident investigation process provided. In particular, the authors would like to express their gratitude to the Boeing Commercial Airplane Company, and specifically Charles R. Higgins, Vice President, Air Safety and Performance, and Russ Benson, Senior Manager, Aviation Affairs, for the time spent in providing briefings and insights on the design and manufacture of today's commercial aircraft. Similarly, the authors would like to express appreciation for the knowledge and hospitality provided by Airbus Industrie, and in particular, John Lauber, Vice President for Training and Human Factors, and Yves Benoit, Director, Flight Safety. Airline operators also provided essential insights and data to the study. We would very much like to thank the senior members of United Airlines, American Airlines and AMR Corp., US Airways, and Northwest Airlines who patiently answered our many questions. The authors would also like to expressly thank Ken Smart, Chief Inspector of Air Accidents, Air Accidents Investigation Branch, United Kingdom, and Paul Arslanian, Director, Bureau Enquêtes-Accidents, France, for the time each spent considering the effectiveness of the NTSB and informing us about the operations of their respective investigative agencies.

The aviation community is represented by many domestic and international organizations that RAND turned to for key elements of the research. Especially supportive of RAND's research were the Air Line Pilots Association, the Air Transport Association, the Flight Safety Foundation, and the National Air Traffic Controllers Association. RAND is also deeply grateful to the many individuals who have lost loved ones in aviation accidents who came forward to support this research and to provide personal insights of immense value. We would particularly like to acknowledge the encouragement provided

by Hans Ephraimson-Apt, Jim Hurd, and the National Air Disaster Alliance, an organization that represents families of victims of major commercial air crashes.

Aviation accident investigation is an activity that involves many stakeholders in the aviation, aviation insurance, and legal communities. We would like to express our appreciation to the many individuals who took the time to meet with us and were willing to participate in lengthy confidential interviews regarding the NTSB investigative process and its influence on civil litigation. We benefited greatly from these interviews and our research was enriched by the candor with which many interviewees approached this task. We appreciate their professional courtesy and insightful discussions, which we hope were of mutual benefit. We would especially like to mention Robert A. Clifford, of the Clifford Law Offices, a plaintiffs' trial lawyer who is also a member of the Board of Overseers of the RAND ICJ, and Fredrick P. Alimonti, a partner at the aviation defense firm of Haight, Gardner, Holland & Knight, who as cochairs of the American Bar Association's 1999 Aviation Litigation Seminar, afforded us an opportunity to test our findings with an interested and demanding audience.

The law library at the University of California at Los Angeles School of Law contains a unique collection of aviation law materials that proved indispensable to this research. The authors would like to thank former UCLA Law School Dean Susan Praeger for arranging access to the David Bernard Memorial Aviation Law Library.

We are indebted to our RAND colleagues Jean Gebman, Beth Asch, Deborah Hensler, and Stephen Drezner, as well as outside counsel Michael Traynor, who provided important advice during the course of the study and who additionally committed the time to participate in the RAND peer review process. We offer a special thanks to James Dewar for his oversight and guidance, which helped to ensure a quality product. In addition, Deborah Hensler, as the former Director of the ICJ, and Alan Charles, as the ICJ's current Director, provided important support and encouragement for this project. We are also most appreciative of the support and guidance that Michael Rich, RAND's Executive Vice President, provided and for the assistance of RAND management in ensuring the completion and publication of this report.

The RAND support staff provides the underpinning of every project and ensures that the work is finalized. We would especially like to thank Phyllis Gilmore, who edited the draft and final reports; Donna Boykin and Darlette Gayle, for their many administrative contributions; and RAND librarians Gail Kouril and Jennifer Casey for helping to assemble references and citations. The authors are, of course, responsible for the observations and judgments contained in this report.

## ABBREVIATIONS

| | |
|---|---|
| DoT | Department of Transportation |
| FAA | Federal Aviation Administration |
| IIC | Investigator in charge |
| NAS | National Airspace System |
| NASA | National Aeronautics and Space Administration |
| NTSB | National Transportation Safety Board |
| OAS | Office of Aviation Safety |
| PM | Project manager |
| TWA | Trans World Airlines |

Chapter One

# STUDY OVERVIEW

> The third step taken by Congress [in enacting the Civil Aeronautics Act of 1938] is to provide . . . for a Safety Board charged with the duty of investigating accidents . . . The Board . . . is not permitted . . . to exercise . . . regulatory or promotional functions . . . It will stand apart, to examine coldly and dispassionately, without embarrassment, fear, or favor, the results of the work of other people.
>
> —*Edgar S. Gorrell, President, Air Transport Association, 1938*[1]

The National Transportation Safety Board (NTSB) is pivotal to the safety of the traveling public in the United States and throughout the world. While it is not a regulatory agency and does not command significant enforcement powers, the NTSB exerts enormous influence based on the independence and accuracy of its accident investigations and the authority of its recommendations. The NTSB is charged with the responsibility of investigating and establishing the facts, circumstances, and probable cause of transportation accidents and with making safety recommendations to governmental agencies to prevent similar accidents from happening in the future. Fundamentally, the safety board provides a quality assurance function vital to the ongoing safety of all modes of transportation. The NTSB's unique role in transportation safety is contingent on the ability of the board members and the professional staff to conduct independent

[1]Nick A. Komons, *The Cutting Air Crash: A Case Study in Early Federal Aviation Policy*, Department of Transportation, Washington, D.C., 1973, p. 1.

investigations of accidents and major incidents and, in so doing, to assure public confidence in the safety of our national transportation systems.[2]

The NTSB has become most publicly identified with its investigations of major commercial aviation accidents. The NTSB has the responsibility for investigating every civil aviation accident in the United States. In addition, based on the agency's mandate under Annex 13 to the Convention on International Civil Aviation (known as the Chicago Convention) and related international agreements, the NTSB participates to a greater or lesser degree in the investigation of commercial aviation accidents throughout the world. The NTSB enjoys a worldwide reputation as "the best in the business," but it cannot afford to run in place. NTSB investigators are going to be asked to unravel increasingly complex accidents in an environment beset by high-stakes litigation and intense public scrutiny. In recent years, the NTSB has undertaken aircraft accident investigations of unprecedented cost, complexity, and length, exemplified by such high-profile accidents as Trans World Airlines (TWA) Flight 800 and USAir Flight 427. These investigations have stretched staff resources to the limit and have seriously challenged the expertise of NTSB investigators.

The integrity of the NTSB's accident investigation process depends on the independence and skills of the agency's investigative staff, combined with the probity of the information provided by the organizations, corporations, and individuals designated to assist as "parties" in investigative proceedings. The safety board's principal resource is its staff; as a consequence, workload, staffing, and training are key determinants of the agency's competence and proficiency. Constraints of budget, personnel, and technical resources have already posed a fundamental challenge to the ability of the agency to do its job. The continuation of "business as usual" will simply not be enough to ensure fulfillment of the NTSB's critical safety mission. The NTSB must embrace new methodologies, new management approaches, and a new awareness of its working environment if future demands and expectations are to be met.

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[2]The term *safety board* is used throughout as a short form for the NTSB. RAND uses *board members* to refer to the five politically appointed Members of the Board of the NTSB.

This report addresses a number of issues relevant to the investigation of major commercial aviation accidents and outlines a specific agenda of actions to bolster the NTSB's independence and to ensure that the safety board has sufficient resources to effectively investigate the kinds of accidents that will occur well into the 21st century.

## A NATIONAL FOCUS ON AIR SAFETY

On July 17, 1996, TWA Flight 800, an early model Boeing 747 carrying 230 passengers and crew, lifted off from New York's John F. Kennedy International Airport bound for Paris. Minutes later, the huge airliner exploded and crashed into the waters off the eastern shore of Long Island. The terrific force of the explosion had torn the aircraft apart, and the disturbing recovery images, along with vivid eyewitness accounts, riveted the attention of a shocked American public for many weeks. It was an all too familiar scene. Only two months earlier, a McDonnell-Douglas DC-9 operated by ValuJet Airlines had slammed into the Florida Everglades killing 110 people. Their aircraft on fire and losing control, the crew struggled to land the crippled airliner. The crash scene was particularly gruesome.

These back-to-back crashes shook the foundation of the aviation community. The traveling public was frightened, and media pundits questioned the perceived safety of domestic airline operations.

The Clinton administration reacted quickly. On July 25, 1996, President Bill Clinton announced the creation of the White House Commission on Aviation Safety and Security.[3] Chaired by Vice President Al Gore, the commission set an aggressive agenda for reviewing the safety of the air transportation system and issued initial recommendations within two months. The final report, issued five months later, outlined sweeping changes calling for regulatory reform and additional research directed toward new, safer technologies. Most importantly, the commission's report prescribed a national goal of dramatically reducing the risk of fatalities in the air.[4]

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[3]Initial concerns that an explosive device or terrorist activity had caused the demise of TWA Flight 800 prompted an early focus on the security aspects of aviation safety.

[4]Office of the President, White House Commission on Aviation Safety and Security, *Report to President Clinton*, Washington, D.C., January 1997. The actual goal,

Concerns over aviation safety expressed in the White House commission's report were echoed by the report of the congressionally mandated National Civil Aviation Review Commission (popularly known as the Mineta Commission, chaired by former California Congressman Norman Mineta), issued in December 1997.[5] The report highlighted an industry analysis showing that existing accident rates and increasing demand could lead to an airline accident occurring somewhere in the world on a weekly basis. Clearly, aviation safety was a matter requiring renewed U.S. leadership and significant national investment.

At the same time, the newly enacted Aviation Family Assistance Act of 1996 mandated the creation of the Task Force on Assistance to Families of Aviation Disasters, overseen jointly by the U.S. Department of Transportation (DoT) and the NTSB. The TWA and the ValuJet disasters had also unveiled the urgent need to find ways to improve the treatment of victims' families by the government, the airlines, the legal community, and the media. Among other things, the White House commission requested that the task force review the accident investigation process utilized by the NTSB and its potential impact on families. The task force's report, containing 61 separate recommendations, amounted to a blueprint for the appropriate treatment of families suffering such grievous losses.[6] Noteworthy among the task force's recommendations was a directive to the NTSB to "formally review" the party system, an essential element of the agency's investigative process, which allows the companies and entities involved with the accident to participate directly in the NTSB investigation.

## THE ROLE OF THE NTSB IN AVIATION SAFETY

From the perspective of the NTSB, the combined effects of these successive commission and task force reports were significant, raising

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embraced and refined within the FAA's Strategic Plan, aims to "reduce the U.S. aviation fatal accident rate per aircraft departure, as measured by a 3-year moving average, by 80 percent from the 3-year average for 1994–1996" by 2007.

[5]National Civil Aviation Review Commission, *Avoiding Aviation Gridlock and Reducing the Accident Rate: A Consensus for Change*, Washington, D.C., December 11, 1997.

[6]U.S. Department of Transportation and the National Transportation Safety Board, *Final Report, Task Force on Assistance to Families of Aviation Disasters*, Washington, D.C., 1997.

important questions about the future mission and workload of the NTSB, as well as concerns about the agency's investigative methods and operations. The NTSB's mission is primarily *proactive*—the prevention of transportation accidents—yet the agency accomplishes this mission primarily by being *reactive* in responding to catastrophic events. The NTSB's goal is to improve quality (safety and performance) through the analysis of failure (the crash of an aircraft). When defects are found, the NTSB issues recommendations that can have profound effects on how aircraft are designed, manufactured, and operated. Because U.S.-made aircraft are sold and operated worldwide, improvements the NTSB suggests have international implications for air safety. Over the years, the NTSB's many safety recommendations, synthesized from tragic events, have helped bring the performance of the National Airspace System (NAS) to its current state of high performance and reliability.

Following the crash of Korean Air Flight 801 in Guam on August 6, 1997, killing 228 passengers, no fatal domestic commercial aviation accidents took place until the June 1, 1999, crash of an American Airlines MD-80 airliner in bad weather in Little Rock, Arkansas, killing 11 people.[7] This 22-month hiatus in major accident events lulled some policymakers into the belief that issues related to aviation safety, at least on the domestic front, had been adequately addressed. Whether this pause in fatal accidents was due to increased government and industry vigilance or simply the highly stochastic nature of aircraft accidents will never be known. However, even if aviation accidents become relatively rare events, the role of aviation accident investigation is germane to this study. What will the NTSB investigate if fewer planes crash? Of course, the NTSB investigates accidents in all transportation modes, but the lion's share of its efforts and its public identity are tied to aviation. The answer to this mission-related question could fundamentally change the form and function of the NTSB in the years ahead.

Both inside and outside the NTSB, concerns have also been expressed that the safety board is becoming fragmented and is

[7]During the period, several major commercial aviation accidents occurred worldwide, most prominently the crash of Swissair Flight 111, involving a McDonnell-Douglas MD-11, near Halifax, Nova Scotia, killing 229 people traveling from New York to Geneva, including 137 Americans.

operating at the limits of its capability. In recent years, the NTSB has undertaken aircraft accident investigations of extraordinary cost, complexity, and length. The investigation of the crash of TWA Flight 800 is still not complete, almost three-and-a-half years later. The investigation of another high-profile accident, the crash of USAir Flight 427 in 1994, took more than four years to complete, yielding a conclusion that was technically controversial and circumstantial.

These crash investigations mark some clear trends. They demonstrate that, when modern airplanes—machines developed with highly integrated systems and high orders of complexity—crash, the subsequent investigation is likely to develop commensurate levels of complexity. NTSB investigators will be quickly immersed in continued media attention and will face new sources of criticism and alternative accident theories flooding in via the Internet. Finally, the economic stakes have never been higher. Today, a major accident can expose manufacturers and operators to enormous potential losses. Companies suffer costly mandated repairs and modifications to aircraft or operating procedures, multimillion dollar liability claims, and the loss of international market share. The magnitude of potential loss can be so high as to call into question the commitment of private parties to full disclosure and technical objectivity during investigations. Since the NTSB has historically depended on the openness of private firms involved in a crash, any change in behavior would significantly affect safety board investigative practices and organizational capabilities.

These factors combine to bring into focus the technical practices, staff capabilities, and operational methods of the NTSB. Can the NTSB, as currently chartered and operated, deal with modern aviation accidents? Can its traditional relationships with stakeholders in the aviation community continue to operate reliably in such a highly litigious environment? These questions make it clear that the NTSB is facing a period of dramatic change. Such realities motivated RAND's detailed review.

## OBJECTIVES OF THE STUDY

The Chairman of the NTSB asked RAND to address two important issues at the heart of the NTSB investigative process: the safety board's interaction with external parties during an investigation and

the internal ability of its staff to train to meet existing and emerging challenges. These issues are highly related, as the research came to clearly demonstrate. Ultimately, RAND's analysis looked closely at the internal operations of the NTSB and carefully examined its relationship with outside stakeholders in the aviation community.

Leadership is a central theme of NTSB operations, providing the essential connection between staff capability and the ability to manage and direct major investigations. From its inception, the safety board was viewed as an agency to lead accident investigations, in concert with the outside parties involved in the crash; i.e., the airline, the aircraft manufacturers, air traffic control, airport operators, etc. This is the essence of *the party process*. It is the core *modus operandi* for the NTSB's investigation of all transportation accidents. The centrality of the party process reflects an appreciation, on the part of legislators and other policymakers, that an agency capable of operating with complete autonomy would be impossibly large, unwieldy, and costly considering the diversity of accidents that the safety board is called upon to investigate. The NTSB must work with parties involved in a crash; there is insufficient in-house expertise within the agency itself. However, this presents a clear and present danger to the integrity of the investigative process—parties that face potentially enormous economic losses if they are found to be the cause of an accident could attempt to disrupt or bias an investigation.

Two basic tenets underpin this somewhat risky policy choice. The first is that the safety board staff must manifest exceptional skill and expertise, combining leadership in relevant technical areas with superior investigative talents and management abilities. The NTSB's principal resource is clearly its staff. How this staff is recruited, maintained, and trained ensures, more than any other single factor, the timely and accurate resolution of transportation accidents. The second tenet underlying this policy choice is that the parties to an accident investigation will participate openly, honestly, and with the highest level of integrity, animated by the notion that safety will be furthered by the expeditious determination of an accident's cause. Although the second principle is necessary to fulfillment of the NTSB's investigative goals, it is not sufficient in the absence of the safety board's exercise of leadership through the excellence and expertise of its staff. Should either tenet be violated, the credibility of safety board products—findings of cause and safety recommenda-

tions—would become suspect. RAND's research can be summarized as a review of these two fundamental tenets of NTSB operations.

The research examined two aspects of the agency's operations:

- NTSB practices and policies with regard to the training and qualifications of aviation accident investigators, including a determination of the adequacy of such policies and practices in light of future technological developments in aviation
- the functioning of the party process as a means of supplementing NTSB skills and technical knowledge, including an examination of the liability environment in which the party system operates.

It is important to note that a strong element of general concern about the NTSB surrounded these specific research objectives. RAND encountered a consistent uneasiness regarding the ability of the NTSB to generate timely, accurate results. Many observers and stakeholders openly expressed a belief that the NTSB's technical capabilities had seriously eroded and that investigations were being hampered by an overloaded staff that was increasingly insulated from the aviation community. Individuals inside and outside the NTSB expressed these concerns. Many stakeholders cited, for example, growing tension between the NTSB and aviation regulators at the Federal Aviation Administration (FAA). Others expressed concern that the NTSB's limited staff was no match for the opposition of large commercial firms facing large potential losses. Inevitably, the information acquired during the course of this research, as well as the resulting findings and recommendations, expanded to incorporate some of these broader questions.

RAND worked with NTSB senior managers specifically to augment the scope of the research in selected areas. For example, while original study objectives called for an examination of NTSB training policies, it quickly became apparent that maintaining a capable staff does not depend only on training but is also influenced by hiring policies and staff workloads. The scope of work was subsequently expanded to address hiring and workload issues. In the course of the research, RAND also noted many areas in which internal NTSB practices either inhibited the hiring and training of staff, added to an already busy workload, or caused breakdowns in communication

with parties involved in investigations. These issues are summarized in this report.

The breadth of the research should also be noted. Resource limitations demanded that RAND focus its analysis on aviation accidents, largely ignoring the four other areas of NTSB authority.[8] Many of the observations made in this report have relevance to these other modes of transportation; however, wholesale extrapolation of the findings and conclusions of this report beyond the sphere of aviation should be avoided. Where possible, RAND has attempted to identify areas applying to the NTSB at large.

Finally, the depth to which these objectives could be explored was, of course, limited by funding. Some aspects of the research could only be touched upon, leaving others inside or outside the NTSB to expand upon the themes RAND identified. In such cases, RAND characterized the issues for the NTSB and recommended additional research and analysis with more focused objectives.

## RESEARCH APPROACH

A study of this magnitude clearly pointed to the need for a multidisciplinary research approach. RAND selected personnel from several different RAND programs, including the Institute for Civil Justice, the Science and Technology Policy Institute, and Project AIR FORCE. The project's staff included aeronautical engineers, public policy analysts, and an attorney to address the diverse set of issues the NTSB presented. The analysis examined both external factors influencing NTSB operations—such as the volume and type of accidents, advances in technology, and the legal environment—and internal factors—such as the policies and procedures the NTSB follows to staff and train its workforce and to conduct its investigations.

RAND created a five-phase research plan to identify critical issues and illuminate the various challenges facing the NTSB. The analysis created a historical perspective of the NTSB and exhaustively studied current procedures and capabilities. Potential solutions must, how-

[8]The safety board also investigates accidents involving (1) railroads; (2) interstate buses, interstate trucking, and other highway accidents selected in cooperation with state authorities; (3) pipelines and hazardous materials; and (4) marine accidents (in conjunction with the U.S. Coast Guard).

ever, remain responsive to projected future demands and present alternatives that are both flexible and resilient. With this in mind, RAND paid close attention to the environment in which the NTSB will operate in the future. The five phases of the research plan consisted of

1. **Baseline Development**—the analysis of information about the NTSB's operating budgets, staff size, accident volumes, and duration of investigations
2. **Emerging Environments**—an assessment of how the aviation environment is likely to change and how the changes could shape NTSB operations
3. **Liability Environment Review**—an examination of the current civil legal system as it affects the settlement and litigation of aviation accident cases and the behavior of stakeholders in the party process
4. **Staffing and Training Review**—an analysis of current staffing and workload, as well as the state of training of accident investigators
5. **Internal Process Review**—a critical assessment of the internal management and operating processes in use at the NTSB.

RAND quickly determined that the NTSB had a limited amount of quantitative data. These data were often of insufficient fidelity to support analyses of the magnitude intended in the research plan. The research team acquired such NTSB financial and staffing data as could be obtained with a reasonable expenditure of project funds. The team also acquired accident statistics and information about the status of investigations and integrated the information to form an initial baseline characterization of the safety board.

RAND used internal NTSB records on personnel, workload, training, budgets, accidents, and accident reports to characterize NTSB operations. Usually these records could not be used directly and had to undergo considerable processing to answer research questions. To augment the NTSB's quantitative data, RAND relied on the following research methods:

- **Structured Questionnaire**—RAND created a confidential survey instrument and distributed it to all professional staff (not limited to aviation) at the NTSB headquarters in Washington, D.C., and the NTSB's field and regional offices. Quantitative analysis of the

responses to this questionnaire provided additional information about the NTSB staff that standard management information systems do not normally capture. Results were subjected to statistical tests to characterize the degree of uncertainty arising from the response rate.[9]

- **Structured Interviews**—RAND interviewed board members and senior management and technical staff at the NTSB's headquarters and regional offices. Representatives of a broad cross section of stakeholders in the aviation community were also interviewed, including defense and plaintiff attorneys, insurers, air safety educators, air carriers and general aviation manufacturers, airline training personnel, aviation researchers, union representatives, families of accident victims, government regulators and policymakers, Canadian and European accident investigators, and European aircraft manufacturers.
- **Legal Review**—RAND completed a comprehensive review of available legal materials related to the NTSB investigative process, including applicable federal regulations, published and unpublished judicial opinions, legal treatises, and legal periodical materials.
- **Site Visits**—In addition to frequent visits to NTSB facilities, RAND visited the reconstruction of TWA Flight 800 at the NTSB site at Calverton, New York; National Aeronautics and Space Administration (NASA) research facilities; large and small aircraft manufacturing sites; flight simulation facilities; and aviation safety schools to gain first-hand knowledge of the environment in which accident investigation takes place.
- **Case Studies**—RAND selected a set of case studies to review NTSB procedures and practices. Accidents were selected that taxed NTSB resources, either technically or organizationally.[10]

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[9]For a more complete description of the RAND skills and experience questionnaire administered to the NTSB staff and for a detailed analysis of the survey results, see Appendix C of the companion technical report: Cynthia C. Lebow, Liam P. Sarsfield, William Stanley, Emile Ettedgui, and Garth Henning, *Safety in the Skies: Personnel and Parties in NTSB Aviation Accident Investigations, Technical Report*, Santa Monica, Calif.: RAND, DRU-2150-ICJ, forthcoming.

[10]A list of the accident investigations in the case study set can be found in Appendix C of the companion technical report to this summary (Lebow et al., forthcoming).

- **Workshops**—Three workshops were held with stakeholders from government and industry, senior government aviation officials, and families of accident victims to discuss many disparate viewpoints. These workshops were conducted without attribution to facilitate the free exchange of information.

Additionally, RAND relied on extensive telephone interviews, an exhaustive literature review, and extensive use of Internet-based quantitative and qualitative data to augment the methods listed above.

Collectively, the numerous data sources provided a rich set of information with which to perform case studies and other more quantitative data analysis that addressed project objectives.

Chapter Two

# AIR ACCIDENT INVESTIGATION TODAY

Congress originally established the NTSB as part of DoT in 1966. Later, the Independent Safety Board Act of 1974 reestablished the NTSB as a completely independent agency separate and apart from all other Executive Branch agencies or departments. The act provided for a five-member board appointed by the President, by and with the advice and consent of the Senate. No more than three members are to be appointed from the same political party, and at least three members are to be appointed on the basis of technical qualification; professional background; and demonstrated knowledge in accident reconstruction, safety engineering, human factors, transportation safety, or transportation regulation. The term of office for each member is five years. Separately, the President designates a Chairman (requiring Senate confirmation for a two-year term), who serves as the chief executive and administrative officer of the safety board.

The NTSB acts as an independent oversight agency with no vested interest in the results of its investigations, other than accident prevention, regardless of where the accident occurs or who was involved. The safety board conducts accident or incident investigations to determine accurately and expeditiously what caused an accident so that steps can be taken to guard against a similar occurrence. These investigations are intended to be fact-finding proceedings with no formal issues and no adverse parties. They are not subject to review under the Administrative Procedures Act and are not conducted to determine the rights and liabilities of any person or company. An NTSB investigation has priority over those of another department or agency, including criminal investigations.

The NTSB is authorized to make safety recommendations to federal, state, and local government agencies and private organizations to reduce the likelihood of recurrence of transportation accidents. It may initiate and conduct safety studies and special investigations on matters relating to transportation safety. When the NTSB submits a recommendation about a safety matter to the Secretary of Transportation, the secretary must formally respond to each recommendation in writing no later than 90 days after receiving it. The secretary must report to Congress every year on DoT's actions regarding each proposed NTSB safety recommendation.

## INVESTIGATING A MAJOR COMMERCIAL AVIATION ACCIDENT

When a major commercial aviation accident occurs, an NTSB "go team," led by an investigator in charge (IIC), is dispatched from the agency's Washington, D.C., headquarters to the accident site, usually within a couple of hours of notification of the event. The IIC, a senior air safety investigator with the NTSB's Office of Aviation Safety (OAS), organizes, conducts, and manages the field phase of the investigation, regardless of whether a board member is also present on the scene.[1] The IIC has the responsibility and authority to supervise and coordinate all resources and activities of the field investigators.

The NTSB go team will form as many as ten investigative groups. Discipline teams will be formed around subject-matter areas, such as power plants, systems, structures, operations, air traffic control, human factors, weather, and survivability. Cockpit voice recorder and flight data recorder groups are formed at the NTSB laboratory in Washington. All NTSB staff assigned to a particular investigation are under the direction of the IIC.

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[1]The OAS conducts the investigations of all major commercial aviation accidents. This activity includes investigating the factual circumstances of the crash (on site and afterward), preparing final reports for submission to the board members, initiating safety recommendations to prevent future accidents, and participating in foreign accident investigations. OAS also encompasses the six regional offices and four field offices that are responsible for investigating general aviation accidents.

## The Party Process

The party system allows the NTSB to leverage its limited resources and personnel by bringing into an investigation the technical expertise of the companies, entities (such as the pilots' union), and individuals that were involved in the accident or that might be able to provide specialized knowledge to assist in determining *probable cause*. Except for the FAA, party status is a privilege and not a right. The IIC has the discretion to designate the parties that are allowed to participate in an investigation, and each party representative must work under the direction of the IIC or senior NTSB investigators at all times. No members of the news media, lawyers, or insurance personnel are permitted to participate in any phase of the investigation. Claimants or litigants (victims or family members) are also specifically prohibited from serving as party members.

The specialists any party assigns to an investigation must be employees of the party and must possess expertise to assist the NTSB in its investigation. Providing the safety board with technical assistance gives parties many opportunities to learn what happened and to formulate theories as to the cause of the accident. Party representatives are not permitted to relay information back to corporate headquarters without the consent of the IIC, and then only when necessary for accident prevention purposes. Information is not to be used for litigation preparation or for public relations. Sanctions for failing to abide by the NTSB party rules and procedures include the dismissal of individuals or even the party from the investigation team. Party representatives must sign a party pledge, a written statement agreeing to abide by the NTSB rules governing the party process.

## Accident Report Preparation

Following completion of the on-scene phase of the investigation (which may last for several days or weeks), each NTSB group chair (the senior investigator overseeing a specific area of the investigation) completes a factual report on his or her area of responsibility. All factual material is placed in the public docket that is open and available for public review. Thereafter, the investigators involved in the case begin an often lengthy period of further fact gathering, usually involving one or more public hearings, and final analysis of

the factual information that has been collected. This process eventually results in a publicly available printed report that, barring reconsideration at a later date, is the NTSB's final product concerning the investigation. The final accident report includes a list of factual findings concerning the accident, analysis of those findings, recommendations to prevent a repetition of the accident, and a probable cause statement.

There is no time limit on NTSB investigative activity. Safety board procedures have a target date for completion of the final accident report within one year of the date of the accident, but recent major commercial aviation accident investigations have taken as little as four months and as much as more than four years.

A key milestone in the report-preparation process is the group chairs' preparation of analytical reports in their respective areas of expertise. The parties may contribute to the analytical reports through their continued contact with the NTSB group chairs and the IIC, but parties are not allowed to review, edit, or comment on the analytical reports themselves. The parties also contribute to the safety board's analytical process through written submissions, which are sometimes extensive and become part of the public docket.

The IIC and the NTSB senior staff create a final draft report, called the notation draft, for presentation to the board members. This draft includes safety recommendations and a finding of probable cause. Following a period for review of the draft report, a public meeting (referred to as the "Sunshine Meeting") of the board members is held in Washington. The NTSB staff will present and comment on the draft report; party representatives are permitted to attend but may not make any kind of presentation or comment. At this meeting, the board members may vote to adopt this draft, in its entirety, as the final accident report; may require further investigation or revisions; or may adopt the final accident report with changes that are discussed during the meeting.

Technically, NTSB investigations are never closed. Parties to the investigation may petition the safety board to reconsider and modify the findings and/or probable cause statement if the findings are believed to be erroneous or if the party discovers new evidence. Petitions from nonparties will not be considered.

### Investigating a General Aviation Accident

The investigation of general aviation accidents is a simpler process requiring fewer staff members per accident. Inasmuch as the NTSB investigates many general aviation accidents per year, abbreviated investigations are generally necessary, given the agency's limited staff and budgetary resources. Most general aviation accident investigations are conducted by one of the NTSB regional or field offices. In a *field investigation*, at least one investigator goes to the crash site; a *limited investigation* is carried out by correspondence or telephone. Some, but by no means all, general aviation accidents generate safety recommendations approved by the board members.

## THE ROLE OF THE NTSB IN INTERNATIONAL AVIATION ACCIDENT INVESTIGATIONS

The NTSB is the government agency charged with the responsibility for assuring compliance with U.S. obligations under Annex 13 to the Chicago Convention, the international treaty that provides the structure for the governance of civil aviation throughout the world. The NTSB's international responsibilities represent a significant portion of the agency's overall aviation workload and are mounting. In the event of a civil aviation accident outside of U.S. territory, the NTSB appoints the accredited U.S. representatives to the investigation and oversees advisors from the U.S. aviation industry. The NTSB provides an objective representative to assist the authorities charged with the management of an investigation in foreign countries, whether the accident involved an American airline or U.S. manufactured aircraft or components. In many instances, the NTSB provides direct assistance to the state conducting the investigation. Depending on the sophistication of its own investigative capabilities, the state where the accident occurred might delegate all or part of its responsibilities to the NTSB. In addition, NTSB involvement enables U.S. authorities to take necessary accident prevention measures based on the findings of the investigation. The safety board also provides needed technical support, such as the readout of cockpit voice recorders, to foreign investigators.

## FAMILY ASSISTANCE AND THE OFFICE OF FAMILY AFFAIRS

Following the enactment of the Aviation Disaster Family Assistance Act in 1996, the President designated the NTSB as the lead federal agency for the coordination of federal government assets at the scene of a major aviation accident and as the liaison between the airline and the families. The role of the NTSB includes integrating the resources of the federal government and other organizations to support the efforts of state and local governments and the airlines to aid aviation disaster victims and their families. The NTSB's Office of Family Affairs assists in making federal resources available to local authorities and the airlines, for example, to aid in rescue and salvage operations, and to coordinate the provision of family counseling, victim identification, and forensic services. The safety board has sought to maintain a distinct separation between family assistance activities and the NTSB's technical investigative staff.

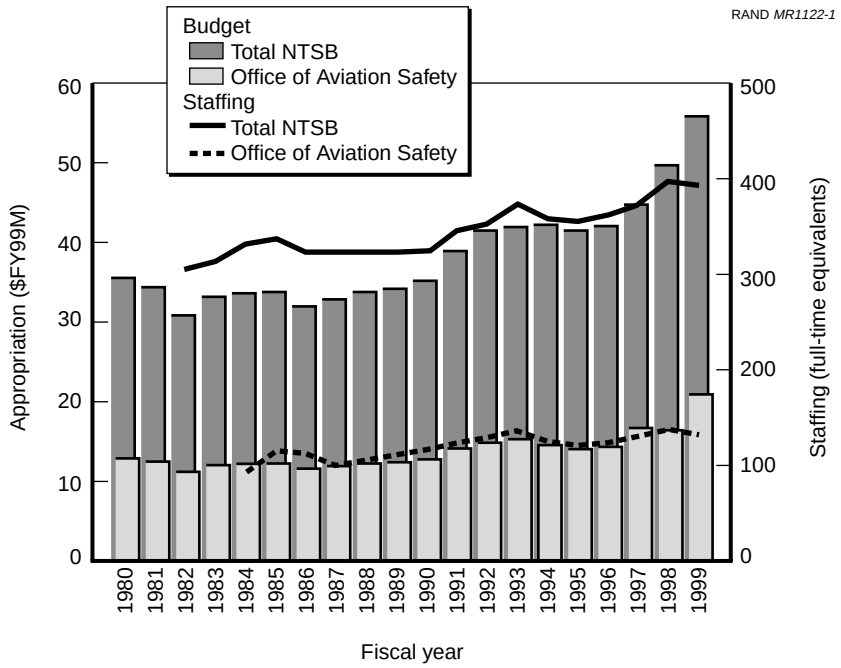
Chapter Three

# STUDY FINDINGS

The NTSB is one of the smallest federal agencies. Approximately 400 employees cover the five major fields of accident investigation. Of the approximately 270 professional staff members at the NTSB, 131 are dedicated to the investigation of aviation accidents within OAS. In 1998, the NTSB investigated more than 2,000 large and small aircraft accidents and incidents, more than 15 events for each aviation professional.

As shown in Figure 1, the NTSB's budget has risen modestly since 1980. Funding for Fiscal Year 1999 was approximately $56 million. In the same period, the worldwide commercial air transport fleet has more than doubled, to over 12,000 aircraft, of both U.S. and foreign manufacture. The NTSB also carries responsibility for the general aviation community: corporate aircraft, rotorcraft, and other small private and experimental aircraft, comprising a fleet of approximately 180,000 vehicles.

This brief factual summary underscores RAND's first major finding: that the NTSB is an agency coping with serious overload and is in urgent need of additional resources and management reform. Such a stark finding may seem contrary to the esteem in which the NTSB is usually held. In recent years, however, a number of investigations of growing complexity have outpaced available resources. In its review, RAND found an agency that is wholly dependent on the professionalism of its staff for success. So far, the staff has been able to deliver, but this strategy cannot ensure the NTSB's long-term independence or continued technical excellence. In significant ways, the NTSB is already at or near the breaking point. Avoiding the breakdown will




NOTE: The figure shows initial annual appropriations. On several occasions, supplemental appropriations have been sought to cover extraordinary expenses. For example, the NTSB sought and was awarded supplemental appropriations for the investigation of TWA Flight 800 in the amount of approximately $36 million, almost doubling the NTSB's FY 1997 budget.

**Figure 1—NTSB Budget and Staffing Levels**

require the cautious infusion of additional resources, redesign of internal NTSB practices, and exemplary leadership. These steps are necessary to ensure the continued vitality and independence of the safety board. *Taking these steps is a matter of considerable national importance in the face of new and ambitious air safety and security goals.*

RAND's second major finding is that limitations in the party process, the central organizational practice for conducting safety investigations, must be addressed. In general, the party system serves a necessary purpose because it allows the NTSB to leverage its technical

expertise. Under certain circumstances, however, the party system may compromise, or be perceived to compromise, the integrity of the NTSB investigative process. Party participants in an NTSB investigation may have conflicting agendas if, at the same time, they are defendants in related civil litigation. Today, the rising financial stakes surrounding a major crash can put the integrity of information supplied to the NTSB's investigation at risk. Augmenting the party process through expanded use of nonparty resources or expertise is the best way to ensure continued independent investigations. For complex, high-profile investigations, this is a wise precaution.

The viability of the party process is inextricably linked to the NTSB's ability to lead complex investigations. RAND's third major finding is that a lack of training, equipment, and facilities has placed the NTSB's ability to independently lead investigations of major commercial aviation accidents at risk. NTSB investigators must be able to ask the right questions and understand whether they have received the right answers. However, professionals at the safety board have little opportunity for on-the-job training in specific technical areas. Unlike a professional in industry or government, who is constantly utilizing and expanding technical skills, an NTSB engineer, pilot, or technician acquires additional professional development only through focused training programs. On-the-job training at the NTSB, by nature, emphasizes accident investigation skills. Little time for training and insufficient emphasis on professional development have combined to cause a general decline in professional skills. This is a significant threat to continued safety board independence.

RAND's fourth major finding is that the management of information, plus the NTSB's access to external sources of information, must be significantly improved. A major aircraft accident investigation generates a tremendous amount of information and data. Over time, the NTSB's institutional collection of air accident data has become a national resource. Accurate and timely information is essential to accurate and timely investigations, to identifying potentially dangerous trends, and to helping the larger aviation community chart a course of continuing improvement in air safety. The quality of the NTSB's information systems has not, however, been adequately assured, and insufficient attention has been paid to information sharing with external agencies.

RAND's fifth major finding is that various NTSB investigative and operational processes need to be revamped. Generally, the NTSB's practices are archaic when measured against the complexity of the systems the NTSB is called upon to analyze. When an accident occurs, the NTSB's leadership role is embodied in a single individual, the IIC. Most accidents are readily resolved, and the IIC model works well. However, the model fails when a modern airliner crashes and the cause of the accident is not readily apparent. In accidents involving high levels of complexity and system-level interrelationships, the investigation is more likely to resemble an applied research project than police detective work, requiring a fundamentally different organization and approach. The NTSB has no other model for responding to the complexity and magnitude of a major aviation accident and turns to less effective ad hoc methodologies. Revamping investigative methods also encompasses a more proactive role for the NTSB in the investigation of incidents—episodes that may reveal systemic weaknesses or operational deficiencies long before lives are lost.

The need for improved methods does not mean, however, that probable cause, the ultimate product of an NTSB investigation, should be abolished. Many within the aviation community oppose the use of probable cause and have vocally recommended that it be abandoned. RAND disagrees with this approach. There are valid reasons for keeping the statement of probable cause as the central output of NTSB reports. However, the formulation of the probable cause statement should be reconstituted to provide more consistency and substance. The result will be a clearer statement with greater utility to the goal of aviation safety.

Many of the aforementioned findings imply the need for improved management of the safety board's limited resources, the subject of RAND's sixth and final finding. Because the NTSB cannot integrate various types of accounts, managers lack the ability to track either the total cost of an investigation or the workload of their staffs.[1] The lack of even rudimentary management tools means that the NTSB's senior staff cannot balance resources across the many investigations

[1]Management of resources depends on the ability to merge nonpay expenditures, such as the cost of accident reconstruction, with the cost of salaries to capture the full cost of each investigation. The NTSB currently has no such capability.

and special studies being conducted throughout the organization. Without management tools, there can be no assurance that current or future resources are being used most efficiently and effectively. This matter requires urgent NTSB attention.

The following discussion expands on each of these six major thematic findings. The concluding section will present a set of concise conclusions and recommendations that form the steps to be taken to improve and revitalize the NTSB.

## THE NTSB IS NEARING THE BREAKING POINT

The NTSB enjoys a reputation for technical excellence and independence throughout the world. Indeed, its practices have spawned similar organizations in many countries, and its investigators and technical support staff are increasingly called upon to support foreign accident investigations. But beneath the surface, the NTSB is running to stay in place. One measure of this struggle is reflected in the employee workload. The *sustained average workweek* for NTSB aviation professionals, shown in Figure 2, is 50 hours—consistently higher than the average workweek for comparable professional occupations in the U.S. workforce as a whole. During a major accident investigation, the average workweek climbs to 60 hours per week; peak workloads are higher still. Compounding long working hours is the nature of air crash investigative work. This is a high-stress profession, in which the NTSB staff is exposed to gruesome crash scenes, the frenzy of the media, and the emotional trauma of dealing with the victim's families. When time pressure is added to the equation, the result is a professional staff that is burning out.

RAND found a highly dedicated and motivated staff, and this professionalism has allowed the safety board to maintain its traditional high standard of performance. Over the long term, however, RAND believes that the NTSB's ability to sustain both excellence and independence cannot be ensured. These findings are consistent with other studies that have expressed concern about workload and stress at the NTSB.[2]

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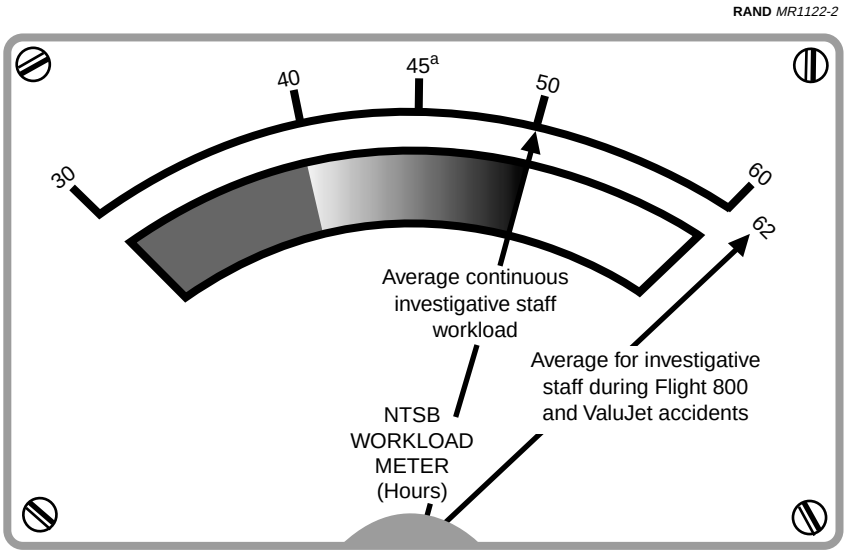
[2]For example, see Carolyn Coarsey-Rader, *Stress Partnership Committee: Report to the Chairman of the National Transportation Safety Board*, Washington, D.C., January 22, 1998.




SOURCE: Current Population Survey, U.S. Bureau of Labor Statistics, 1997.
[a]Average workweek for comparable professionals in the U.S. workforce.

**Figure 2—Workload at the NTSB's OAS**

RAND found that the time required to complete a major accident report and the accident rate are closely coupled. Another measure of overload is the growing delay in completing investigations. The average time to complete a final accident report is rising; for major accidents, the period is climbing alarmingly. The NTSB's recent investigation of the USAir Flight 427 crash took more than four years to complete. Tardy completion of an accident investigation is antithetical to the goal of improving air safety. Although the NTSB does provide recommendations for safety improvements early and throughout an investigation, the fact remains that unsafe conditions could exist for years until the completion of the NTSB's technical analysis. Victims' families must also endure a long period of uncertainty and the delay of related civil legal proceedings pending completion of the NTSB investigation.

As noted earlier, some observers might ask how the NTSB could be approaching overload in an era when domestic airline crashes

appear to be (and are intended to be) increasingly rare occurrences. The answer has both simple and complex components. The most important word for understanding the issues facing the NTSB is *growth*. The NTSB is experiencing growth across the board—in aircraft complexity, in the magnitude of the investigations, and in the number of investigations it is called upon to conduct.

It is important to appreciate that the NTSB's investigative portfolio goes well beyond major domestic airline accidents. As has already been described, the safety board must investigate accidents and major incidents in all sectors of aviation. Further, the NTSB investigates both fatal **and** nonfatal accidents. When the history of accidents is reviewed, the picture of a rising workload is easier to comprehend. As Figure 3 demonstrates, the fatal accident rate has been stubbornly consistent over time, with approximately one fatal commercial transport accident occurring every two months.[3] The nonfatal accident rate has nearly doubled over the past five years. These statistics are major drivers of the NTSB's workload. The principal respondent to this workload is the OAS Major Investigations Division, whose work log shows a 30-percent increase in the number of accidents and major incidents the staff has been called upon to support over the past ten years.

The relatively steady number of fatal accidents combined with recent growth in the number of nonfatal accidents only partly explain the NTSB's increasing staff workload. Figure 3 demonstrates that the NTSB has dealt with higher accident loads in the past. An additional factor is the increasing complexity of air crashes. Complexity comes in many forms. Fundamentally, aircraft are very complex devices; when they crash the amount of analysis required to establish causal factors is commensurately complex. Figure 4 presents a simplistic measure of complexity, an index of the severity of air carrier accidents.

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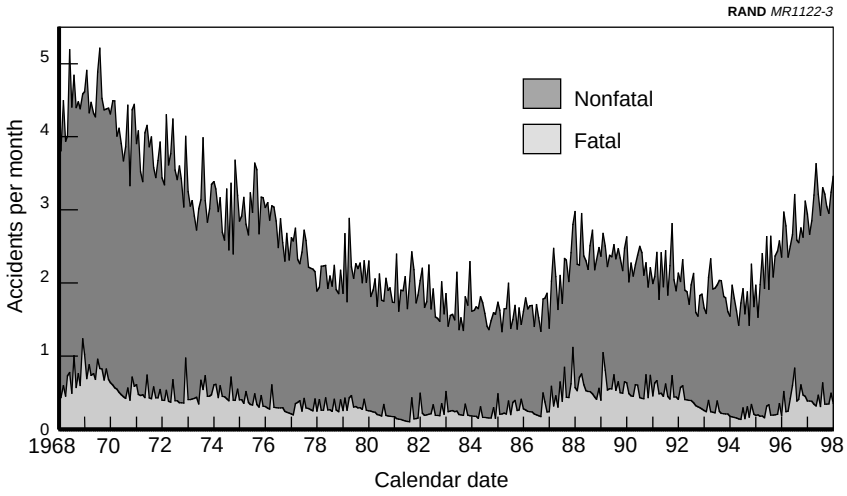
[3]These data mask a decline in the number of major domestic airline crashes, which, of course, consume a great deal of NTSB resources when they occur. As the demand for air travel accelerates and passenger exposure increases, however, the potential exists for more accidents in spite of the very low accident rate. The NTSB's future workload depends significantly on the success of efforts to reduce an already low accident rate—the goal established by the White House commission.




NOTE: The data presented are a six-month moving average extracted from the NTSB's accident database for commercial transport aircraft operating under Federal Aviation Regulations Part 121.

**Figure 3—Thirty-Year Accident History**

When a complex system fails, the number of potential scenarios rises proportionately. NTSB investigators must carefully unravel the performance of many highly integrated systems, a very time-consuming task requiring a diverse set of skills. Often, this requires extensive and costly salvage and reconstruction of the aircraft. Complexity affects more than just staff workload. The growing complexity of aircraft crashes also has a profound effect on how investigations must be structured to reveal hidden failure modes. This will be discussed in an upcoming section on limitations in investigative procedures.

Figure 4 links the size of the aircraft to the complexity of the accident investigation. Commercial aircraft of the future will have a comparatively greater capacity than the fleet of today; single aircraft, such as the Boeing 747-400, are capable of carrying more than 500 passengers. The crash of a single airplane, killing hundreds of people, would all but consume the NTSB staff, and few resources would remain available for other investigations. Aging aircraft issues could

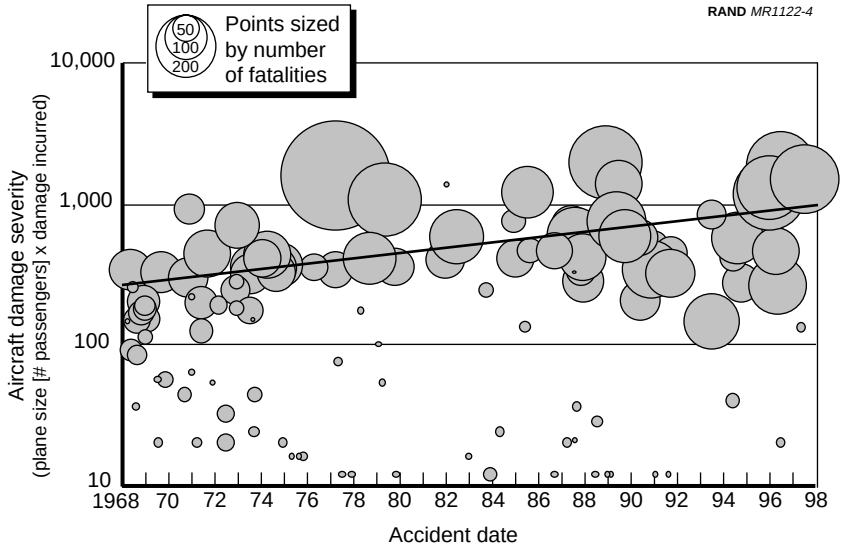



**Figure 4—The Growing Complexity of Transport-Category Aircraft Accidents**

also rise in importance in aviation accident investigations as the fleet ages, although there is insufficient evidence to predict an increased accident rate based on aircraft age alone.

The NTSB is also increasingly called upon to support international investigations. In many cases, the NTSB need not dispatch resources abroad to support these requests, but support to on-site investigations is increasing. The magnitude of international work is reflected in Figure 5 for the OAS's Major Investigations Division. Clearly, international work is a significant contributor to NTSB workload.

Finally, a major factor in the NTSB's workload is the amount of resources devoted to general aviation, or Part 91, investigations. The NTSB investigates approximately 2,000 general aviation accidents per year through its regional and field offices. Nearly half of the resources of the OAS (mostly in the field and regional offices) are devoted to the investigation of general aviation accidents. There is no way to assess future general aviation accident trends definitively,

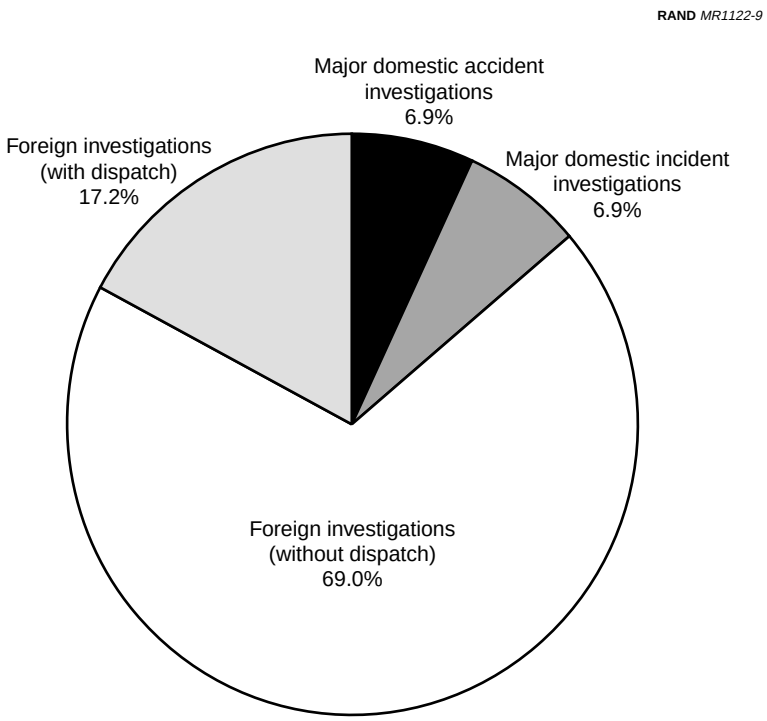



**Figure 5—Dispatch Distribution for the Major Investigations Division in 1998**

although various factors indicate that it is unlikely that the rate will decline significantly. Previous declines in general aviation accidents were principally due to reductions in the amount of flying. However, this sector is growing in popularity, a trend that might portend a significant rise in the accident rate. Yet accident numbers and the size of the fleet do not tell the full story of general aviation accident investigation. The NTSB faces a renaissance in general aviation, reflected by an extraordinary diversity in the types of aircraft now in the air. An accident investigator dispatched to a general aviation crash site could find a traditional metal airplane of known heritage, a homebuilt aircraft, or a vintage fighter aircraft of foreign manufacture. A crash of a general aviation aircraft can also result in a complex investigation. Many general aviation aircraft, especially new

homebuilt designs and kit aircraft, are built and operated using state-of-the-art technology. Some general aviation aircraft accidents involve famous individuals and result in a great deal of public and media attention.[4]

A small percentage of general aviation accidents lead to the identification of safety issues and the issuance of industrywide safety recommendations; for many others, the cause is unremarkable. With high workloads affecting the quality and timeliness of investigations, the process used to respond to general aviation accidents is a matter of great import.

## THE PARTY PROCESS HAS STRUCTURAL LIMITATIONS

An investigation into the causes of a major aviation disaster does not take place in isolation. While the stated mission of the NTSB is to investigate the facts, circumstances, and probable cause of an accident and to make recommendations for preventing similar accidents from happening in the future, this activity takes place within an environment permeated by the aviation liability and claiming process. The effects of litigation begin to be felt at the moment of impact. The specter of dozens, if not hundreds, of lawsuits arises as soon as the magnitude of the tragedy is known. The parties likely to be named to assist in the NTSB investigation—such as the air carrier, aircraft or component manufacturers, or the FAA—are also the most likely to be named defendants in the civil litigation that inevitably follows a major accident. The investigation process, inherently important to the safety of the flying public, has become equally, albeit unintentionally, important to the ultimate establishment of legal fault and blame.

The effective separation of the NTSB investigative process from the litigation process is an ideal that has little connection to the reality of current practice. Isolation of the NTSB from the litigation environment is virtually impossible so long as the NTSB relies substantially on the party process in a major investigation and, conversely, so long as the litigation and resolution of claims substantially depend on

[4]The recent loss of John F. Kennedy, Jr., and members of his family led to an investigation rivaling the loss of a large commercial airliner.

NTSB findings. Few limits remain on the use of NTSB reports in civil litigation. As a consequence, NTSB final accident reports, which both plaintiff and defense attorneys often consider to be the "road maps to liability," figure prominently in court proceedings.

The stakes of aviation accident litigation have evolved as a reflection of the industry itself. Today's jumbo jets may routinely transport hundreds of passengers. Commercial air crash litigation exposes the principal defendants—most often the airline or aircraft manufacturer—to the risk of liability for dozens, even hundreds, of deaths or injuries. Beyond the multimillion dollar awards, such litigation is highly publicized, subjecting the defendants to extensive adverse publicity that may affect market share and international competitiveness. Although RAND's benchmark 1988 study of the compensation of aviation victims has not been updated,[5] confidential interviews with numerous insurers and plaintiff and defense lawyers reveal a more litigious climate, characterized by fewer early settlements, the increased involvement of aviation specialists, and a propensity for family groups and individual claimants to pursue litigation as an alternative means of determining what happened to cause the accident.

The party process presents inherent conflicts of interest for entities that are both parties in an investigation and "parties defendant" in related litigation. Indeed, RAND has found that, at least in certain complex types of accidents, the party system is potentially unreliable and that party representatives may be acting to further various interests beyond prevention of a similar accident. Such potential conflicts may, in some instances, threaten the integrity of the NTSB investigative process, raising numerous questions about the extent to which party representatives are motivated to influence the outcome of the safety-related investigation in anticipation of litigation. NTSB rules governing party participation were designed to be sufficiently stringent to ensure that the parties do not prejudice the investigation. However, in important ways, NTSB investigations of major commercial aviation accidents have become nothing but preparation for anticipated litigation. Although regulations specifically bar

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[5]See James S. Kakalik, Elizabeth M. King, Michael Traynor, et al., *Costs and Compensation Paid in Aviation Accident Litigation*, Santa Monica, Calif.: RAND, R-3421-ICJ, 1988.

lawyers for the parties from participating in an investigation, anecdotal information indicates that such lawyers are involved, at least in an advisory capacity, in most, if not all, aspects of an NTSB investigation. Further, insurers are routinely granted access to the crash site that may not be available to any other party or claimant.

NTSB rules also bar family members, claimants, and their representatives from participating in an investigation. From the perspective of family members whose loved ones have perished in an aviation disaster, no issue is more frustrating than exclusion from the party process, particularly since the essential purpose of an NTSB investigation is to determine "what happened"—to prevent it from happening again. Family members contend that they have an equal, if not greater, interest in accident prevention than any party to the investigation. Plaintiffs and their attorneys complain that permitting the airline, aircraft manufacturer, or other defendants to participate in the NTSB investigation puts the victims at a severe disadvantage from the beginning of the case, a disadvantage that may continue for months or years until the NTSB investigation is concluded.

Despite the emotional appeal of this suggested reform to the NTSB rules, there are a number of well-grounded objections to family member participation in the NTSB party process. Foremost among these concerns is the difficulty of selecting an appropriate "family representative" from dozens, if not hundreds, of family members and their attorneys without exacerbating concerns about client solicitation or violating the NTSB requirement that party representatives possess specific technical expertise.

At the same time, expanding the role of party representatives to allow party participation, beyond written submissions, in the NTSB analytical and report-writing process would only amplify concerns over potential or perceived conflicts of interest inherent in the party process.

Despite its limitations, the party system is a key component of the NTSB investigative process. Parties are uniquely able to provide essential information about aircraft design and manufacture, airline operations, or functioning of NAS systems that simply cannot be obtained elsewhere. However, RAND has determined that there is a limit to the effectiveness or integrity of the party system under certain circumstances, particularly in accidents that implicate fleet

design or operations, costly product liability or design defect claims, or the failure of complex systems. These kinds of accidents also tend to involve significant threats to the competitive position of one or more of the parties and have resulted in NTSB investigations that last two or more years.

To address these concerns, NTSB resources and expertise must be selectively increased. Establishing formal working agreements with other relevant government agencies (such as NASA, the Department of Defense, and government scientific laboratories) and with academic and private-sector experts would moderate the NTSB's overdependence on the party system and would allow new perspectives and expertise to inform the agency's investigations. The expansion of available NTSB resources is diagrammed in Figure 6, demonstrating a continuing role for party representatives, an augmentation of NTSB's in-house resources, and direct access to additional outside expertise. Additionally, parties should not be allowed to veto or influence the investigative work of outside experts that the NTSB has asked to support or review investigations.

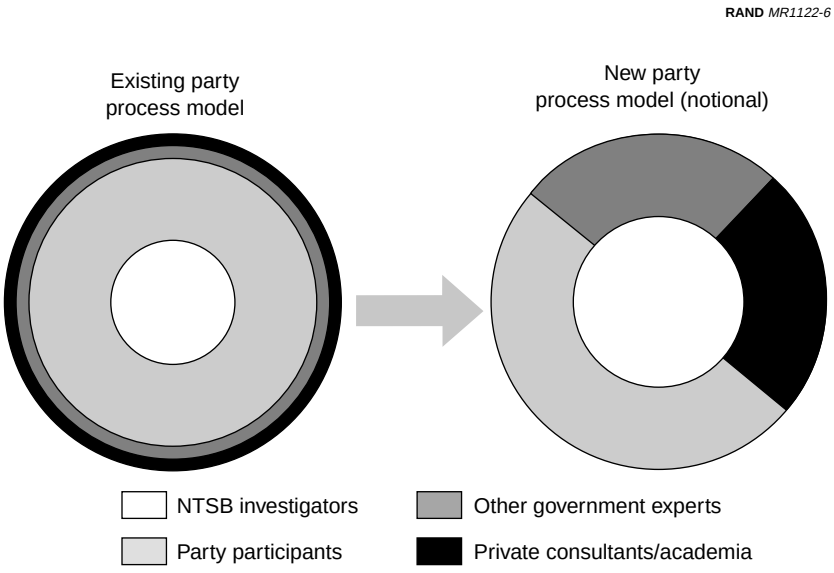


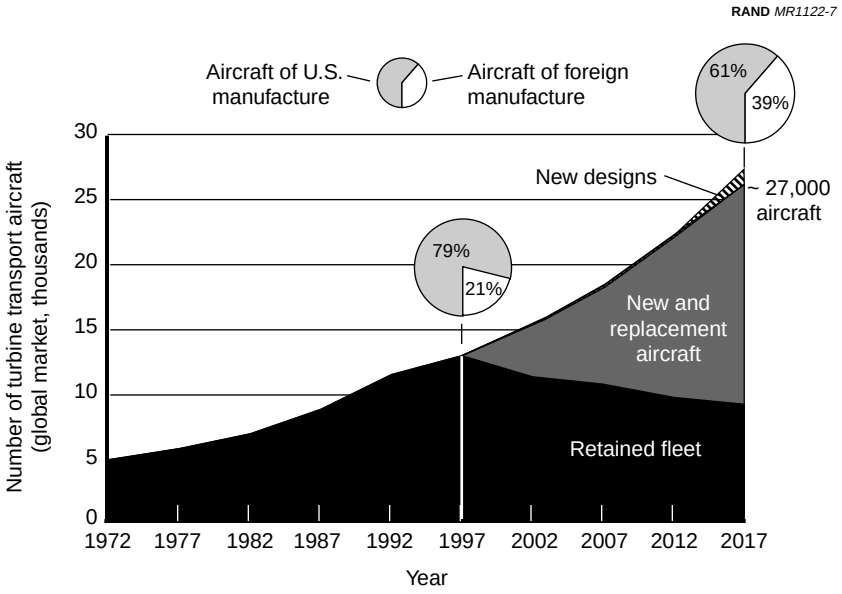

**Figure 6—Notional View of Existing and Revised Party Process Models**

## LACK OF TRAINING, EQUIPMENT, AND FACILITIES IS THREATENING NTSB INDEPENDENCE

All parties interested in national aviation safety agree that a well-trained and well-equipped safety board is essential to success. Two driving forces determine how best to equip and train within the NTSB. The first is the nature of accident investigation, which includes an understanding of why the safety board is unlike most technical organizations. The second relates to how external events require a dynamic and evolutionary approach to hiring and training, as well as to equipping the organization to meet pending challenges.

The job of investigating accidents is difficult. Accident investigators must demonstrate a broad set of technical skills and combine them with an acquired set of skills unique to the examination of technical failures on a massive scale. Also unique is the challenge of maintaining technical proficiency. Pilots and engineers invest large portions of their lives obtaining technical skills, then refine and expand this skill base after gaining employment, through a natural combination of on-the-job training and additional professional development. This is not the case at the NTSB. A pilot, for example, may have 5,000 commercial flight hours in a transport category aircraft when joining the NTSB. Once he or she is inside the safety board, however, the pilot's skills are no longer reinforced. Without an aggressive, carefully implemented training plan, technical skills are likely to wither, and the employee becomes more distant from the accelerating state of the art.

Externally, the world of general and commercial aviation is undergoing dramatic change. These changes will shape the professional staff the NTSB needs and the way in which it must maintain its facilities. For example, the fleet of aircraft, both private and commercial, that the NTSB must monitor is changing significantly. The number of transport aircraft needed to meet burgeoning demand will likely double by 2015, as shown in Figure 7. Most importantly, the makeup of that fleet is changing. New aircraft designs will not be a major component of fleet expansion; however, serial upgrades to existing designs involve substantial changes at the system and subsystem levels. The NTSB must monitor and respond to this evolution.




SOURCE: Compendium of data from the Boeing Commercial Aircraft Company, Current Market Outlook, Seattle, Wash., June 1997; Airbus Industrie, Global Market Forecast: 1998–2017, Blagnac, France, April 1998.

**Figure 7—Projected World Transport Fleet**

The NTSB must also keep pace with the growing diversity of the fleet and changes in the manufacturing base. The percentage of foreign-built aircraft is expected to nearly double in the next 20 years, from 21 to 39 percent. The NTSB will have to become much more familiar with the design and operation of such aircraft than it is today, which will require working with the foreign manufacturers, operators, regulators, and accident investigators. This is particularly applicable to the regional or commuter aviation segment of the industry, in which the vast majority of the U.S. fleet is of foreign manufacture.

And change is not restricted to the aircraft fleet itself. Fundamental changes are also occurring in the air traffic control system, the acquisition and transmission of flight performance data, and navigation methods. The magnitude of change is sweeping, and the NTSB has no formal or informal process for keeping pace. These changes

will strongly influence the process of accident investigations. In the near future, a flight's navigation record, for example, will derive from the satellite-based Global Positioning System instead of the traditional radar record.

A variety of new vehicle types are expected to become operational during the first decade of the next century. These "aircraft" will include unmanned aerial vehicles; civil tiltrotors; and manned and unmanned, commercial reusable launch vehicles. Because these vehicles will share the civil airspace with other aircraft, the NTSB will need to follow their evolution and become familiar with their designs and operations.

It has already been made clear that the success of the NTSB critically depends on ensuring the technical excellence of its staff. In light of the factors that will so strongly influence the safety board in the near and far terms, one would expect the safety board to have an exemplary training program and a commensurate set of facilities that support both training and engineering analysis. Unfortunately, this is not the case.

The NTSB's approach to training is generally haphazard. Current levels of training are quite limited because of workload, funding, and other constraints, particularly when measured against the amount of training other members of the aviation community receive. Much of the training that does take place has an in-house orientation, because the NTSB relies only to a limited degree on outside training opportunities. The NTSB's limited training program does little to inform the professional staff about state-of-the-art technologies or the future aviation environment. Because of the stochastic nature of accident events, investigators only become familiar with the intricacies of new equipment when an accident occurs. There is no guarantee that investigating an accident involving an older aircraft, such as a Boeing 747-100, will prepare an investigator for a subsequent investigation involving a more modern airliner, such as an Airbus 340 or a Boeing 777. The amount of time available to maintain proficiency and to acquire new skills is also woefully inadequate. For example, aviation investigators reported that they typically spend more than twice as much time answering public inquiries (such as accident scenarios posted on the Internet or mailed directly to the NTSB) as they do training. This may reflect an inappropriate allocation of staff resources to this kind of noninvestigative activity.

The consequences of the NTSB's limited provision of training are depicted in the top panel of Figure 8. The NTSB often hires experienced personnel who enter the agency at a high skill level. Over time, however, as workload demands limit the frequency and extent of training, skill levels can diminish, forcing the NTSB to rely heavily on the party process to supply the expertise needed for accident investigations. The result is a steady erosion of staff skills. The current situation is particularly alarming because of the expectation that the NTSB will likely face more complex accident investigations in the future, especially involving design-related issues associated with high levels of system integration. Accident investigators must be trained not simply in basic investigative techniques but in a broad multidisciplinary routine matching the complexity of the systems they will be called upon to analyze. New approaches will be needed, and the NTSB must seek cooperative relationships with manufacturers, operators, academia, and other government agencies.

The integrity and independence of the safety board could be threatened if substantive changes in training programs do not occur. A more responsive training cycle, such as the notional cycle shown in the bottom panel of Figure 8, would address many of the shortcomings of the current situation. To retain proficiency, investigators would train more frequently and to a greater extent, thereby renewing their skills on a regular basis. In this circumstance, reliance on parties and outside expertise would stabilize, safeguarding the integrity of the accident investigation process.

Staffing is equal to training in importance. An inadequate training program exacerbates staffing deficiencies, of course, but acquiring new staff could pose a significant challenge. The safety board needs additional midcareer engineering professionals, but this market is highly competitive. Currently, NTSB pays its midcareer engineering professionals lower salaries than the rest of the aerospace industry. Although current attrition rates are relatively modest, this could make it more difficult for the NTSB to attract and retain the skilled staff needed to perform the agency's future investigative work. The NTSB's OAS also has a disproportionate number of older employees, including numerous staff at or above age 55. In a small organization having limited staffing depth, managing their replacement could pose a substantial challenge for the NTSB in the near future.

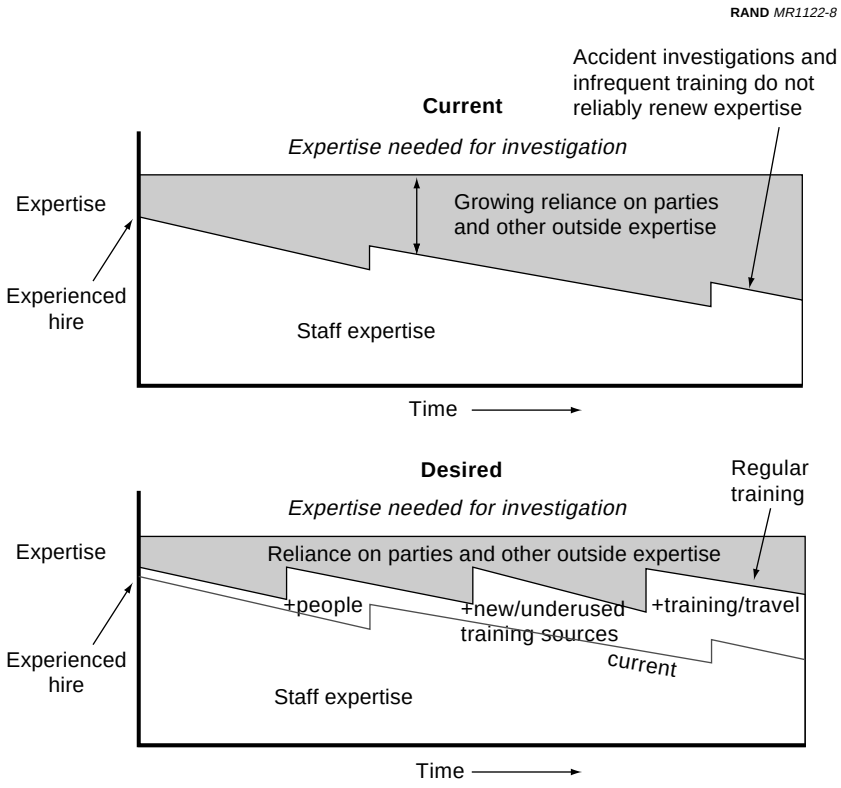



**Figure 8—Two Notional Views of the NTSB Training Cycle**

Finally, the NTSB's limited technical facilities lead to an excessive dependence on party members for engineering analysis. These facilities cannot be used to any significant degree for training because they are fully committed for investigative work. The NTSB's approximately 4,000 square feet of laboratory facilities are barely adequate for current workload. Resolving accidents of growing complexity will require many more investigative tools. The NTSB has not performed a strategic assessment of its current and future facility requirements, assessed opportunities for leveraging the capabilities of other federal agencies, or examined the investigative requirements of highly complex accidents.

## POOR CONTROL OF INFORMATION HAMPERS INVESTIGATIONS

The investigation of accidents and incidents is largely a job of information management. If the NTSB can be legitimately viewed as an information agency, the quality of the official record of domestic aviation accidents, known as the Aviation Accident Database, and other sets of data the agency maintains, should be viewed as centrally important to the NTSB's overall mission. The accident record not only supports ongoing internal investigations but also is heavily used by external organizations, such as insurers and manufacturers, for planning and decisionmaking related to aviation safety. However, there is neither oversight nor an emphasis on accuracy in the collection and maintenance of NTSB records. As a result, the accuracy of most of the NTSB data sources was rated as "poor" in the RAND analysis. Various offices control and manage information, with little coordination among them. This complicates the job of conducting investigations and offers insufficient confidence to outside users of accident data.

The communication of information to and from the NTSB is another area needing improvement. As mentioned earlier, augmenting the party process will require the NTSB to monitor and acquire outside sources of information. However, the NTSB is an insulated organization—a proud, self-contained agency with limited ties to the broader aviation community. Change will be resisted. The NTSB's insularity is a by-product of its desire to preserve its independence and to remain neutral during the course of aviation investigations. However, in an environment of growing complexity, insularity seems to be unwise. The party process itself is based on a recognition that the NTSB cannot operate successfully on its own. Through a network of new alliances with other government agencies and academia, enabled through a new emphasis on the acquisition and management of knowledge and expertise, the NTSB could greatly, and efficiently, augment its capabilities. The implementation of a "knowledge management" program that would afford ready identification of and access to needed outside expertise would greatly assist in making such expertise available when required.

A less insular environment should also expand training opportunities and encourage the NTSB technical staff to inform the aviation com-

munity of the wealth of knowledge acquired at great cost during the course of its investigations. The NTSB has important information to share. NTSB staff members have developed critically needed experience in many areas important to the goals of aviation safety; for example, in the area of aging aircraft. The NTSB has a responsibility to ensure that the knowledge and insights its technical staff has gained are shared as broadly as possible with the aviation community.

## INVESTIGATIVE METHODS NEED TO BE IMPROVED

The nature of investigations and the future workload of the NTSB will be heavily influenced by the changing aviation environment, characterized by increasing technological complexity, growth in general and commercial aviation air traffic, and important changes in the composition of the air transport fleet. These factors have long challenged aviation accident investigators. However, the pace of innovation is accelerating sharply, and some of the changes ahead will put unprecedented strain on the NTSB. Most importantly, the adequacy of the investigative methods the NTSB has traditionally used will be challenged. These practices have remained largely unchanged since the inception of the NTSB in 1967.

The recent TWA Flight 800 and USAir Flight 427 accidents were not anomalies in terms of the complexity of the investigations that followed; rather, they are harbingers of the future. The growth in complexity is exponential in many areas, with the most significant trend being the interconnectedness of systems. Current-generation aircraft are highly integrated systems with extensive cross-linking. As complexity grows, hidden design or equipment defects are problems of increasing concern. More and more, aircraft functions rely on software, and electronic systems are replacing many mechanical components. Accidents involving complex events multiply the number of potential failure scenarios and present investigators with new failure modes. The NTSB must be prepared to meet the challenges that the rapid growth in systems complexity poses by developing new investigative practices.

Safety board investigators are well prepared for accidents in which the failure mode reveals itself through careful examination of the wreckage and analysis of the debris, that is, those in which a

"permanent state failure" had occurred. Complex-system events, however, present greater challenges to traditional NTSB investigative practices. *Here, failure states can be "reactive," leaving no permanent record to discover in the wreckage.* In such cases, safety board investigative practices and analytical facilities and methods are less reliable.

The kinds of complex investigations the NTSB will face in the future will have attributes similar to those of applied research projects. Solving complex accidents—accidents involving aircraft conceived and built in a structured team environment—will require the safety board to step beyond its current discipline-oriented go-team model. As depicted in Figure 9, this model decomposes the accident investigation into disciplines and assigns investigative teams. But this is not how modern complex aircraft are built and operated. The construction of aircraft relies on highly integrated, multidisciplinary teams. The NTSB's traditional structure of discipline teams, coordinated through a single IIC, does not encourage multidisciplinary analysis, testing, or synthesis. Such a structure is less likely to resolve problems of growing complexity. Multidisciplinary teams functioning in parallel and coordinated by a project manager, as illustrated notionally on the right side of Figure 9, offers one of many alternative structures potentially more conducive to the analysis of complex events.

Part of resolving more complex accidents depends upon a thorough knowledge of prior incidents. The number of major airline incidents the FAA reported in 1997 was ten times the number of major accidents. Although the NTSB does examine a significant number of major incidents, only a small portion of the NTSB's aviation resources are focused on incident events. NTSB investigators rarely access outside data sources that describe incidents, and when a fatal accident occurs, NTSB's staff is frequently unaware of previous significant events. The NTSB's principal job is to examine accidents. However, the historically light treatment of incidents means that important safety monitoring is not performed. Investigations are also hampered, because investigators are not up to speed when an accident occurs.

The end product of the NTSB's investigation is the final accident report. RAND also closely examined the process of developing acci-

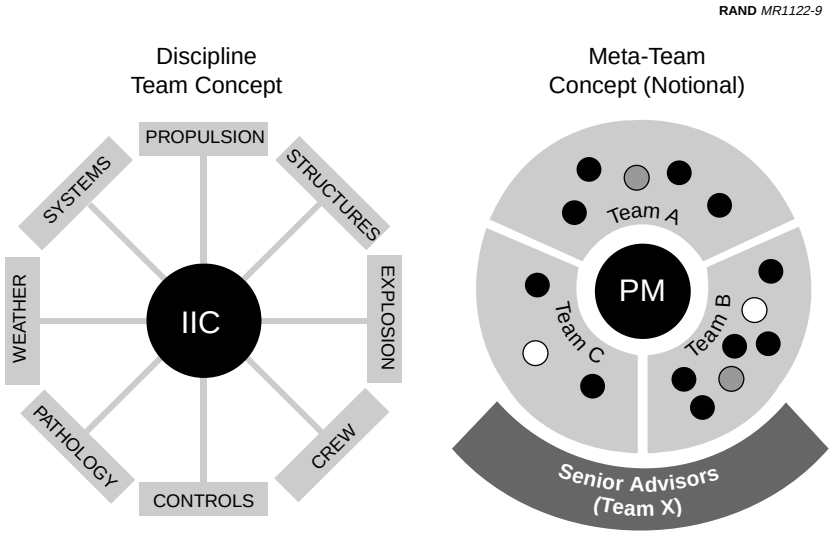



**Figure 9—Structuring Investigative Teams**

dent reports and preparing recommendations. Here, too, the safety board could streamline the process and improve the quality of its outputs. The process of completing final accident reports puts heavy demands on NTSB professionals at all levels. The intensity of the report-preparation workload will continue to be heavy, particularly for major accident investigations. A review of the overall report-preparation process would be an important first step. Among other things, the board members should be afforded greater opportunity to monitor the progress of a report. In addition, board members should have the authority, on a selected basis, to request peer review of the draft final accident report when the stakes are high and the investigation is lengthy and complex. The preparation of recommendations could also be more consistent and could be structured around a statement of expected performance rather than operational or design solutions.

The most controversial result of the NTSB's investigation process is the statement of probable cause found in the final accident report. The NTSB's fundamental objective is to investigate accidents and to establish the facts, circumstances, and cause or probable cause.

Within the NTSB environment, this statement reflects the cumulative fact-finding and analysis of the NTSB investigative process. However, probable cause reverberates far beyond the halls of the NTSB. In terms of the assignment of fault and blame for a major aviation accident, by the media or in a legal proceeding, the NTSB's probable cause finding is the "ball game."

Probable cause sets off a chain reaction of regulatory activity that may result in the FAA issuing new safety regulations; airworthiness directives; service bulletins; or a myriad of other, and often expensive, requirements. Beyond the regulatory effects, a finding of probable cause is a highly significant event for the civil litigation associated with a major commercial aviation accident. These findings provide the "road map to liability" that allows the lawyers on both sides to pursue the theories of liability or defenses that the NTSB factual and analytical reports suggest. Although the determination of potential liability is not part of the NTSB mission, the safety board's findings and conclusions are such a powerful statement of what caused the accident that conclusions about liability are inevitably drawn.

The NTSB's emphasis on probable cause as the ultimate finding from an investigation has been criticized by those who claim that the statement is too accusatory or that its scope is too limited. Current NTSB procedures call for probable cause to be summarized as part of the NTSB final accident report, but a full discussion of contributory causes is sometimes relegated to the accompanying volumes of technical material. Other investigative bodies handle this issue quite differently, generally including all causes or causal factors in some form or another. The NTSB has been inconsistent in the procedures it uses to report probable cause, sometimes issuing a single-paragraph statement, other times listing a comprehensive list of causal factors.

The safety board's factual findings and analytical conclusions are authoritative statements, and the statement of probable cause carries considerable weight in the aviation community. Lacking regulatory or enforcement authority, the NTSB's influential and highly public pronouncement of probable cause is one way the agency can play a central role in aviation safety. Probable cause serves an important purpose and should be retained. However, revising the procedures

to identify all factors material to the cause of an accident and ranking them in terms of their contribution to the event would improve the quality of the NTSB's output. This is a more appropriate means of taking into account the complexity of many major accidents. Additionally, over time, a more complete picture of causal factors would be available to individuals responsible for planning and implementing safety programs. The consistent application of the practice would help make the NTSB's probably cause statement a useful tool in the quest for improved air safety.

## NTSB RESOURCES ARE NOT EFFECTIVELY UTILIZED

Finally, the management of resources in an agency as small as the NTSB is vital. Currently, the NTSB has no way to accurately measure how human resources are applied to a given accident investigation. Inadequate accounting information precludes management of the human resources that the NTSB has at its disposal. The NTSB relies on DoT to process employee pay costs and therefore has no way to merge pay and nonpay accounts. The adage "you can't manage what you can't see" aptly applies to current safety board practices. NTSB managers have little information with which to plan the utilization of staff resources or to manage staff workloads properly. The development of a real-time, full-cost accounting system would enable a project management capability to emerge within the NTSB. Currently, NTSB senior managers cannot ensure efficient use of resources or adequately balance the workload among the myriad of activities under way at any time.

Chapter Four

# CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes comments that form an overall conclusion based on RAND's extensive research and analysis. Overall themes are presented, and common threads are reinforced and amplified. The last section contains recommendations that respond to the fundamental questions being faced by decisionmakers.

## CONCLUSIONS

While the NTSB urgently needs more resources and internal improvements, the historical constructs on which the agency was founded are basically sound. No significant changes in law are needed to provide for the changes that must be made. The party process, the central organizational mechanism of air crash investigation, should continue to exist as an important source of vital information for the safety board. When the economic stakes are unusually high, however, the risks increase that the process could falter. When a modern airliner crashes, implicating design factors with fleetwide effects portending serious economic loss, it is only prudent that the NTSB be prepared to augment the party process through other avenues of securing technical expertise.

The equivocal nature of the party process has historically been balanced by the NTSB's technical leadership. If the party system places the integrity of the investigative process at risk, the steady erosion of the NTSB's base of expertise and the strength of its professional staff are of the greatest concern. Workload is a key factor here. The NTSB's professional staff is currently working too hard; the training necessary to retain proficiency and to exercise leadership has become wholly inadequate.

It is unlikely that the NTSB's heavy workload will suddenly abate. The safety board will be called upon to resolve more complex accidents and to do so in the face of mounting scrutiny and rising economic stakes. The NTSB must also accept the challenge of studying incidents more carefully, both to support its own investigative processes and to advance national aviation safety goals. The NTSB will also play an increasingly visible role as a leader around the globe, supporting foreign investigations and playing a strategic role in reducing the risk of aircraft fatalities worldwide. Therefore, although the number of major airline crashes may diminish as the nation pursues an aggressive aviation safety agenda, the NTSB's workload will at best remain neutral and will most likely rise.

It is clear that the NTSB needs additional resources. More staff members are needed to reduce work overload. This will provide the flexibility to support increased training of the NTSB's professional staff, but revised training approaches are also vitally needed. The NTSB's current engineering laboratories are barely adequate and are not sufficient for the complexity of the systems being analyzed. When faced with inadequate training and tools, the NTSB has tended to rely on the facilities and equipment the parties supply. This reliance increases the risk of conflict of interest, threatening the safety board's independence, especially on those high-profile cases when leadership is even more important. However, resources alone will not ensure a return to responsiveness and excellence at the NTSB. There is insufficient assurance that resources currently allocated to the safety board are adequately managed to produce the most efficient and effective result. Arcane management practices and a lack of an independent agency financial system are significantly at fault.

The challenge is clear: The NTSB must substantially revise its practices, more closely manage its resources, and break the cultural insularity that is widening the gap between its staff and the broader aviation community. NTSB's leadership must make the requisite improvements while continuing to ensure the independence of investigations and the leadership of its professional staff. As the NTSB embraces the need for change and undertakes the many challenges that lie ahead, sufficient resources must be made available to support needed modernization.

## RECOMMENDATIONS

Uniquely structured as an independent investigative agency with no regulatory authority, the NTSB must rely on the credibility of its findings and recommendations to persuade other governmental agencies, as well as powerful commercial interests and companies, to accept and implement its conclusions. Excellence is demanded, and the recommendations outlined below emphasize the need for a safety board that is a *model of technical and managerial leadership*.

A theme that will consistently appear in the recommendations is insularity. The NTSB has become a highly insular agency. This is a dangerous trend that will increasingly alienate the safety board from the aviation community upon which it depends for cooperative investigation and for the collaboration required to ensure the safety of the NAS. The NTSB must instead be *an open and impartial agent* pursuing the cause of aviation safety. NTSB senior management must focus on breaking the cycle of insularity, seeking greater cooperation without jeopardizing the independence of the safety board.

Another theme that is constant is the need for efficiency. In the glare of media publicity and heightened public attention, the NTSB must marshal an array of resources and expertise within the constraints of a small budget and limited staff. *The NTSB must exemplify efficient operations*. With a large mission and limited resources, the NTSB simply has no other choice.

RAND's recommendations are divided into eight objectives designed to assist the NTSB in meeting future requirements for accident investigation. Virtually all of the recommendations are within the purview of the NTSB to implement without the need for legislation or new regulations.

### Strengthen the Party Process

The NTSB must consider methods for augmenting the current party process model to provide access to independent analytical and engineering resources during the investigation of high-profile accidents. The NTSB should not, however, augment the party system by including family representatives, plaintiff experts, insurers, or other individuals or organizations that have no direct involvement in identify-

ing the technical cause of the accident. In adopting a strategic view of alliance-building,

- The NTSB should perform a nationwide assessment of federal laboratories, universities, and independent corporate resources to identify tools, facilities, and experts capable of augmenting NTSB resources. It should seek formal memoranda of understanding and other forms of strategic alliances with these entities as required. The exercise of alliances to strengthen NTSB technical capabilities should be viewed as a mechanism for augmenting the existing party system, not corrupting it.
- The NTSB should issue an NTSB board order establishing formal guidelines for the chairman's discretionary authority to form independent review and assessment teams. These guidelines should define a process in which the chairman, with the support of board members and in consultation with the OAS, can move aggressively to supplement NTSB teams with outside expertise. The board order should make clear that the approval of participating parties is not required for the NTSB to assemble investigative teams with alliance representatives or to include alliance experts as part of ongoing party analyses, should this be deemed beneficial to the technical work.

The current party pledge reflects an unrealistic view of the factors at work during an investigation. This pledge should be revised to reflect the actual and inevitable involvement of parties in related civil litigation and the widespread use of the NTSB materials in the litigation process. In particular, the NTSB should assess available sanctions to enforce party rules and should apply such sanctions consistently and expeditiously when the rules of party participation have been violated.

Additional information concerning an accident that comes to light following litigation could significantly affect aviation safety. The NTSB should provide a procedural mechanism other than formal reconsideration to allow review of important safety-related findings. The NTSB should interpret existing rules governing petitions for reconsideration to allow submissions from nonparties, including claimants or their attorneys, when new evidence relating to probable cause or safety recommendations has been discovered through civil

litigation. Such an interpretation might, for example, allow supplemental material to be appended to the public record. The NTSB should not require formal proceedings for nonparty submissions unless the submissions make it necessary to amend the probable cause finding or to issue additional safety recommendations.

### Create a More Expansive Statement of Causation

The statement of causation is the safety board's most controversial output; it is crucial that this statement be as clear and complete as possible. The NTSB should view the probable cause statement not simply as the final investigative word on an accident but in a larger context, as a signpost supporting future aviation safety goals. To accomplish this, the NTSB should move away from simplistic, one-line probable cause statements and instead *consistently* adopt a comprehensive statement that reflects the reality that a modern aircraft accident is rarely the result of one error or failure. The probable cause statement should clearly state the principal event or failure that led to the accident. The probable cause statement should then also include all related causal factors. These causal factors should be ranked in terms of their contribution to the event, according to methods to be outlined in safety board investigative procedures.

### Modernize Investigative Procedures

The NTSB should take a more proactive stance in examining incidents, both to support far-reaching national goals and also to ensure that its investigators are "up to speed" should a major accident occur. NTSB procedures for prioritizing workload should be modified to include a modest expansion in the resources dedicated to identifying and investigating aircraft incidents with critical safety implications. In parallel, the NTSB should perform more safety studies and report safety trends from incident analyses. Reflecting national priorities and concerns, the NTSB should also formally recognize a legitimate role in the investigation of breaches of security, both in the air and on the ground.

The NTSB should undertake a comprehensive independent review of its existing statutory mandate to investigate all general aviation accidents, potentially leading to the legislative revision of this require-

ment. The growth of general aviation traffic and the proliferation of types of personal aircraft are likely to increase the NTSB workload, both in terms of the number of accidents and the complexity of general aviation investigations. The NTSB should examine whether every general aviation accident raises nationally important safety issues sufficient to merit the expenditure of NTSB resources in conducting an investigation. The NTSB should consider the feasibility of training state and local investigative authorities to conduct more routine general aviation accident investigations, thereby confining the NTSB role to data collection and dissemination, the investigation of complex accidents of national importance, and the conduct of broad-based safety studies in the general aviation field.

The NTSB must also adopt strategies that successfully meet the challenge of modern air accident investigation, while reflecting a broadening investigative role. Most importantly, the NTSB should comprehensively review procedures and contrast them with the increasingly complex world of aviation. Modernizing the methods used to investigate accidents should begin with these steps:

- The role and responsibilities of the IIC should be thoroughly reviewed, especially in terms of major aircraft accident investigations. The NTSB should explore the notion of recasting the IIC role into one of a project manager in charge of the accident investigation and should provide the tools required to manage the ensuing effort.
- Alternative team structures (such as the notional Meta-Team concept) should be examined, particularly in relation to investigating complex-system accidents. The NTSB's review of team structures should compare and contrast the approaches of other failure boards, such as those the U.S. Air Force and NASA use. This examination should stress the efficacy of multidisciplinary teams to examine complex events.
- The NTSB should also evaluate the potential of a Senior Advisory Team to best utilize its senior investigative staff. The use of senior staff members to manage investigations should be limited. Instead, the NTSB's most senior staff members should be viewed as a shared resource, as a source of expert team review, and as mentors to junior investigators to promote the development of midlevel managers.

## Streamline Internal Operating Procedures

There are several things the NTSB should do to reduce workload and improve the flow of products. Most importantly, the current process for producing the final accident report should be less cumbersome and more visible to those who must ultimately approve the product, the board members. The following recommendations should reduce the time and resources required to complete accident investigations:

- Provide the chairman and board members with the option of requesting a technical peer review of final accident reports and safety studies prior to review by board members. This course should be reserved for complex investigations and should have the aim of ensuring the technical excellence of the final product. As a baseline, the peer-review team should consist of at least three technical experts who should be selected at random from NTSB senior investigators and should include at least one reviewer external to the NTSB with no party affiliation. Peer review comments should be confidential, and the accident investigation team should formally respond to peer-review comments.
- Enforce strict timelines for the preparation and release of final accident reports. The NTSB should lengthen its one-year baseline for major accidents to a more realistic eighteen months, with a 30-month maximum for any investigation. The current board order describing the overall process for report preparation should be revised to include this timeline and to allocate a greater percentage of the time to investigation and analysis than to report writing.

One final set of streamlining recommendations relates to how the NTSB manages information. The safety board does not design or manufacture airplanes and does not operate an airline. Rather, its investigations involve fact finding and analysis, and its final product is information. The quality of NTSB products must be very high, and accuracy must be ensured. This assurance depends, to a large extent, on the agency's ability to acquire, control, and distribute large quantities of information. The following recommendations are designed to improve the NTSB's internal and external information flows:

- Elevate information management to a higher level in the organization by establishing an Office of Information Management. This office would be responsible for the overall management of information and would integrate public inquiries, information technology, and analysis and data functions in the current NTSB structure. The office would also integrate such safety board functions as notation schedules and the management of dockets. The office would also be responsible for logging all information relevant to investigations that moves *into* or *out of* the NTSB.
- Improve the quality and management of accident or incident information by assigning one full-time person the task of quality control. This individual would ensure the coordination of accident record, recommendation, and publication databases; maintain a tight linkage between the information-management and project-management functions; and validate the ongoing technical accuracy of NTSB-generated data systems that are being propagated outside of the safety board.
- Evaluate the potential of a "knowledge agent" to improve electronic access to worldwide incident databases, to monitor and establish relationships with outside sources of expertise, and to ensure dissemination of NTSB-generated knowledge to the broader aviation community.

## Better Manage Resources

Reducing the staff's workload is a prerequisite to improved training and to the more effective and timely completion of investigations. A key to success in this area is the development of management practices and tools that allow tracking the expenditure of resources. The NTSB must establish the requirements for management devices that achieve this goal. Without such practices, there is little assurance that additional resources provided to the safety board will be most effectively employed. The NTSB should take the following steps:

- Implement a system that permits full-cost accounting of all safety board activities. This could be accomplished by modifying the NTSB's current relationship with DoT for time and attendance reporting, or, preferably, by establishing an independent NTSB timekeeping practice. Individual project numbers should

be assigned to each investigation. Specific project numbers should also be provided for support activities, such as training, to a level of fidelity high enough to ensure a comprehensive view of NTSB operations. Time charges and other expenditures for a given project should be merged and provided to project managers at least biweekly. The NTSB should endeavor to complete the implementation of an integrated cost accounting system within one year.

- Enact project management practices at all levels by assigning schedules and budgets to all investigations and safety studies. Project workload should be actively balanced across technical efforts at the level of the Office of Managing Director. Detailed project schedules should also be prepared electronically and should be available throughout the NTSB internal computer network in near real time.

## Maintain a Strategic View of Staffing

The NTSB should continuously assess its long-range staffing requirements, taking into account fluctuations in the labor market, the fleet mix, and the evolving nature of investigations. Such a staffing plan should be a safety board priority. In the near term, it is clear that some modest growth in NTSB staff levels will be required to reduce excessive workloads. RAND recommends that the NTSB initially pursue an increase in OAS personnel of between 12 and 14 percent over FY 1999 levels. In creating a long-range staffing plan, the NTSB should

- Explore the feasibility of personnel exchange arrangements for load-sharing using other civil, military, and private centers of accident investigation expertise. Intergovernmental Personnel Act assignments are one type of exchange relationship that the NTSB should explore for the future.
- Assess the effects of aging staff on the NTSB's future skill mix, especially in terms of replenishment of critical expertise. The NTSB should include in its staffing plan methods for using mentoring, training, and hiring to ensure the maintenance of critical skills.

- Ensure competitive compensation by measuring the competitiveness of NTSB's compensation structure relative to government and industry. A review of compensation should include a broad set of options, such as the use of signing and retention bonuses; National Resource Specialist positions; and the judicious use of senior-level and senior-technical positions, including the Senior Executive Service.

## Streamline Training Practices

The NTSB must assign a higher priority to training a staff capable of unquestioned leadership during an investigation. In streamlining existing training programs, the NTSB's senior staff must create the correct balance in a training program that builds management skills, professional capabilities, and investigative background. The following recommendations attempt to broaden the NTSB's approach to training:

- Create a baseline training plan that establishes standards for each major job title. This plan should first set minimum baseline training requirements for various levels within the NTSB. Technical managers at the NTSB should then build upon this baseline by selecting elective training options tailored to the needs of each employee. Training accomplishments should be maintained in employee records. Costs for training accomplished within the baseline plan should be managed within NTSB's overhead structure. Elective training, however, should be paid from training accounts assigned to individual technical managers. An emphasis on training should be engendered by making staff training accomplishments part of each manager's work performance evaluation. A minimum of two weeks per year of formal elective training should be established, with a three-week minimum goal for less-experienced staff.
- The NTSB should create a full-time training officer position to build and maintain the training plan. The training officer should be responsible for identifying and developing training opportunities and maintaining an agencywide database of training opportunities from which technical managers can identify elective training to meet the needs of individual staff. Although emphasis should be placed on creating coursework that exploits

on-site technical capabilities and senior staff for training and teaching, the training officer should maintain a complete catalog of relevant outside training opportunities. Training opportunities should be listed on an electronic catalog available as an internal Web page. The training officer should also prepare training budgets and report quarterly to the NTSB chairman on training program status.

- The NTSB general counsel should clarify the NTSB's policy regarding gift taking in relation to accepting training opportunities offered by private corporations and other government agencies. The acceptance or denial of training opportunities should not rely on ad hoc interpretations set forth by the Office of the General Counsel. Rather they should be evaluated on their technical merit and cost by following NTSB guidelines and elucidated in a standing board order. The NTSB should be encouraged to seek outside sources of training whenever it is demonstratively cost effective and of high merit. Especially important is training in advanced technologies, such as foreign aircraft systems, aging aircraft failures, new vehicle designs and operations, human factors, cockpit automation, emerging NAS design and operation, and complex-system failure diagnosis.
- Emphasize cross-training whenever possible to build multidisciplinary capabilities. The NTSB should consider staff rotation through NTSB organizations, the use of in-house colloquia to share skills and resources, and the expanded use of invited speakers and site visits to gain insights into alternative methods. The NTSB's emphasis should be on broadly based training, limiting the training with very focused outcomes. For example, training resulting in the type-rating of pilot-investigators should be limited to exceptional circumstances.

### Improve Facilities for Engineering and Training

The NTSB should review its internal technical capabilities to support future accident investigations, including the potential for crash reconstruction and the requirements for system testing in support of complex accident investigations. The safety board's long-term requirements for facilities should include consideration of their use for staff training, recognizing that facilities can serve a dual function.

To conduct this review, the NTSB should commission an external study that looks at technical and training requirements for the next 15 to 20 years for all transportation modes. This multimodal study should

- evaluate projected analytical facility and laboratory requirements based on assessments of future accident trends, including the ability of the NTSB to respond to complex failure events
- analyze the cost and efficacy of building and equipping new facilities to meet projected needs, as opposed to procuring services and/or obtaining additional capabilities through strategic alliances with other government agencies, the private sector, and academia
- include the cost and efficacy of using NTSB technical laboratories and capabilities for training instead of obtaining training from outside sources
- specifically highlight the cost and efficacy of an NTSB flight simulator facility to support investigations and training.

The NTSB should also improve its technical ability in the areas of modeling and simulation. The number and fidelity of simulation tools should be expanded, and aircraft models should be available in house for all transport category aircraft currently operating in the fleet.

The NTSB has become a critical link in the chain that ensures the safety of the traveling public in the United States and throughout the world. That link cannot be allowed to weaken. However, unless purposeful steps are taken to modernize the internal workings of the NTSB, to supplement its overloaded workforce, and to enhance the resources and facilities available to the investigative staff, the continued vitality of the NTSB cannot be ensured. It is in the interest of everyone who travels, by whatever mode, to ensure that the NTSB continues to set the world standard for independent accident investigation.