CHAPTER 6
IMPROVING NTSB INVESTIGATIVE AND OPERATIONAL PROCESSES

The NSTB is facing a period of dramatic change. The aviation industry, now emerging from a decade of consolidation and defense budget drawdowns, faces growing pressures from an increasingly competitive international marketplace. A more litigious legal environment has raised the stakes for resolving airplane crash liability, and the growing popularity of flying for pleasure, personal transportation, and business continues to feed the seemingly limitless demand for air travel.

Perhaps the biggest development facing the NTSB is the growing emphasis on increased aviation safety as a national policy goal. Because the NTSB provides domestic (and by extension, international) quality control, its mission is closely linked to flight safety. The importance of the NTSB's mission has never been greater, nor has the need for change and forward progress in aviation safety been more profound.

RAND has identified areas in which the NTSB can improve its operations, particularly in regard to staffing, training, and its interaction with the parties to investigations and the broader legal community. These findings are within the scope of this study's original work plan and are reported in Chapters 3 through 5 of this document. During the course of our research, however, RAND collected other findings related to the manner in which the Safety Board conducts its operations, manages limited resources, and controls the massive amount of information required to successfully conclude an investigation. This chapter outlines these additional findings.

The NTSB is an organization with a *proactive* mission and a reactive process. That is, the primary role of the NTSB is to *investigate* accidents, yet the agency's mandate is to *prevent* them. The reactive nature of the Safety Board has evolved from the difficulty of its mission. However, the NTSB has become *too* reactive. Very few of its resources are devoted to taking a more proactive stance related to aviation safety. Its relative inattention to the investigation of safety incidents is the most visible example of the Safety Board's lack of proaction. This is not to suggest that the NTSB should shift its priorities from investigating accidents to investigating incidents, but it should direct more resources to examination of the latter. This change alone would strongly reinforce national policy goals related to aviation safety. It would also serve the cause of accident investigation because Safety Board investigators would be more up-to-speed when an accident occurs.

The investigation of accidents and incidents is largely a matter of information management, and the NTSB is in some important ways an information management agency. The NTSB is the main repository of domestic accident information used by other government agencies and many private firms for monitoring and planning purposes. Yet the NTSB does a relatively poor job of managing information. The control and management of information is spread across the organization with little coordination among offices. This complicates the job of conducting investigations and makes outside users less confident of the accuracy of the NTSB's accident data.

The passage of information to and from the NTSB is another area needing improvement. The NTSB's insularity is a by-product of the agency's determination to preserve its independence and remain neutral during the course of accident investigations. Yet, in an environment of growing complexity, working in isolation seems an unwise course of action. The party process is predicated on the notion that the NTSB cannot successfully operate in a vacuum. This is truer today than ever before.

The key to improving the investigation process and strengthening the independence of the Safety Board lies in making the agency less insular while maintaining an experienced staff with unquestioned technical ability. A network of new alliances with other government agencies and academic institutions would allow the NTSB to greatly augment its capacity to acquire and manage knowledge. A less insular environment would also create new training opportunities and encourage NTSB technical staff members to share with the aviation community the wealth of knowledge they acquire at great cost during the course of investigations.

RAND has closely examined the process of developing accident reports. Here, too, the Safety Board could improve the quality of its output and the means for generating it. The process of completing Final Reports puts heavy time demands on NTSB professionals at all levels. Because the workload required to complete reports will likely continue to be heavy, particularly for major accident investigations, the process must be streamlined.

The current process emphasizes reporting over analysis, and NTSB Board members have very little formal opportunity to monitor reports in progress. In fact, Board members have little formal knowledge about major accident investigations until shortly before an NTSB Board meeting is scheduled. Considering the complexity and high stakes involved in a modern accident investigation, this lack of preparation by the Board can cause problems during the review cycle. The limited window of opportunity for Board members to examine the investigative results can lead to breakdowns in the review and approval process.

One way to facilitate the review and approval process is through selective application of peer review. Granting Board members the authority to request a peer review of a draft Final Report when the stakes are especially high and the investigation particularly complex would help ensure that exceptional care has gone into the preparation of the Final Report. In addition, the NTSB could improve the content of its reports by structuring its recommendations around a statement of expected performance rather than focusing on operational solutions.

The core of the NTSB’s operation, the accident investigation process itself, should be reexamined in light of the growing complexity of aviation accidents. The current process deconstructs an accident along discipline-oriented lines with separate teams conducting elements of the investigation largely in isolation. This runs counter to the current methods used to design aircraft and the multidisciplinary approach needed to resolve complex system events.

Resolving issues surrounding increasingly complex accidents requires a larger set of tools. The Safety Board’s limited technical facilities will likely be strained by future investigations. NTSB laboratories now perform at their operating limit, and the Safety

Board’s technical staff already rely heavily on the facilities of party members for testing and analysis. Although the NTSB should not plan to develop expansive research capabilities, it urgently needs to examine its long-range facility requirements.

The management of financial resources in an agency as small as the NTSB is of vital importance. Currently, the NTSB has no way to accurately measure how efficiently and economically human resources are applied to an accident investigation. Because the NTSB relies on the DOT for processing employee payroll costs, it has no means of merging pay and nonpay costs. The development of a complete real-time cost-accounting system would give the NTSB project management capability. Without this capability, Safety Board senior managers cannot assure efficient use of resources nor effectively balance work hours among the myriad activities under way at any given time.

INSUFFICIENT ATTENTION TO AIRCRAFT INCIDENTS

A general agreement exists within the aviation community that studying incident events best illuminates the path to improved aviation safety. More often than not, an accident is simply a failure to detect a preexisting problem. Incidents reveal systemic weaknesses and operational deficiencies, usually long before lives are lost. An accident, particularly a fatal accident, usually occurs following a history of precursor incidents. In turn, the cause of incidents can usually be traced to a larger body of operational data that until recently has rarely been investigated. Taking action based on incidents rather than accidents is becoming more and more critical to improving aviation safety (National Research Council, 1998, p. 29).

In 1997, the FAA recorded 433 major airline incidents, approximately 10 times the number of accidents that are reported to the NTSB.[1] In terms of the amount of attention that incidents elicit from the NTSB, it is a tenth of that given to accidents. As shown in Chapter

---

[1]These data come from the respective FAA incident and NTSB accident databases. The nature of major incidents, which must be immediately reported to the FAA, is defined in 49 CFR 830.5(a).

5, approximately 10 percent of all dispatches made by the investigative staff at NTSB headquarters each year are related to incident events.

At the regional offices, where virtually all GA incidents and accidents are investigated, the number of investigations is even more skewed toward accidents. As shown in Table 6.1, incident investigation accounts for only 3 percent of the total activity in the NTSB's regional offices (National Transportation Safety Board, February 1996). This is not surprising given that very little national attention has been focused on incident trends in GA (National Research Council, 1998, p. 51).

In keeping with its mission, the NTSB is clearly organizationally focused on the job of investigating accidents. Interestingly, the Safety Board's Strategic Plan places accidents *and* incidents as its first stated goal in meeting its proactive safety mission (National Transportation Safety Board, September 1997, p. 3).

Investigating incidents is crucial to the NTSB carrying out its safety mission. Incidents can relay important messages in regard to impending failures of a system. Icing incident reports were routinely filed on the ATR-72 aircraft before a crash that killed 68 people in Roselawn, Indiana, in 1994 (Fredrick, 1996, p. 142). Longitudinal control problems with the Boeing 737 were recorded in a long series of incident reports prior to the loss of United Flight 585 in 1991 and USAir Flight 427 in 1994, accidents that were later found to have been

Table 6.1

1995 Regional Office Activities

	Type of Investigation				
	Major	**Field**	**Limited**	**Incident**	**Public**
Number of requests	687	2385	1400	90	120
Number of investigations	6	331	1810	67	12
Number of reports	97	1005	1025	60	29

SOURCE: Statistics provided by the NTSB Office of Aviation Safety.

caused by a malfunction in the aircraft's rudder actuation system (Air Line Pilots Association, 1994, p. 13; Brenner, November 8, 1995).[2]

While they are important harbingers of accidents to come, incidents also *inform* accident investigators of what exactly prompted a crash. This is especially true with serious accidents involving complex systems in which destruction can be total, or with events in which low-fidelity FDRs are encountered. In these situations, related incidents provide vital clues regarding the failure mode at work in the accident. In the future, FDRs with more parameters will speed the task of identifying causal factors. However, familiarity with a history of related incidents will help investigators untangle the cause of major accidents that involve complex systems interactions.

Another set of incidents overlooked by the NTSB lies in the area of aviation security. The NTSB has no clear policy related to the investigation of security incidents, even though such incidents constitute a clear threat to aviation safety. Although major security incidents have come to the attention of Safety Board investigators, no report has been forthcoming in this important area.

Reviews of several investigations have demonstrated to RAND that the NTSB has frequently overlooked the incident history on an aircraft prior to a major accident and investigators have had to conduct extensive research to make up for lost ground. Four principal reasons exist for NTSB's lack of focus on incident investigations:

- **Conflicting Mission.** RAND interviews revealed that many investigators feel that incident investigations clash with the FAA's certification role, thereby threatening the NTSB's independence.
- **Loss of Important Information Paths.** Incident investigations often rely upon information channels that are personal and confidential, and providing information through these channels is optional. In contrast, revealing any relevant information

---

[2]Control upsets involving the B-737 occurred throughout the operational life of the aircraft. Most of these events were minor and were traced to problems with a system that dampens slight aircraft yaw movements.

pertaining to a major accident is mandatory. NTSB investigators fear that if they pursue incident investigations more aggressively, their information channels will disappear. Because these information channels also operate during an accident investigation, a loss of rapport with aircraft manufacturers and operators could seriously hamper the NTSB's operational effectiveness.

- **Relevance.** The relative importance of an incident event is frequently tied to the current status of accident investigations. Events that are considered irrelevant to ongoing efforts tend to be ignored while ones that are relevant to ongoing investigations become elevated in importance.
- **Resource Constraints**. As indicated in Chapter 5, NTSB investigator resources are usually heavily strained. In a period of peak workload even a very major incident can be overlooked. Therefore, a qualitative assessment of the magnitude of an event must be performed. Incidents that involve ATC issues, operational factors, a clear threat to safety, or fleetwide mechanical implications are more likely to receive attention. Depending on workload levels and perceived importance, the incident may be passed to a regional office to be examined by a field investigator. In the vast majority of incident cases, the NTSB passes the investigative function to the FAA. At times, of course, the NTSB's workload permits more attention to incidents. At such times, additional investigators are dispatched and the incident can be used as a training opportunity for new personnel.

A lack of resources, combined with the NTSB's cultural focus on accident investigations noted earlier in this chapter, acts to deemphasize the importance of incident investigations. As a result, the NTSB maintains relatively little digital connectivity to the various incident data systems available throughout the world (Federal Aviation Administration, June 1997).[3] The Safety Board lacks investigative

[3]The lack of coordination between aviation accident and incident information has been a long recognized problem. Broader coordination is

support for routinely accessing electronic incident data systems. Without this capability, it is left up to the individual investigator to exercise this function. Because the level of computer literacy varies widely within the investigative staff, critical information can be overlooked.

Many civil aviation incident reporting systems are maintained across the globe, including the following:

- **Accident/Incident Data System (AIDS).** Maintained by the FAA's Accident Investigation Office, AIDS tracks major incidents that are reported to the FAA under mandatory reporting rules. AIDS reports are available via the World Wide Web but the interface is not sufficiently robust to support large-scale incident investigations.
- **Aviation Safety Reporting System (ASRS).** In operation since 1976, the ASRS accepts more than 30,000 incident records each year (National Aeronautics and Space Administration, January 1998a, p. 8). ASRS is a voluntary system maintained by the NASA Ames Research Center. Submittals to ASRS are treated as highly confidential and submitters are protected under FAR §91.25 which ensures that information cannot be used in administrative hearings. The FAA also waives fines and penalties in order to encourage the candid reporting of unintentional errors that cause safety incidents.
- **Flight Operational Quality Assurance (FOQA) systems.** Errors in aircraft operation or minor technical mishaps mostly go unreported in incident reporting systems. FOQA systems capture this operational data, providing a wealth of information with which to closely monitor world aviation. FOQA programs are coordinated through the Air Transport Association's Data Management Committee.[4] NASA also manages the Aviation

---

being managed under the FAA's new Global Aviation Information Network (GAIN) initiative.

[4]FOQA programs are operated voluntarily by U.S. airlines. These systems acquire data in much the same way as the aircraft FDR except the data are retained in quick access devices. Because of Freedom of Information Act rules and federal discovery procedures, airlines have

Performance Measuring System (APMS), a joint research effort with the FAA that aims to complement FOQA efforts by providing tools for data reduction, interpretation, and visualization. Work is under way to electronically link the APMS to the FAA's National Aviation Safety Data Analysis Center (NASDAC) (National Aeronautics and Space Administration, January 1998b, p. 3).

- **Accident Data Reporting System (ADREP).** Managed by the Accident Investigation Group of the ICAO and maintained by Britain's Civil Aviation Authority's Research and Development Authority, ADREP follows rules similar to the FAA's for the mandatory reporting of significant accidents and incidents.[5] As a worldwide data system, ADREP is an important tool for analyzing events that could affect flight safety. ADREP also provides an incident reporting standard that is used by domestic reporting systems, such as Australia's Confidential Aviation Incident Report (CAIR) System, New Zealand's Information Collected Anonymously and Reported Universally for Safety--Confidential Aviation Reporting System (ICARUS-CARS), South Africa's Southern African Aviation Safety Council (SAASCO), Canada's Safety Issues Reporting System (SIRS), Britain's Confidential Human Factors Incident Report Program (CHIRP), the European Union's Confidential Aviation Safety Reporting Network (EUCARE), as well as NASA's ASRS.

The NTSB's use of these resources is slight. For example, Table 6.2 shows one-year user histories for NASA's ASRS system. Safety Board investigations account for 2 percent of the inquiries made to the system.[6]

---

long been concerned about preserving the confidential nature of FOQA. A recent FAA policy decision to protect confidential data is expected to encourage broader use of FOQA information.

[5]The design and operation of ADREP are outlined in ICAO Document 9156, Accident/Incident Reporting Manual.

[6]Many NTSB investigators expressed concern over the accuracy and ultimate use of ASRS data. ASRS solicits incident reports from all aviation sectors. Individuals who submit information are granted confidentiality and limited immunity in the form of a "waiver of

Table 6.2

Requests to NASA ASRS, 1997

Organization	No. Req.	Organization	No. Req.
FAA	70	Individuals	34
NASA	19	Law firms	8
NTSB	10	Manufacturers	6
Military	9	Professional organizations	34
Other government	10	Foreign organizations	29
Research offices	40	Air carriers	24
Educational offices	8	Media	62
		Other	31
		TOTAL	394

SOURCE: National Aeronautics and Space Administration, January 1998b, p. 14.

Failure to use the many resources available to accident investigators has retarded progress on many occasions. In one recent major investigation, significant incidents that corroborated NTSB analysis and findings were discovered only when an investigator happened upon a relevant article in an aviation magazine. This discovery triggered a subsequent search of the FAA Civil Aeromedical Institute's Pilot Incapacitation database that uncovered additional, highly relevant incidents.

Because they are immersed in the world of aviation and have an active network of professional contacts, NTSB personnel are usually made aware of major incidents involving specific aircraft designs or operational procedures, despite their not being focused on incidents and not having the benefit of consistent and sustained use of electronic media. NTSB managers and investigators rely on this informal system to

---

disciplinary action" in order to encourage the reporting of incident information. Many NTSB investigators feel that this encourages an errant proliferation of reports from pilots seeking exoneration, which biases the data and masks more serious incidents. ASRS has, however, proven itself a valuable source of trend information and safety threat warnings.

identify critical incident events that carry the greatest risk to aviation safety.

The general sense within NTSB is that significant problems receive enough attention within the aviation community or from the media to ensure that they do surface. On many occasions, the informal system has worked; serious problems are detected and safety recommendations are issued. But the fact remains that most incident events are not reviewed by the NTSB. Informal background channels have failed in the past, and minor incidents are almost completely ignored. Without a vigorous and sustained analysis effort, opportunities to identify incident patterns are largely lost.

The NTSB’s limited response to incidents is not consistent with its proactive safety mission. Whereas accident investigation should remain at the center of the NTSB’s core functions, recognizing the importance of incidents and reevaluating their significance within the organization should be a top priority. Increasing the allocation of resources to incident investigation could increase safety investigators’ awareness of accident trends. It could also help identify the need for key safety studies, while speeding the job of accident investigation by making the incident record more widely available.

Although additional Safety Board staff resources could permit a broader examination of incidents, this alone will not ensure that a more appropriate balance is achieved. Accident investigators will remain focused on accident events, a proclivity that will continue to limit the importance of incident analysis. Likewise, merely improving access to electronic information is not a sufficient response to this issue. Investigators often lack the proficiency required to manipulate complex data systems effectively; data mining across widely diverse systems is not a job best left to accident investigators.

The NTSB might consider the idea to functionally separate incident analysis from accident investigation. A separate function would have two objectives: to search and synthesize incident records to inform Safety Board managers of urgent safety issues, and to retrieve targeted information in response to accident investigator needs.

The Safety Board must also deal with adopting a new approach to incidents in terms of its organizational culture. This should be done in close cooperation with the FAA to clarify roles, establish rules of engagement, and design the necessary linkages to data systems. Prior recommendations have called for greater NTSB-FAA cooperation on incident investigations related to human factors (Federal Aviation Administration, June 1996, p. 5). Cooperative investigation of incidents and trends could greatly advance safety goals.

MANAGING INFORMATION AT THE NTSB

Information management is an extremely important function at the NTSB. Although the NTSB is a small agency, it is a source of critical safety information for the nation and for the world. As previously noted in this report, the impact of NTSB decisions can be profound. The quality of Safety Board products must be very high and their accuracy must be unquestioned. This assurance depends on the NTSB's ability to acquire, control, and disseminate large amounts of information, in both written and electronic form, in an effective and efficient manner.

This section discusses the decentralized nature of information management at the Safety Board, the seeming lack of attention to managing information, the insularity of the NTSB in terms of acquiring outside information and knowledge, and the potential to improve the investigation process by accessing outside knowledge.

Control and Management of Information Is Decentralized

The NTSB must speak with one voice. However, the assurance of accuracy and uniformity in the messages it delivers is hampered by a fragmented approach to information management and production. Neither the inflow or outflow of information is centrally controlled, nor does much formal coordination exist among components of the organization in regard to information sharing. Information communication within the Safety Board is often incomplete, inaccurate, and hampered by poor coordination. This finding is consistent with a recent review of internal NTSB management and training practices (Ender et al., February 22, 1996, p. 6).

The NTSB views itself mainly as a technical agency. Whereas a great deal of engineering analysis goes into Safety Board activities, the final product is information, primarily in written form. Information management is, therefore, almost as important as the Safety Board's engineering function. The NTSB's technical staff does not generally share this awareness.

In a practical sense, this lack of "information awareness" interferes with many aspects of operations. The public docket, for example, is crucial to tracking the progress of an investigation and is open to any interested individuals. However, important items are not always accurately tracked within the docket and its quality and content are not always reliable.

Information leaks have also been a continuing Safety Board problem. They threaten both the security and independence of the NTSB. Although investigations are ostensibly public information, the Safety Board handles a significant amount of "confidential," "company private," and "trade secret" information. For instance, CVR data and personal information related to deceased crew and passengers must be securely handled, and investigative analyses are not available for review by either the public or the parties.

The family assistance function also influences how the NTSB manages and releases information. Broadening the NTSB's mission to include family assistance has created some tension among staff members. Many investigators were already concerned about the proliferation of accident theories (which has been greatly accelerated by the dissemination of information via the Internet) and view family rights organizations as yet another source of alternative theories. Other investigators are concerned about the need to deliver accurate information to families during the course of an investigation, but fear that the increased visibility stimulates adverse reactions among party members. At the very least, the additional responsibilities that accompany the family assistance program further elevate the importance of information management within the NTSB.

Unquestionably, the proliferation of communication networks has complicated the accident investigation process. The NTSB accepts its public mandate with an unusual degree of dedication to responsiveness. A mail control process is used to date stamp, catalog, and route the hundreds of pieces of correspondence received during the course of a major investigation. The Safety Board's acceptance of unsolicited theories leaves it open to possible manipulation through the production of excessive or purposefully inaccurate information. The spread of inaccurate information via the Internet has been well documented recently, as has the gullibility of the media (Hanson, May/June 1997).[7]

As the Safety Board's information requirements have grown, spot solutions have evolved in response. In some cases, new organizational elements were created to handle information needs and in others a new function was simply added to existing ones. The chart in Figure 6.1 identifies the various NTSB elements that acquire, manipulate, or distribute information. The figure also shows the major database systems that have been constructed to maintain information. Although these databases enjoy connectivity to a robust LAN/WAN system, they are weakly coordinated.

Decentralized information functions work against the need to integrate information during the course of an investigation. The NTSB must be able to integrate hundreds of relevant facts and data fragments from disparate sources. A chain of evidence must be preserved, making cataloging critically important.

The information gathered during the course of an investigation also generates a wealth of opportunities for later training efforts. Much of this potential is lost because information is not centralized.

Figure 6.1 also depicts the distribution of publication functions. The NTSB produces numerous written products, and their accuracy and quality are crucial. For example, the final Blue Book report is an important milestone for the families of airline accident victims and is a benchmark for litigation and a resource for plaintiff and defense

[7]Internet-based misinformation can not only quickly spread but appear to become factual. For example, in February 1999, Reuters reported that hackers had seized control of four British military intelligence satellites. The story later proved to be erroneous, but many newspapers ran the story without verification.

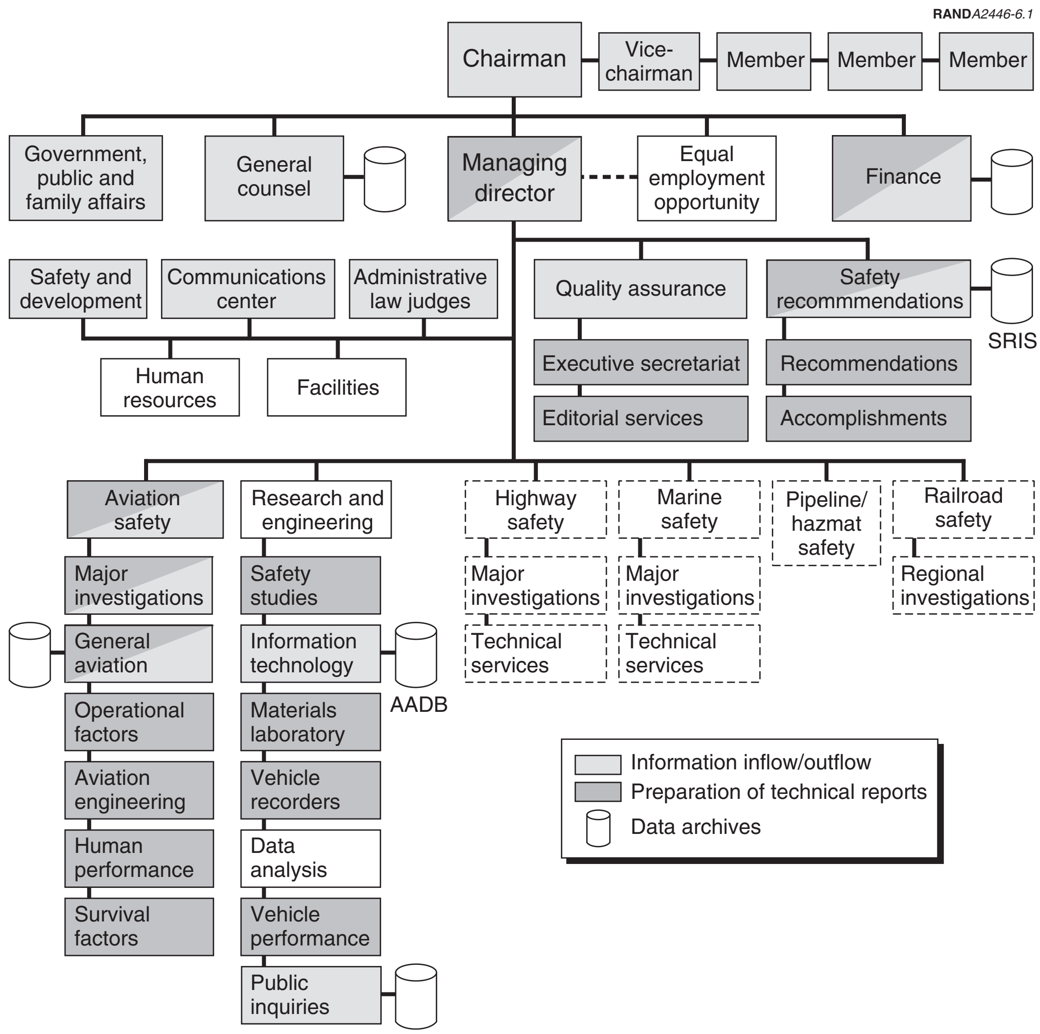


Figure 6.1--Entities Acquiring and Distributing Information Within the NTSB

attorneys alike. Safety recommendations can have an immediate and far-reaching impact on air safety.

Quality, uniformity, and accuracy are difficult to maintain when production of information is spread across numerous areas of the organization. The NTSB maintains no central publications department. Report writing is distributed throughout the organization and each transportation mode is largely responsible for generating its own material.

Graphic representations, a vital part of explaining complex accidents to NTSB Board members, families, the general public, and the media during sunshine meetings, are also largely distributed by technical offices of the NTSB. In most cases, the responsibility for developing complex graphics falls upon the technical staff. While some of this workload is difficult to avoid (such as the graphics generated by complex computer simulation), the NTSB would benefit from a dedicated staff of artists with expertise in the development of technical graphics.

The editorial review and comment process is also informal. The NTSB’s complete editorial policy is contained in a 250-word description of general practices (National Transportation Safety Board, 1998b, attachment 1).

Considering the importance of final information products to the Safety Board’s mission, the decentralized approach to producing them is less than ideal. The NTSB’s information needs are such that its resources should be realigned to create a higher-end information agency. A notional outcome would call for more centralized information management and production, or at least improved coordination of the operations that are currently distributed across various offices.

More Attention to Database Management Is Needed

The previous section describes how the NTSB is dependent upon the accuracy and uniformity of the information it disseminates. In this section, the quality of the *accident record,* one of the NTSB’s most important information resources, is discussed. The accident record supports not only ongoing internal investigations but is heavily used by external agencies for planning and decisionmaking related to aviation safety.

Accident records are vastly important to safety planners, airline insurers, manufacturers, and the traveling public.[8] Accident information is also crucial to the FAA, where it is combined with inspection and

---

[8]The U.S. Senate has recommended that safety data be more widely available to the general public (U.S. Senate, 1996). Congress has also expressed concern over the way in which accidents are categorized. In response to this, the NTSB has prepared new methods for classifying accidents.

surveillance data to optimize the agency’s mission of aviation system monitoring (GRA, Inc., January 1997, p. 13).

The official record of domestic accident information is the NTSB’s Aviation Accident Database (AADB). The AADB is cited extensively and authoritatively throughout the world in the study of aircraft accidents. It is electronically linked to the FAA’s NASDAC and can be queried openly through that connection and through the NTSB’s own Web site.

The AADB is not the only source of accident information. Australia’s BASI, Great Britain’s Aviation Accident Investigation Board (AAIB), and other aviation accident investigation agencies maintain similar records. Private organizations, such as England’s Airclaims, Ltd., also closely track accident statistics. These alternative sources often correlate their information against the AADB, however, and monitor the AADB closely. Arguably, the NTSB’s accident record is the most detailed and comprehensive in the world.

As previously discussed, RAND relied heavily upon the NTSB data records to gain an appreciation of the NTSB’s accident investigation workload and output.[9] Table 6.3 lists the various sources RAND used for analysis, the organizational “owner” of the information, and a qualitative assessment of the accuracy of the information RAND encountered. The NTSB primarily uses its accident and safety recommendation databases as an archive. The quality and content of the data records are generally adequate for this purpose. Nevertheless, they are subject to only limited quality control and often the data entry to update the archives is a low priority.

The AADB essentially functions as a “master index” for the NTSB. Other NTSB databases should be indexed from this record and thereby correlation should be assured. The NTSB should also consider using the AADB to conduct its analytical research. The AADB could be used, for example, to track and study the Safety Board’s central finding--the *probable cause* of an event. This important outcome, along with any contributing factors, is generally not used in the study of aviation

[9]Additional discussion of limitations found while integrating disparate NTSB data sets can be found in Appendix B.

Table 6.3

Issues Associated with and Quality of NTSB Data Sources

	Database contents	Source	Issues	Quality
Investigations/workload	Major reports, 1978–current	OAS	Data are not comprehensive of all investigations, have few data fields, and have high number of errors.	Poor
	Recommendations (SRIS)	OSRA	Data are not comprehensive of all investigations, have few data fields, and have high number of errors.	Poor
	Fatal Accident List, 1982–current	Internet	Data are not comprehensive of all investigations, have few data fields, and have high number of errors.	Poor
	All parts, 1962–1974, 1975–1981	ORE	Never validated therefore error rate unknown, many fields intermittently recorded, and no part number pre-1975.	Archival
	All parts, 1982	ORE	Error rate unknown, used different data fields from other databases, did not maintain report date.	Archival
	All parts, 1983–1998 (AADB)	ORE	"Fatal incidents" error rate unknown, many fields intermittently recorded, and report date blank 1983–87.	Good
	HQ Dispatch Log	OAS	Data are not comprehensive of all investigations and have few data fields.	Archival
Resources	Organizational staff levels	HR, CFO	Varying measures of "full time equivalent" staff and no ability to track individual investigation level-of-effort.	Poor
	Organizational budget levels	CFO	Difficult to track "comp time" and no full-cost accounting on per-investigation basis.	Poor

RAND*A2446-T6.3*

safety. A report of causal factors would be an important information adjunct for planners and analysts responsible for developing solutions to meet aggressive U.S. aviation safety goals. The use of the AADB as the source of such a report is in keeping with a proactive NTSB.

The importance of the accident record justifies a close examination of information management practices. The need for improvement in this area has previously been brought to the attention of the Safety Board (Lamb, March 29, 1994, p. 153). The NTSB is now working to improve the acquisition and management of information. Efforts are under way to capture much more information in the event of a Part 121/129 accident and to substantially increase the amount of data related to human factors. The problems in this area are mainly due to a lack of human resources and, to a lesser extent, inadequate equipment. Nevertheless, management's continued attention to this important issue is also needed.

Insularity Inhibits Exploration of Alternatives

The NTSB is a small, self-contained organization that co-exists within a vast collection of designers, builders, and operators that make up the nation's aviation community. However, the NTSB's ties to this community are surprisingly limited.

The insularity of the NTSB is reflected in the few standing alliances and agreements that it has established with government agencies, research laboratories, and academic institutions. The alliance-building movement that has swept through the federal government over the past 15 years has been largely ignored by the NTSB. Table 6.4 summarizes the NTSB's long-term relationships with other federal agencies.[10] The Safety Board perceives this limited set of agreements as being adequate to support its ongoing operations.

The insularity of the Safety Board can be traced to four factors:

- **Interpretation of Its Independent Role.** The NTSB's corporate focus on independent and unbiased accident investigation, in keeping with its mission, discourages openness and cooperation with other agencies.
- **Reliance on the Party Process.** The Safety Board has principally relied on the party process to augment its technical resources during an accident investigation. Evidence indicates that this process has indeed served the Safety Board's mission well. The NTSB staff's confidence in the party system has largely eliminated the need for exploring alternative relationships.

---

[10]The NTSB is currently attempting to fully document the nature of its alliances with other agencies and institutions. Senior NTSB officials, responding to interim RAND recommendations, are attempting to broaden alliances in key areas. Table 6.4 reflects formal alliances that were in place at the time this report was written.

Table 6.4

NTSB Alliances with Other Government Agencies

Agency	Primary Service Provided	Other Roles
Armed Forces Institute of Pathology	Pathology and forensic examination	Yes
Federal Aviation Administration	Rapid deployment flight services	No
	Data collection and analysis	Yes
Federal Emergency Management Agency	Search and rescue	No
Health and Human Services	Pathology and forensic examination	No
Naval Surface Warfare Center	Data collection and analysis	No
United States Coast Guard	Search and Rescue	Yes

SOURCE: NTSB, Office of the Managing Director, May 1999.

- **Staff Pride and Insecurity**. Safety Board staff members pride themselves on maintaining standards of excellence. Most NTSB professionals see the agency as "David" in a land of "Goliaths" and are proud of its technical performance despite its size. However, the professional staff is oftentimes lagging in awareness of technical developments in the aviation field, given the rapid pace of progress in aviation R&D and the limited opportunities for technical training at the NTSB. This combination of pride and insecurity hampers the ability of Safety Board staff to develop mutually beneficial relationships with outside agents.
- **Generalist Nature of the Staff.** One of the great dangers the Safety Board faces is the potential deterioration of the technical staff's professional skills. RAND analysts were frequently told that the best investigators are "generalists" who have enough knowledge in a variety of fields that they are able to ask the right questions at the right time. However, an exclusive focus on multidisciplinary talents can ultimately become detrimental to an employee's professional development.

> Lacking an area of specialty, over time a generalist can lose touch with his or her original technical foundation and bypass training and professional symposia that would supply continuing education. Staff work overload compounds this problem. In Chapter 5, RAND acknowledged the importance of training accident investigators as widely as possible. The challenge facing the NTSB is to broadly train a cadre of generalists while ensuring that technical expertise in at least one specialty area is retained.

Developing working relationships with other federal agencies and academic institutions can only serve to benefit the NTSB and encourage the professional development of its staff. Future accident investigations most likely will require expertise that the NTSB, or party members, will not have. In this regard, new relationships are mandatory. The Safety Board will need fresh strategies for identifying opportunities for cooperative agreements and building valuable alliances needed for the future. Strategies such as this are discussed in the next section.

Rapid Access to Outside Knowledge Would Assist Investigations

As defined in Webster's, *knowledge* is a body of facts and ideas acquired by study, investigation, observation, or experience. Maintaining and providing access to knowledge is a primary job of the NTSB. In modern parlance, the term *knowledge management* (KM) typically refers to the process by which organizations acquire and codify knowledge. Like many new terms, the meaning of *KM* depends somewhat on its application. The following definition of "knowledge management" is most applicable to the work of the NTSB:

> The identification and analysis of available and required knowledge, and the subsequent planning and control of actions to develop knowledge assets so as to fulfill organizational objectives (Macintosh, May 1996, p. 3).

RAND applies this term to the challenges facing the NTSB of locating relevant *external* knowledge to support its investigative goals, and capturing the extensive tacit knowledge that exists *internally* at the NTSB.

As discussed in previous chapters, the NTSB's size requires that it heavily leverage knowledge from outside sources. The party process is the traditional source of this knowledge and the party system as a central source of information is likely to continue for the foreseeable future. Nevertheless, the following three factors should compel the NTSB to consider expanding its current sources of knowledge and expertise:

- **Increasing Complexity.** As aircraft accidents grow in complexity there is no assurance that party members can deliver the knowledge the Safety Board needs to fully understand the cause of failures.
- **Research Focus.** In a similar vein, increasing complexity will force the NTSB to perform more research in relation to accident investigations. The NTSB is unlikely to see an expansion of its authority to the point that it can match the capabilities of current government, private sector, and academic R&D institutions. It can, however, increase its involvement with such institutions and through new relationships acquire much needed knowledge.
- **Investigation Effectiveness.** Compelling reasons exist for improving the timeliness of Safety Board reports. Investigators must be able to stay focused on establishing as quickly as is practical the cause of an accident. Ready access to outside experts will become increasingly important to ongoing investigations.

A recurrent theme of this report has been the growing importance of the NTSB as a *source* of knowledge. Currently, the Safety Board is primarily a *knowledge consumer*. The NTSB could play an important role in helping to bring about national air safety objectives by recognizing that its staff possesses knowledge relevant to safe aircraft design. But, the Safety Board does little to codify lessons learned from safety investigations, which could be used to educate young engineers who will design future aircraft, or that could contribute to the body of scientific and technical knowledge related to aircraft systems.

In areas such as aging flight systems and fire and explosion research, NTSB investigators and analysts have amassed a substantial amount of knowledge that is important to aviation safety R&D. Developing even safer aircraft in a world of already exceptionally safe systems requires the establishment of better safety requirements and the expanded use of integrated design teams (Weener, August 1997, p. 4). Supplying NTSB briefings to these teams can help ensure that valuable insights are taken into account at the very beginning of the new aircraft design process.

NTSB training is a two-way street. Safety Board managers should be concerned with not only obtaining better training for their staff, but also ensuring that staff members participate in training others in the aviation community. A regular practice of sharing knowledge gained through event investigations would help make the Safety Board less insular and encourage the formation of new communication pathways.

Figure 6.2 introduces the notion of a “knowledge agent” within the NTSB to perform the KM function. A knowledge agent would serve as a clearinghouse for locating, accessing, and distributing knowledge to professionals within the Safety Board and would identify opportunities

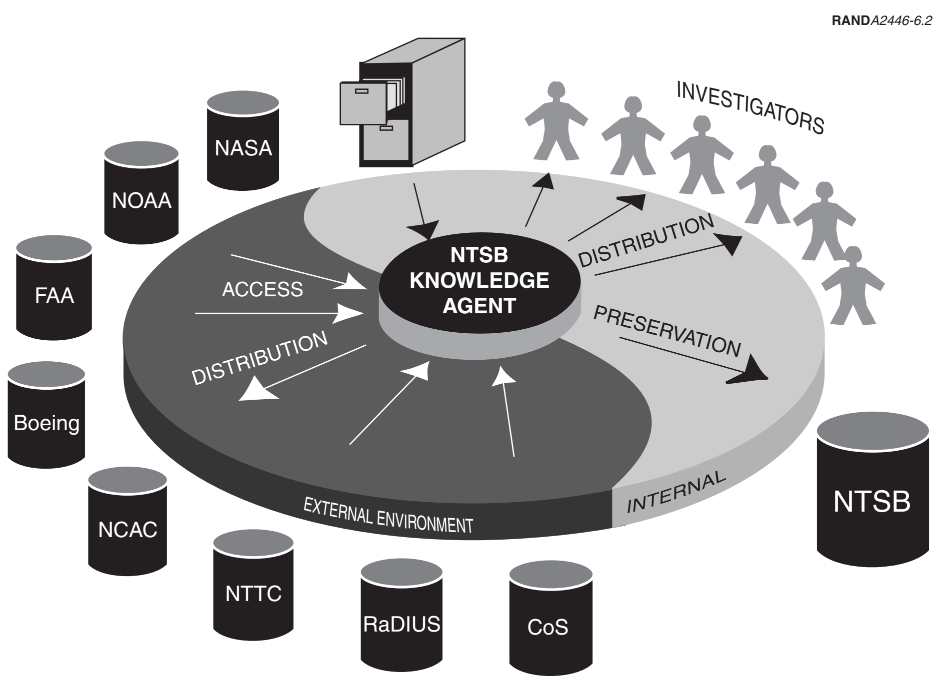


Figure 6.2--Information Access, Distribution, and Preservation Through a Notional NTSB Knowledge Agent

for NTSB analysts and investigators to make key contributions in their technical fields.

A knowledge agent could take advantage of two current developments--the emergence of electronic knowledge-based systems and the steady growth in extramural research, strategic alliances, and cooperative agreements among government, private sector, and academic institutions. As shown in Figure 6.2, knowledge bases are proliferating at a rapid rate. Here are just a few of those shown in the figure:

- **Community of Science (CoS)** is a knowledge system created to assist scientists in operating across discipline boundaries, establishing lines of communications, and locating funding. The COS knowledge system is Internet-based and searchable, linking over 200,000 scientists, 215 universities, leading R&D corporations, and government agencies.
- **National Technology Transfer Center (NTTC)** was established by Congress in 1989. The NTTC provides technology transfer support to researchers in government, industry, and academia. The NTTC monitors federal R&D programs and supports Internet-based searching of research abstracts.
- **Research and Development in the United States (RaDiUS)** was developed by RAND's Science and Technology Policy Institute, with the support of the National Science Foundation. RaDiUS tracks all government R&D activities and resources. RaDiUS is free to government agencies and allows users to quickly search individual research programs and contacts.

These knowledge-based systems and many others like them provide synopses of ongoing research and technology projects in addition to providing contact information to encourage alliance building.

A formal practice of KM, possibly centered on the notion of a knowledge agent, could greatly assist the NTSB's investigative function. This concept would be reinforced by elevating the importance of information management within the Safety Board. Strategies for improving access to and control of knowledge, while improving the quality and uniformity of the information itself, could greatly improve the NTSB's ability to more effectively respond to complex and challenging accident investigations.

ACCIDENT INVESTIGATION AND REPORTING PROCESSES

Airline transportation accidents garner a disproportionate share of media attention when statistically compared with human and financial losses from incidents involving other transportation modes. It is fair to say that an airliner crash is only the beginning of an accident cycle. The conclusion of the cycle is the NTSB’s sunshine meeting in which the findings, probable cause, and final recommendations are presented. This meeting is quickly followed by the release of the Blue Book. All of NTSB’s work is synthesized in the Blue Book, which is often the culmination of several years’ work.

This section examines the investigation and report writing processes in more detail. It presents notional concepts aimed at streamlining current practices. This section also discusses the creation of safety recommendations and examines the adequacy of Safety Board facilities to support future accident investigations.

Final Report Preparation Process Should Be Streamlined

The sudden loss of hundreds of people generates intense public attention. For the aviation industry, however, an accident’s impact lies in the Blue Book and its power to influence the production and sales of aircraft. A direct and very tangible socioeconomic connection exists between the outcome of an accident investigation and the aviation marketplace. Aerospace products generate hefty revenues and, as shown in Table 6.5, they continued to be a major positive factor in the U.S. balance of trade.

The sale of transport category aircraft accounts for more than half of civil aerospace exports. While remaining strong, the contribution of all U.S. aerospace exports to the U.S. balance of trade has been generally declining as a percentage of total merchandise exports since the early 1990s. During this period, military exports have grown slightly, signaling a loss of U.S. dominance in civil aircraft markets. This is due in large part to emergent international competition from Airbus and other manufacturers. Today, the international market can

Table 6.5

Import/Export Balance for Civil Aerospace Products, in $Millions

Year	Aerospace Exports	Aerospace Imports	Aerospace Trade Balance	Overall U.S. Trade Balance
1988	26,947	9,087	17,860	[118,526]
1989	31,111	10,028	22,083	[109,399]
1990	39,083	11,801	27,282	[101,718]
1991	43,788	13,003	30,785	[66,723]
1992	45,018	13,662	31,356	[84,501]
1993	39,418	12,183	27,235	[115,568]
1994	37,373	12,363	25,010	[150,630]
1995	33,071	11,509	21,561	[158,703]
1996	40,270	13,668	26,602	[170,214]
1997	50,374	18,134	32,239	[181,488]

SOURCE: Aerospace Industries Association, 1998, p. 115.

support only a single sizable U.S. commercial transport aircraft enterprise, the Boeing Commercial Aircraft Company.[11]

Increasingly, safety is a major component of the aerospace industry’s economic performance. A major airline accident can quickly erode confidence in the performance of an aircraft, destabilizing its market position. Repeated accidents and incidents involving a particular type of aircraft can devastate the market position of its manufacturer. n the increasingly competitive aviation marketplace, such opportunities are quickly exploited. The history of the DC-10 is illustrative.

The United States dominated the post-war aviation economy, a reign that was mostly unchallenged until the emergence of Europe’s Airbus consortium in 1970. Several experts have linked the loss of U.S. dominance in international aviation markets to the safety performance of the DC-10 aircraft (Golich, 1989).[12] The Airbus consortium as a

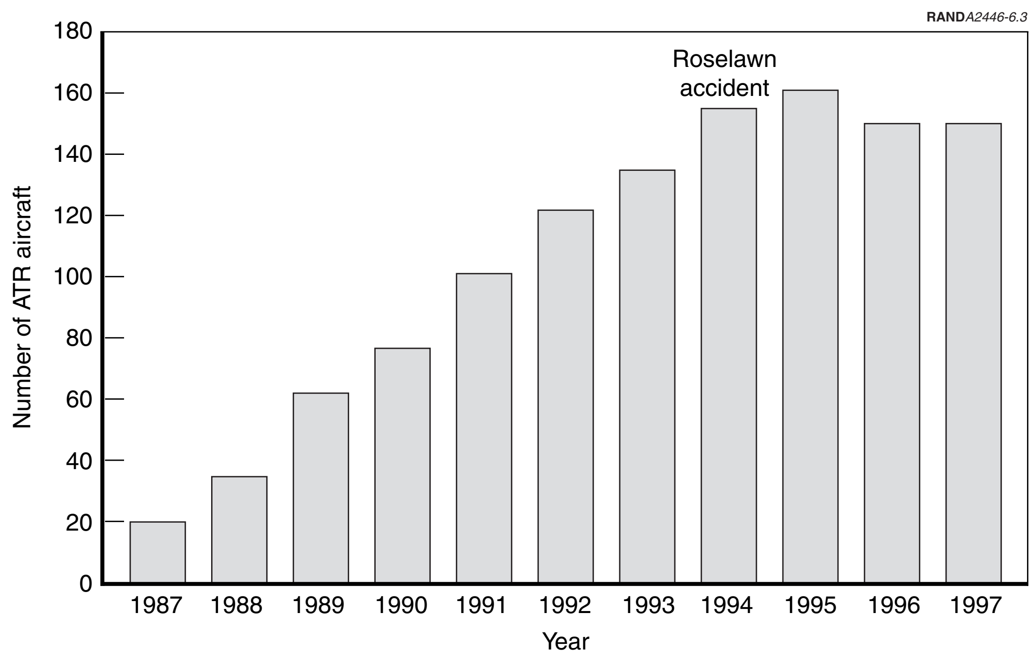
[11]Boeing acquired the McDonnell Douglas aircraft manufacturing operation in 1996. Lockheed withdrew from the commercial transport sector after the market failure of the L-1011 transport.

[12]Built by the McDonnell Douglas Corporation, the DC-10 suffered several major accidents and repeated safety incidents associated with its design. The 1974 crash of a Turkish Airline DC-10 in Paris and the 1979 loss of an American Airlines DC-10 in Chicago killed 346 and 258 passengers, respectively. The Paris crash was traced to a failure of the aft cargo door, a mode that had been preceded by a 1972 incident in which an American Airlines DC-10 suffered a cargo door failure without a loss of life. The Chicago crash was attributed to improper airline

manufacturer of large civil transport aircraft today builds very popular airliners, supplying planes for a significant portion of the domestic airline fleet purchases (interestingly, the DC-10 and its competitor the Lockheed L-1011 were originally called "Airbuses").

As mentioned in Chapter 3, an accident can have a powerful impact on sales, as demonstrated by the 1994 Roselawn, Indiana, crash that involved the European Aerospatiale Avions de Transport Regional (ATR) 72 aircraft. Following the accident, the historically strong sales of the aircraft declined as it became less popular with U.S. operators, as shown in Figure 6.3.

Clearly, major aircraft accidents can have a significant impact on the U.S. economy. Chapter 3 of this report argues that whereas accidents will likely be fewer in number in the future, they will increasingly bring into question design factors and the performance of individual



SOURCE: Aerospace Industries Association, *Aerospace Facts and Figures*, 1992, 1995, and 1997, Table of Active U.S. Air Carrier Fleet. Data include both the ATR-42 and -72 variants.

Figure 6.3--ATR Aircraft in the U.S. Air Carrier Fleet

---

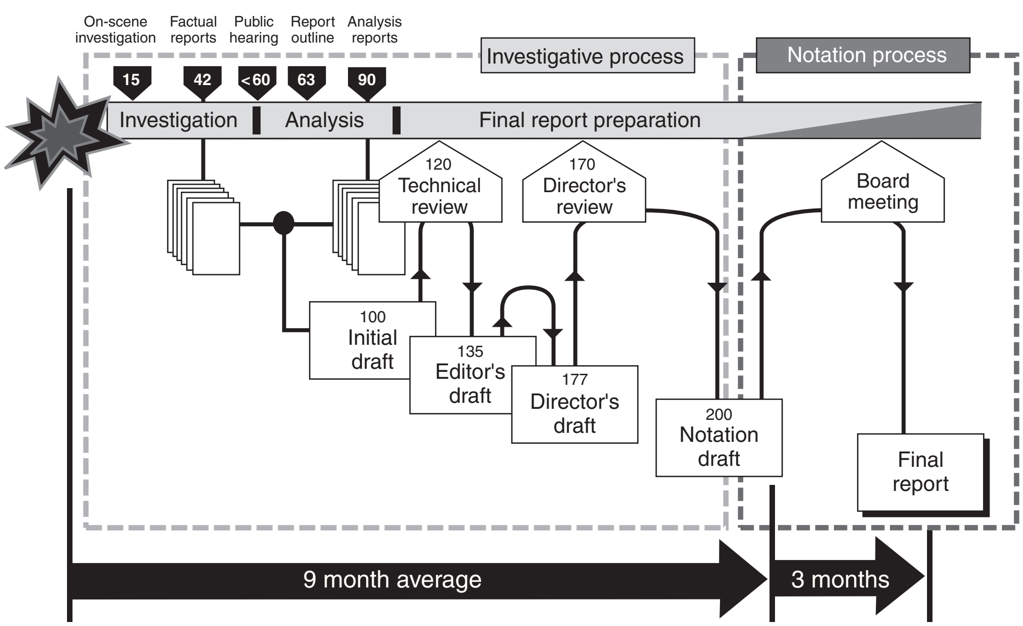
servicing of the engine mounts, but design deficiencies were also noted as contributory.

aircraft types. Therefore, the amount of attention paid to NTSB reports will likely grow. This added attention will come not only from manufacturers and litigators, but also from the traveling public, for whom safety is an increasingly important topic.

NTSB personnel often undervalue the importance of their role and the need for assured quality in their products. The current process of developing and reviewing final reports does not necessarily reflect the importance placed on them by the external community.

Figure 6.4 outlines the process used by the NTSB to produce an Final Accident Report.[13] The figure depicts a baseline in which the

RANDA2446-6.4



SOURCE: NTSB Board Order #2B (expired); NTSB Board Order #300; NTSB *Accident Investigation Manual*.

Figure 6.4--NTSB Investigation and Report Process

---

[13]The actual time line for production of Final Reports was specified in a now outdated process description document for report preparation, NTSB Board Order No. 70 (dated March 16, 1998). This was later replaced by Board Order No. 300 that contains much less specificity in the time line. The current NTSB *Accident Investigation Manual* references the outdated Board Order No. 70 and was therefore used to create Figure 6.4.

Final Report is to be completed within one year from the date of the accident. If it is clear at the outset that an investigation will continue beyond the baseline period, the IIC must obtain approval for an extended investigation.

Several elements in this timeline warrant attention. Most important, in the baseline investigation the time available for accident investigation and analysis is approximately one-third of the total period. The process of writing, editing, and gaining approval therefore takes twice as long as the investigation itself.

The process for bringing a Final Report to the NTSB Board creates a tense interface between the technical staff and Board members. Investigators and technical group leaders are responsible for delivering factual and analytical reports to the IIC who then drafts, or oversees the drafting of, the Final Report. The draft is prepared in accordance with guidelines established by the ICAO (National Transportation Safety Board, November 22, 1995; International Civil Aviation Organization, July 1994). An editorial review process refines this draft before it is distributed to the NTSB directors. The edited Final Report is logged in for formal review by the Board through a tracking procedure known as the Notation Process.

Theoretically, Board members gain official access to the draft Final Report only after the document enters notation and a hearing date has been selected for the sunshine meeting. In practice, this rarely occurs. Quite naturally, Board members want more than a few weeks to digest a highly technical report that contains complex arguments. Therefore, the process outlined in Figure 6.4 is often circumvented as NTSB Board members seek to obtain early drafts of the factual and analytical reports.[14]

Many members of the aviation community and representatives of victims' families suggested to RAND that party members exert disproportionate influence over the preparation and content of Final

[14]An internally conducted review by the Report Quality Committee of the NTSB noted that improved communication between the technical staff and the Board members was needed and recommended that direct interaction between the staff and the Board be planned prior to the sunshine meeting (National Transportation Safety Board, February 1998, p. 3).

Accident Reports. Some observers contend that parties directly manipulate the NTSB's technical staff. The RAND analysis found no indication that such direct intervention occurs.

Few outside observers appreciate the extent to which internal debate occurs among technical staff and the aggressive challenges to analysis and findings that occur within the NTSB as a whole during a major accident investigation. However, there are other ways for parties to exert influence. In a major investigation, the technical staff is consumed by the focus on the final review and obtaining NTSB Board approval. The technical staff is motivated by the fear that outside forces will exert influence on Board members and unravel the analysis, findings, and recommendations through aggressive questioning before the report reaches the sunshine meeting. From the perspective of the technical staff, the essentially "political" Board is an easy target for manipulation through suggestion.[15]

To understand why reports for a major investigation can take so long to complete, one has to appreciate the fact that the NTSB technical staff is committed to leaving no stone unturned prior to proceeding to notation. Whether or not the theories of cause are believed to be plausible, each theory must nevertheless be reviewed, and counter-arguments must be prepared, before the sunshine meeting. RAND did find evidence that when the stakes are high, external stakeholders sometimes endorse theories of cause that even they do not believe, with the knowledge that doing so will likely lengthen the Safety Board's investigation. The proliferation of accident theories also is potentially useful in later litigation procedures.

---

[15]At least three Board members are appointed based on "technical qualification, professional standing, and demonstrated knowledge in accident reconstruction, safety engineering, human factors, transportation safety, or transportation regulation" (49 CFR 1111[c]). In practice, however, Board members cannot be expected to demonstrate proficiency in the many areas of technology and operations discussed in a major accident report. They are not in a strong position to conduct a technical review and can be forced to either accept or reject the entire report based on high-level assessments that must be concluded very quickly.

Members of the aviation community have called for the NTSB to open its analytical phase to party participation. This would not serve the best interests of the NTSB’s independent investigation. Isolation from party review is essential during the analytical phase because it provides the NTSB time to formulate and test hypotheses that are not considered or supported by party members.

Isolation from the NTSB’s analytical phase does not, however, prevent party members from tracking the progress of an investigation. NTSB’s limited resources require frequent use of external resources, often owned by party members, to conduct engineering tests and evaluations. The Safety Board, in some cases, also retains experts and consults with other agencies. These activities demonstrate a clear pattern of NTSB activities to the careful observer. Information leaks from the NTSB provide additional clues on the direction of an investigation. It can be safely assumed that party members are fully aware of the direction of an investigation.

In summary, the process of completing a Final Report requires gathering together a technical staff suspicious of the Board’s motives and who will attempt to keep Board members in the dark as long as possible, the NTSB Board members themselves who must confront extraordinarily complex arguments without benefit of adequate preparation, and, indirectly, party members who are aware of findings and recommendations and are possibly motivated to introduce contrary theories. Out of this process, the NTSB must deliver a final product that reflects unbiased thinking, evenhandedness, and technical proficiency--and it must be *probably* right.

The report review process needs a major overhaul. The process should be refined to promote thoroughness by the technical staff while removing elements that lead to behavior that may impede the timely completion of reports. To achieve these objectives, RAND suggests that the NTSB consider the selective application of peer review in the report preparation and review process. While many within the Safety Board may perceive peer review as a diminishment of the NTSB’s independence, a properly crafted peer review process would accomplish the following goals:

- Provide an important incentive for the technical staff by setting a standard of high achievement.
- Assure investigators that work products will be judged on the basis of technical merit.
- Assure Board members that analyses and findings have withstood a rigorous and unbiased technical review.
- Strengthen the independence of the Safety Board and provide additional evidence to the public that its mission is being fulfilled with vigilance and thoroughness.

Peer review has been endorsed throughout the federal government as a mechanism for improving the quality and timeliness of products (U.S. General Accounting Office, June 1996; U.S. General Accounting Office, September 1996b).[16] It was noted that the NTSB was prompted by earlier suggestions to improve report quality and the Safety Board agreed to distribute completed reports to the EAA, AOPA, and FAA for their review (NTSB, March 29, 1994b, p. 26).[17] RAND was not able to establish whether such post-completion reviews resulted in substantive contributions to NTSB product quality; in any event, no modifications to the production process were discernible.

In addition to considering the addition of peer review, the Safety Board should develop a means for providing greater insulation from outside influence. In many respects, the evaluation of an accident report mirrors the federal procurement process and the activities of contract Source Evaluation Boards. The NTSB should evaluate the similarities between these processes and the possibility of moratoriums on access to Board members during the period when an Accident Report is reaching notation. A refined report generation and review process employing such tactics will simplify and improve the timeliness of Accident Reports.

---

[16]Kostoff, 1997, provides a thorough review of the application of peer review to federal programs.

[17]In particular, Recommendation 44 of Volume II of the 1994 NTSB proceedings document deals with this issue.

Tension over NTSB Findings and Recommendations Will Likely Increase

Theory and practice are easily confused in the entanglements of accident investigation. The NTSB, as well as the various entities that preceded it, were founded on an ideal of truth-finding and truth-telling.

In theory, the NTSB enjoys statutory insulation from matters related to the economic performance of aviation stakeholders. Its deliberations are mostly private and its findings highly public.

In practice, the NTSB operates in a quite different world. Safety Board investigations can have a major impact on aviation economics worldwide. The NTSB's influence extends into the foreign policy arena, such as in cases involving aircraft from foreign manufacturers or in matters affecting overseas operations. In practice, the NTSB operates in a world of technical imperfection, with limited human resources and limited technical facilities.

Perhaps the most readily apparent concession to practicality is the goal of establishing "probable cause." When initially established by the Air Commerce Act of 1926, aviation accident investigations were thought unlikely to yield definitive results; as a result, an investigation was meant to identify only the "probable" cause (Miller, Winter 1981).[18] The Safety Board's recommendations should exhibit a similar concession to practicality. While the NTSB must not be swayed from energetic fact-finding and analysis, it must exercise caution to prevent overextension of its recommendations.

A never-ending tug-of-war, albeit a productive one, exists among managers and staff within the Safety Board regarding their view of recommendations. One end is supported by a *functional viewpoint* that understands the volatile nature of the aviation economy and favors caution in exercising NTSB authority.[19] The other end is supported by a

---

[18]Miller provides an excellent review of the early history of aviation accident investigation.

[19]Exercising prudence in recommendations has been very important to Safety Board managers and the organization to ensure that "each proposed recommendation is carefully evaluated to make sure that it is practical, feasible, and capable of being implemented." (Sweedler, March 29, 1994, p. 78).

visionary viewpoint that favors setting high standards, and pushing the aviation community to attain higher levels of safety.[20] Both perspectives share a focus on safety and an appreciation of the potential impact of Safety Board recommendations, and each viewpoint is tempered by a desire to ensure NTSB credibility and thereby maintain its independence. No viewpoint has ever been victorious, but as leadership of the NTSB Board has changed, the balance has shifted, at times dangerously, toward one end or the other.

Under close public scrutiny, the NTSB's recommendations must be made in full recognition of two myths--the myth of risk avoidance and the myth of uniformity of system safety:

- **The Myth of *Risk Avoidance*.** Through constant reassurance, air travelers have come to believe that aircraft manufacturers and airline operators avoid risk at all costs. In fact, risk is a managed resource and is calculated and traded throughout the aviation system. An aviation company balances two separate but interrelated goals--its economic performance and the safety of its products (Flight Safety Foundation, January/February 1994, p. 1). Certainly all stakeholders in the aviation industry have demonstrated a dedication to safety that has contributed to a remarkable reduction in accidents and incidents. Aircraft are not, however, designed with risk *avoidance* in mind; risk must be traded against the practical measures of economic operation. Only in extraordinary conditions can an engineering enterprise afford to avoid risk at any cost. Examples of such situations do exist, including the human space-flight program, the development of nuclear power plants, and the manufacture of hazardous biomedical materials. In the realm of aviation,

[20]Many NTSB recommendations have "raised the bar" on transportation safety. For example, in 1969 the Safety Board recommended that the legal age to purchase alcoholic beverages be raised to 21 years. This recommendation, issued at the state level, initiated a national debate on teenage drinking and driving and the subsequent passage of stricter laws. Another example of NTSB leadership was a 1972 recommendation calling for the installation of GPWS in large transport aircraft. This call, for what was at the time a technology only nearing maturity, accelerated development efforts.

however, risk is minimized within the boundaries of affordable acquisition and operating costs. An airplane is an imperfect device characterized by design considerations that must balance cost, performance, and risk.

- **The Myth of *System Uniformity*.** A second myth is that of safety consistency within the aviation industry. Manufacturers, airlines, and support organizations do not operate with equal levels of safety. Yet, variations across the industry must be tolerated by federal regulators, industry representatives, and insurance underwriters--indeed all members of the aviation community.[21] This tolerance promotes the appearance of uniform safety across the industry in order to achieve the vital high level of confidence among the traveling public (Wald, March 16, 1997; Hedges, Newman, and Cary, June 16, 1998; Barnett et al., May 1998).

An airspace system in which risk is not avoided but instead is managed, and safety is nonuniform, is the reality into which NTSB recommendations are cast.

NTSB recommendations cross a broad spectrum, from simple advisories to better inform operators to complex directives that can alter the design of operating fleets. Priorities can also range from long-term fixes (Class 3--approximately 5 percent), to moderate priority modifications (Class 2--approximately 86 percent), to high priority changes that require urgent action (Class 1--approximately 9 percent).

Tensions surrounding NTSB recommendations increase the more they suggest fleetwide design implications and the greater their urgency. System complexity will continue to increase rapidly and accident investigators will likely delve into issues related to the design of aircraft systems more and more. For this reason, the NTSB should

---

[21]Some within the aviation community thought that the FAA would take a tougher stand if the agency's long-standing "dual mandate" to simultaneously regulate and promote the industry was removed. The mandate was in fact removed in 1996, yet the FAA has not assumed a more aggressive regulatory posture. Even as a regulatory body, the FAA remains constrained by the reality that it must oversee an industrial sector that is critical to the health of the national economy and is at the same time battling within a fiercely competitive global arena.

anticipate heightened tension surrounding its recommendations and act to ensure that the process of formulating and reviewing them is bolstered to maintain a balanced perspective.

Dealing with issues that can potentially influence the design selections made by aircraft and system manufacturers, as well as issues related to the original certification of new aircraft types, has always been a challenge for Safety Board investigators, and this situation is likely to intensify. In cases in which the investigation points to problems associated with the design of the aircraft, the NTSB will inevitably encounter trade-offs made by engineers when they designed the aircraft.

In such cases, the NTSB must resist the temptation to issue recommendations containing design solutions, which it has neither the tools nor the expertise to develop. Positing design solutions is especially dangerous for the NTSB, as it implies that investigators have conducted some amount of cost/benefit analysis that they are legally precluded from conducting. The NTSB can and should issue recommendations that establish the *level of performance* expected of a system to ensure safety. Borrowing language from performance-based contracting models could be particularly useful in this regard.

Augmenting the party process with a broader set of strategic alliances, as discussed earlier in this chapter, would also help ensure an outcome of balanced and reasonable recommendations. Although the party process will continue to be crucial to successful NTSB investigations, it may prove insufficient in complex, high-stakes investigations. In these cases, it is quite possible that the original equipment manufacturer may not understand a failure mode and therefore may not be capable of resolving technical issues.

The NTSB must also ensure that a strong linkage exists between recommendations and probable cause findings. The nature of probable cause statements varies widely in NTSB Final Accident Reports. When the NTSB wishes to focus attention on a particular safety issue, a single statement of cause is often used. This prevents any straying from the focus of the investigation and what is perceived to be the central safety threat. Approaches to formulating probable cause findings have varied under the changing Safety Board leadership. In practice, however, events rarely have a single cause. This is especially true of very complex accidents. In some cases, the aviation industry has been slow to accept safety recommendations because the recommendations were not associated with a cause listed in a Final Accident Report (Hagy, March 29–31, 1994, p. 166).

The NTSB is guided by a doctrine of reasonableness that has well-served the interests of the American public. With attention to reinforcing the process in the face of increasing tensions, the NTSB should be able to maintain balance by issuing recommendations that lead to steady and stable improvements in aviation safety.

Future Accidents May Challenge NTSB Investigative Methods

The NTSB's core function centers around the activities of its investigative staff. Before discussing ways to improve the structure of these investigations, it is important to first distinguish between investigations occurring in the field (regional offices), which focus on GA accidents, and those staffed from the Safety Board's headquarters offices.

As detailed in Chapter 2 of this document, both types of investigations are built on the structure of appointing a lead investigator.[22] In the field, the Air Safety Investigator (ASI) dispatched from a regional office usually works alone and investigations do not receive extensive support from the OAS in Washington. Field investigations are also usually much smaller in scope, making only occasional use of the Safety Board's headquarters-based laboratories facilities.

The field ASI is arguably more independent and "in charge" than a comparable IIC dispatched from Washington, D.C., to a major investigation. Parties have long complained to the NTSB about inconsistencies in the process of investigations, particularly in the regional offices where classification of accidents and the methods used

[22]The authority of the lead investigator is specified in 49 CFR 831.8, which gives the investigator broad lateral authority during the course of the investigation.

to investigate them vary widely (McCarthy et al., March 29, 1994). Although a standard process has been defined by the Safety Board, in practice its application varies according to the size and complexity of an accident, and even a particular investigator's style.

While field investigations are important, RAND's analysis focused on major accident investigations being controlled from NTSB headquarters. The meaning of the term "IIC" is elevated when an accident involves an airliner in which many lives are lost. The NTSB naturally reserves its most senior investigators for such events. The NTSB has invested heavily in the maturation of a small cadre of highly trained, versatile, and talented individuals who form what is essentially a "front guard." These individuals form the Major Accidents Division within OAS. Currently, there are seven senior accident investigators in the Major Accidents Division.

The traditional NTSB investigative model, called here the Discipline Team Model, is shown in the left-hand diagram in Figure 6.5. In this model, a rotation process places available IICs (as well as an NTSB Board member) on call in the event of a major accident. When an

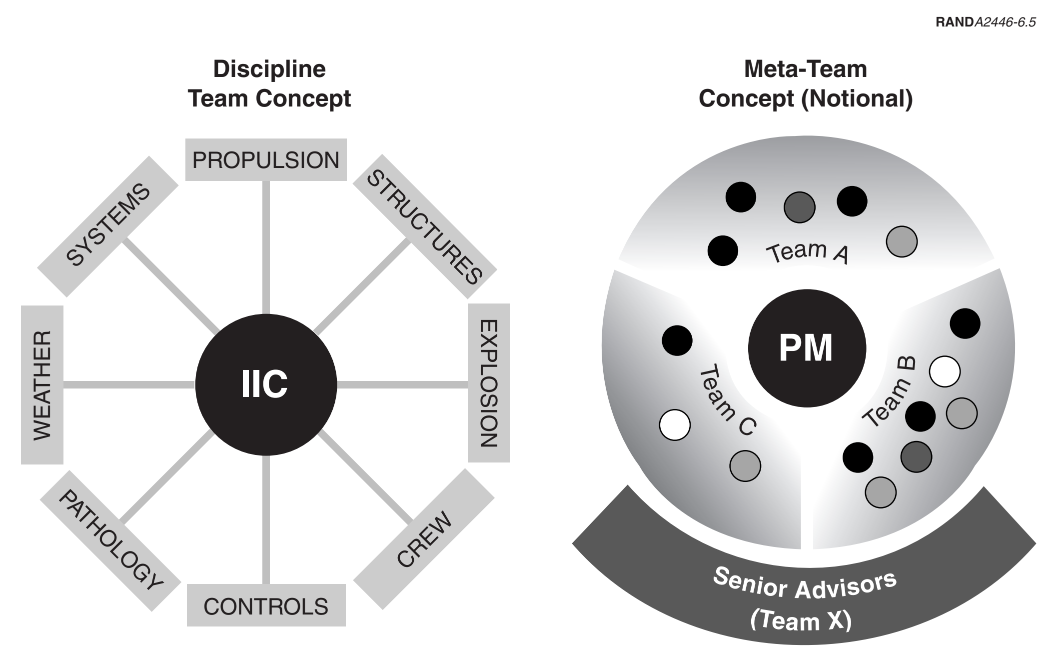


Figure 6.5--Discipline Team Model vs. Notional Meta-Team

accident occurs, the NTSB's dispatch time is rapid. *Go-teams* are formed and are on scene usually within 12 hours. The pressures on an IIC during a major accident investigation are enormous. A senior IIC must quickly manage an array of go-teams operating in parallel and reporting daily, respond to media inquiries, manage the accident scene itself while ensuring that all critical information that will later be needed is captured, and coordinate party member actions and inputs. Most important, the IIC is looked upon to establish the tone of the investigation. Decisions made at the accident site can determine the direction of the investigation, and changing direction later can be accomplished only with great effort.

The implementation of the Discipline Team Model is especially important. Go-teams are led by NTSB investigators and are composed of both Safety Board personnel and party representatives. These teams are charged with examining the accident from the *perspective of their technical expertise*. The IIC controls the interaction of these teams and the integration of team inputs. There is usually little interaction between the teams, formal interchanges being limited to daily debriefings led by the IIC during which team leaders summarize progress.

Viewed from the outside, the IIC appears to be the control point, even for a major investigation. In practice, however, responsibility for the progress of a major investigation can shift quickly from the IIC and the Major Investigation Division to a higher level of management in the OAS. Several factors determine how fast and to what extent IIC responsibilities roll off following the conclusion of the on-scene portion of an investigation:

- **Anticipated Magnitude of Investigation.** It is usually possible to quickly assess the level of analysis required for an investigation and to estimate whether a single individual is likely to succeed in adequately controlling it.
- **IIC Capacity and Experience.** A complex accident investigation requires extensive coordination and mastery of diverse subjects. If it is estimated that the investigation will require an exceptional breadth of skills, OAS managers will often feel the need to augment the IIC.

- **Staff Workload.** OAS managers are usually facing staff overload problems, and IICs from the Major Accident Division are particularly vulnerable because of their senior status and limited numbers. Although it is difficult to prevent work overload, OAS managers attempt to prevent burnout among senior IICs and try to build a reserve for possible emergency responses.

Although the IIC continues to play an important role in a major accident investigation, the position can be operationally secondary to an informal structure of sub-elements orchestrated at the OAS directorate level. At the sunshine meeting it is often not apparent who led the investigation and little mention is made of the IIC at all.

The process of shifting investigative authority has several drawbacks. Foremost, an attempt to control several major investigations simultaneously places enormous management burdens on the OAS directorate office. It is also difficult to assess who is really in charge of a major investigation without concluding that management authority is ultimately held solely by the OAS director. A good deal of tension exists between the Major Investigations Division and the directorate office, which stems from feelings that on a major investigation the title “IIC” is figurative. In addition, the stochastic nature of aircraft accidents causes the OAS directorate to alternate between calm and crisis. The worst case scenario--several major investigations simultaneously in process--can bring about a protracted period of crisis management that seriously erodes staff interrelationships and productivity.

It is likely that the NTSB will continue to face a retinue of accidents similar in type to those that investigators have faced in the past. However, the Safety Board should anticipate accidents of unprecedented complexity and system-level interrelationships. The investigation of the crash of USAir 427 is a good example of this class of event. In short, the NTSB must organize, train, and equip its staff, and also seek external relationships that support higher-order investigations. These investigations will have attributes not unlike applied research projects. Solving complex accidents, such as accidents representing aircraft conceived and built in a structured team environment, will require that the Safety Board consider stepping beyond the Discipline Team Model.

Alternative investigative models should seek to clarify and strengthen the practice of managing the investigation, ensure that diverse expertise can be brought to the Safety Board when needed for as long as it is needed, and encourage an awareness of systems complexity and associated team cooperation. This last point is especially important. A central weakness of the Safety Board's traditional investigative method is that it does not encourage multidisciplinary analysis, testing, or evaluation. The resolution of complex failures might well be better accomplished through multidisciplinary teams, an integrative and cooperative problem-solving model applied in the design of modern aircraft (Sarsfield, 1998).[23]

Figure 6.5 presents a notional model for accomplishing these objectives. The Meta-Team Model, shown in the figure, is constructed to encourage team interactions in conjunction with centralized *project management*. Such a model does not preclude the need to dispatch go-teams to the accident site to accomplish recovery, interviewing, and fact-finding. It does, however, seek to quickly assemble the go-teams into analytical groups organized to pursue resolution of failure scenarios as expeditiously as possible.

Little research has been conducted on teams operating in engineering environments or on scientific problems. The majority of research on team dynamics has been conducted in relation to business planning and management, oftentimes consisting of artificial constructs and using model participants (in many cases students). Studies to date have shown, however, that technical teams have to be carefully constructed in order to be successful.

Foremost in a technical environment is the desire for creative tensions within the team, tensions that draw out the inquisitive, probing natures of scientists and engineers (Pelz et al., 1966, p. 7). The fuzzy border shown for the meta-teams in Figure 6.5 is meant to

---

[23]This refers to the practice of utilizing Integrated Product Teams in aerospace design.

relay a built-in "looseness" that is important to its success. Looseness here means *autonomy,* a sense of allowing a team to alter or refine tactics and methods to independently achieve its objectives (Nowaczyk, February 1998, p. 8). Team autonomy does not remove the need for clear technical and programmatic objectives set by NTSB senior managers.

Teams operating under high-stress conditions do, however, excel when technical autonomy is combined with a strong project leader (LaBarre, June 1996, p. 77). Operations aboard an aircraft carrier provide a good example of the advantage of flexible team structures. Despite hierarchical organizational structures, considerable flexibility is provided to personnel operating on the ship's deck to form the best solution to accomplish safety and performance goals (Pool, June 1998).

Another feature of the meta-teams concept is the fluidity in the makeup of the team. Team leaders should be able to identify skilled experts and, through pre-negotiated mechanisms, access them for a period of time needed to meet team objectives. The various shaded areas shown within the elements of each meta-team in Figure 6.5 reflect this diversity; it is unlikely that any team would be composed solely of NTSB personnel. Meta-teams reflect a need for rapid access to knowledge and strong communications skills and capabilities. Currently, the NTSB's ability to quickly identify potential team participants is not sufficiently robust to support the notion of meta-teams.

A recent development that might advance the ability of the NTSB to accomplish the kind of operations envisioned by the meta-team is *virtual team* building. A virtual team environment is one in which documents, specifications, drawings, memos, briefings, analytical data, and models can be shared by professionals who are geographically dispersed.

Teleconferencing and e-mail are already used extensively to coordinate accident investigations. Communication via telephone alone is insufficient to convey complex technical data during an aircraft accident investigation (Baum and Huhn, 1997, p. 10). Virtual teams offer a distinct advantage given their increased speed and agility, their ability to leverage expertise and integrate geographically dispersed organizations, reduce travel costs, and minimize lost time. Such concepts are gaining popularity in many sectors of the aerospace industry. NASA, for example, operates a virtual team environment called the Virtual Research Center (VRC) that allows "badged" personnel direct access to online project management systems.[24] Virtual teams are not a quick and easy solution to the challenges associated with an accident investigation. Leading a virtual team requires unique skills and technology must be carefully selected to match specific applications (Duarte et al., 1999).[25]

The notion of a meta-team is built upon strong project management skills. Although training in project management practices has not been applied extensively within the NTSB, the training data in Chapter 5 show that these skills are being taught to investigative personnel. The central limitation in employing project management practices at the NTSB is the lack of cost accounting practices that permit sufficient visibility into how resources are being expended. Such capabilities are required for true project management to work effectively.

The responsibilities of a meta-team would be manifold. The most important function would be to quickly formulate and implement a work plan for the investigation. The PM would have to integrate the factual data from field work, party recommendations, and incident reports and, with the support of senior NTSB advisors, form a set of accident failure scenarios. These scenarios provide the basis for meta-team formation. These meta-teams should be structured to:

- provide sufficient size to examine all aspects of a failure scenario
- comprise NTSB staff, government and academic experts, and consultants
- interact with party members on an as-needed basis (party discussions should flow through the PM to ensure that team requests for information, analysis, and testing are coordinated)
- solicit nondisclosure oaths from external participants pledging that they will not discuss ongoing results

[24]The NASA VRC is available online at moonbase.msfc.nasa.gov.

[25]Duarte provides an excellent treatise on the design and implementation of virtual teams.

- produce a team report, delivered to the PM, outlining the failure scenario the team formed, the test plan used, the analytical methods used to resolve the scenario, test results and error potentials, and team conclusions.

Meta-teams would be led by NTSB investigators responsible for performing an initial assessment of the scope of work. Each team leader would create a staff and financial plan for the investigation. The PM would then integrate meta-team resource requirements, estimate requirements for reserves, and submit requests to the NTSB’s chief financial officer (CFO). Immediate funding should flow from the NTSB’s emergency fund and would depend on having sufficient reserves to quickly procure the necessary staff and facilities. Finally, the PM would control the level of investigation to ensure that failure scenarios are pursued to sufficient detail to meet Safety Board requirements of probable cause and to prevent analysis beyond the point of efficacy in this regard.

The use of senior advisors, shown in Figure 6.5, is another important element of the notion of employing meta-teams. In the figure, the term “Team X” is borrowed from a model in use at NASA’s Jet Propulsion Laboratory (Smith, January 1997). The central concept here is to employ an agency’s most senior staff across a body of parallel initiatives without committing them wholly to any specific activity.

The IICs of the Major Accidents Division are some of the Safety Board’s most seasoned and best trained experts and would be an ideal source of Team X expertise. Employed in an advisory capacity, current IICs would not be “lost” to a major investigation. Instead they would be available to support all ongoing investigations and to consult to outside organizations to support the goal of improving international air safety and air accident investigations. They would also be available to coach younger employees, helping to groom a new generation of safety investigators.

The notion of meta-teams is one of many possible approaches to streamlining the NTSB’s investigative processes to help it contend with increasing accident complexity and the anticipated continuous growth in workload. Although the Discipline Team Model has served the Safety Board well, there are signs that it is growing difficult to control, requiring heroic efforts on the part of investigators and managers to accomplish the desired outcomes. Sustaining such a stepped-up pace is not a tenable long-term approach for meeting the requirements of modern air accident investigations.

Inadequate Testing Facilities Undermine NTSB Independence

The NTSB conducts investigations and trains personnel using facilities, tools, and equipment that can only be characterized as modest. Figure 6.6 depicts the four principal laboratories that serve the generic requirements of multimodal accident investigations and the types of tools they employ. These facilities, although sufficient up until this point, are unlikely to adequately support future requirements.

As noted in Table 6.4, the NTSB maintains limited relationships with other federal agencies. Fire and combustion studies for several major accidents have also been conducted in cooperation with the FAA

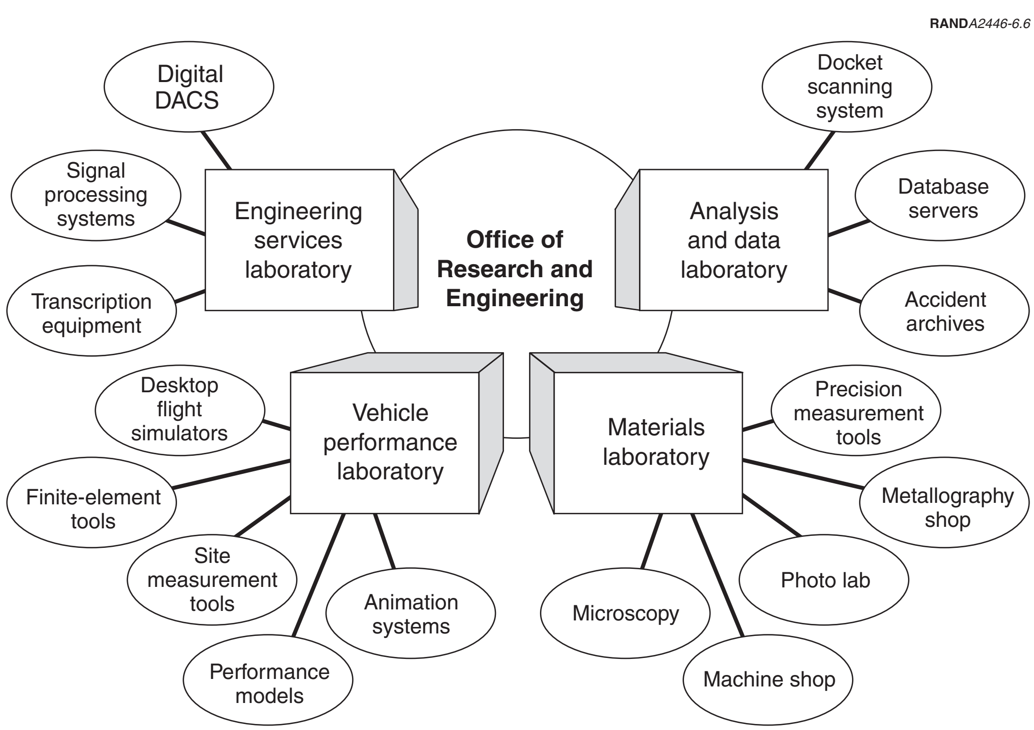


Figure 6.6--NTSB's Four Principal Laboratories

Technical Center's Fire Research Branch. Forensic toxicological analysis related to aircraft accidents is provided, for example, by the FAA's Civil Aeromedical Institute (CAMI) at no cost. Most of this support from other government agencies is provided at no cost to the NTSB. The Safety Board also maintains a limited set of contracts with private laboratories for fire and explosion testing, as well as X-ray and advanced spectrographic analysis.

The floor space for the four NTSB laboratories shown in Figure 6.6 totals approximately 4,000 square feet, no larger than the size of a large private house. In addition to aircraft accident investigations, these facilities support the investigation of rail, marine, highway, pipeline, and hazardous material accidents.[26] The NTSB office and laboratories are used only to a small degree for training. In-house training is limited to a two-week indoctrination course for new employees. These courses are taught in rental facilities by senior NTSB investigators. For more advanced training, the NTSB relies almost exclusively on outside institutions.

Aerospace professionals can obtain accident investigation training from several sources. The Air Force Safety Center's (AFSC's) Crash Laboratory at Kirkland AFB, New Mexico, operates a 29-acre facility devoted to training accident investigators. The facility includes exhibits of destroyed aircraft duplicating the original accident scene, and its laboratories contain failed components and systems.

The Crash Laboratory complements a network of AFSC classroom and conference facilities for initial and ongoing training of investigators. A smaller academic facility is located at the Embry-Riddle Aeronautical University's Center for Aerospace Safety Education in Prescott, Arizona. This eight-acre facility includes the Robertson Aviation Accident Investigation Laboratory, a hands-on facility for investigator training containing several reconstructed crash scenes. The University of Southern California operates the Aviation Safety Program, which offers

[26]As part of the ongoing investigation of the TWA Flight 800 crash, the NTSB leases an additional 80,000 square-foot facility from the city government of Riverhead, New York. This facility houses the reconstructed B-747 aircraft as well as providing temporary storage of victims' personal effects.

classroom programs in aviation accident investigation. The Boeing Corporation maintains extensive in-house training capabilities and also utilizes military and academic training facilities.

For actual conduct of accident investigations, government agencies such as NASA, the FAA, and the Air Force, in addition to large private companies, maintain facilities that vastly exceed the capabilities of the NTSB. These organizations benefit from engineering complexes designed for research and development that can be used to support accident investigations.

It can be argued that the NTSB can continue to utilize the facilities of others when needed, either on a cost-reimburseable basis or through no-cost alliances and agreements. However, there are several reasons why the NTSB should rethink the long-term adequacy of its current physical resources:

- **Reconstruction.** Increasingly, investigators must reconstruct major parts of crashed aircraft to obtain sufficient information about failure mechanisms. If enough wreckage is available, reconstruction can greatly assist the task of understanding complex failure modes. Reconstruction is even more important for accidents involving aircraft that contain FDRs with limited parameters. Reconstructing even parts of a commercial aircraft requires a good deal of floor space and usually high-bay facilities.
- **Simulation.** The NTSB has built an excellent simulation capability based on workstation software models. The importance of these simulations was demonstrated during the course of the USAir Flight 427 accident investigation. This accident involved the near total destruction of the aircraft, a limited parameter FDR, and the interaction of complex aircraft systems. Simulation was an essential ingredient to understanding the accident and supporting the investigative findings. The importance of simulation will certainly grow as a result of this investigation, and future requirements for fidelity and accuracy will likely outstrip the capabilities of workstation-based solutions. Full-scale programmable flight simulators

provide the necessary fidelity. These cabin simulators model actual flight-deck systems allowing more accurate flight reconstruction and an improved ability to understand human-machine interactions. Software changes allow them to mimic the performance of a variety of aircraft. With an adequate library of aircraft models, at least for every transport category aircraft, the NTSB could rapidly model flight profiles with greater accuracy. Cabin simulators are widely available in government and industry. NTSB investigators would probably make heavy use of such a capability, rendering it a cost-effective tool to have in house.

- **Generic Test Tools.** Another important factor is the flexibility offered by in-house (or readily accessible) test tools. No-cost or leased facilities often have to be scheduled well in advance and priorities rarely favor the outside user. NTSB's requirements are driven by critical air safety concerns. An excessive dependence on outside resources threatens the ability of the Safety Board to respond quickly.[27] The NTSB's independent status can also suffer. Many of the facilities used during an investigation are, of necessity, owned by party members. Devices such as flight controls test rigs (iron birds), protoflight and prototype equipment, and system integration labs are impossible to obtain from a source other than the manufacturer. The independence of the Safety Board is strengthened, however, when sufficient resources are quickly available to support testing at critical junctures. A carefully selected set of generic test tools, such as hydraulic test stands, electrical power systems, and avionics testbeds, could support rapid response experimentation.

Expanded technical facilities would also provide new opportunities for in-house technical training. Facilities, like the ones described

---

[27]The size of the current Emergency Fund does not support a strategy of securing rapid access to facilities. Currently a $2 million reserve, this fund has typically been quickly oversubscribed when a major accident occurs.

earlier, serve a dual role--they greatly expand the tools available to investigators and they provide the equipment necessary to train. A flight simulator, for example, is a powerful tool for the parametric study of factors that could have caused an accident. However, simulators are primarily designed to train flight crews.

For reasons detailed in Chapter 3, future accidents will require the NTSB to conduct more research to discover causal factors. This has implications for the Safety Board's organizational culture, and it also determines the kinds of tools the NTSB will need to successfully accomplish its mission. It has been reported that the Safety Board is contemplating some form of facility upgrade (McKenna, February 8, 1999, p. 75). It is not clear, however, that the NTSB has conducted, or intends to conduct, a comprehensive review of its facility requirements in support of such an initiative. The NTSB's Office of Research and Engineering (ORE) does monitor near-term requirements, attempting to ensure that testing and evaluation is accomplished cost-effectively.

The Safety Board has not attempted to analyze the possible impact of emergent investigative trends, or to undertake a long-range plan for facilities planning. RAND did not detect any attempt to merge training and investigation requirements into a cost-effective facilities solution. The requirements for training and for investigative services are handled separately, bypassing consideration of any options that could present lower cost solutions.

Industry professionals interviewed by RAND were unanimous in their agreement that the Safety Board currently operates with insufficient resources. A modest expansion of facility capabilities seems a wise investment in strengthening the capabilities of the NTSB. The NTSB should, however, thoroughly investigate all means of acquiring needed capabilities and ensure that facility plans are comprehensive, responsive, and cost-effective.

LACK OF COST ACCOUNTING DATA INHIBITS MANAGEMENT OF INVESTIGATIVE RESOURCES

It became clear during the course of this study that resource limitations impact many, if not most, Safety Board operations and processes. It was equally apparent, however, that lack of adequate accounting information precludes effective management of the human resources that the NTSB does have at its disposal.

Managers within the Safety Board have little information with which to make planning decisions regarding the utilization of staff resources and properly manage staff workloads. Without such information, *internal* cost/benefit trade-offs cannot be made and the allocation of resources to ongoing accident investigations can quickly become unbalanced.

Figure 6.7 shows the current tracking of salary and nonsalary expenditures within the NTSB. With the existing accounting practices, working-level managers lack sufficient feedback. Time and attendance reporting at the NTSB is completed via electronic spreadsheets. No attempt is made to track employee time against individual accident numbers, although such numbers are assigned for other tracking purposes immediately upon notice of an accident or incident event. The NTSB relies on the processing of salary information through the DOT's Integrated Personnel Payroll System (IPPS). Nonsalary accounting is handled through a financial accounting system (FinAst) managed in-house by the CFO's office.

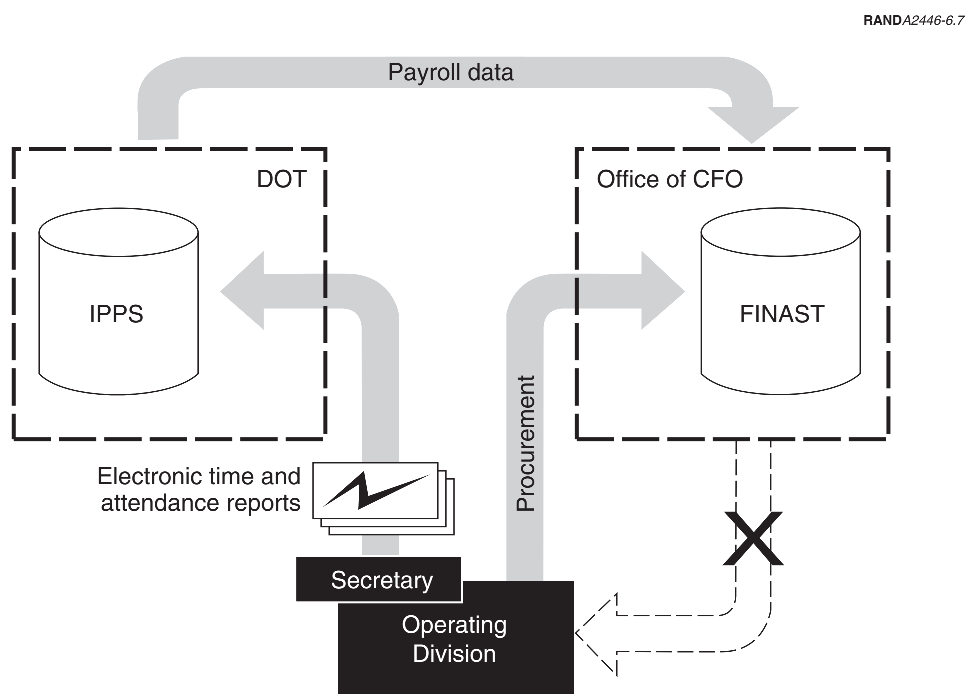


Figure 6.7--NTSB's Open-Loop Accounting System

The IPPS and FinAst databases allow the NTSB to report to congressional oversight offices. As such, these databases have much greater fidelity and are more carefully controlled than the Safety Board's accident and recommendations databases, which are archival in nature. Although the financial systems are tightly controlled, and spending on *purchases* for individual accident/incident investigations is tracked, at present no method exists to merge pay and nonpay expenditures into a single spending profile.

Repeatedly, recommendations have focused on the NTSB's lack of a full cost accounting system. As early as 1980, a General Accounting Office (GAO) analysis of Safety Board planning and management criticized NTSB internal budget practices that prevented the tracking of activities or programs (U.S. General Accounting Office, May 28, 1980, p. 6). The report targeted internal practices in the area of program control, concluding that, "the [Safety] Board has no formal plan for systematically reviewing its programs." At the same time, a Heritage Foundation report also noted the dearth of program analysis at the Safety Board, and noted that its lack of adequate accounting practices inhibited its internal planning abilities (The Heritage Foundation, October 31, 1980, p. 4). Although the Safety Board has experimented with a more complete accounting system, one that combined pay and nonpay costs associated with a given accident investigation, it has not yet made a long-term commitment to such a system.

Accident investigations are akin to projects of varying size and dimension. NTSB managers need the tools with which to manage individual investigations as if they were projects. The old adage "you can't manage what you can't see" can be aptly applied to current Safety Board practices. The NTSB continues to evaluate internally managed time and attendance reporting and the use of project-style practices. Establishing a practice of full cost accounting will require a significant investment of resources by a team from across the NTSB, including the ORE, OAS, the CFO, and the other modal offices of the Safety Board.

Finding the necessary resources among an overloaded staff will be very challenging. Without the necessary financial and human investment, however, it is unlikely that any new system would provide sufficient fidelity and utility to contribute to improved performance. The development of improved resource management tools, especially in regard to monitoring employee workload, should receive the highest priority.