CHAPTER 5
STAFFING, WORKLOAD, AND TRAINING AT THE NTSB

The NTSB is a small agency with a big mission. The projected growth in air traffic and increasing diversity in aviation assure the NTSB a continuing important role in aircraft accident investigation. And, while safety initiatives may reduce the quantity of accidents, paradoxically they leave a residual set of accidents that are harder to diagnose, further increasing the technical challenges that NTSB investigators will face.

Because the NTSB’s responsibilities extend across all transportation modes, and given the diversity of equipment within each of these modes and the spectrum of possible causes that must be explored for every accident, the Safety Board staff must possess a wide range of expertise. At the same time, to maintain the integrity of the accident investigation process, investigators must have the technical expertise required to elicit necessary facts from technical representatives of the parties to an accident.

Given that the NTSB’s staff is limited in number, the quality of its investigators for each specialty area must be exceptionally high. Although the NTSB’s aircraft accident investigation staff covers a broad range of specialty areas, each specialty area typically is staffed with comparatively few people, leaving the NTSB vulnerable to staffing shortfalls when key people leave the agency or when accidents occur in clusters. Especially demanding workloads, salary levels that lag behind those for other mid-career industry professionals, and an experienced staff that tends to be older than the average industry employee and therefore closer to retirement age all contribute to the staffing challenges facing the NTSB.

In the course of their work, NTSB investigators must deal with party representatives from airlines or aerospace firms who use and expand their professional skills on a daily basis. On-the-job experience at the NTSB, although useful for sharpening accident investigation skills is, however, not the best means to systematically acquire new technical skills or refresh old ones. Without periodic training, technical skills can atrophy, putting investigators at a disadvantage in the party system.

Currently, aviation investigators at the NTSB receive far less ongoing training than other members of the aviation community. Ensuring the continued integrity of the accident investigation process requires that NTSB management address these issues.

Staffing, workload, and training policies and processes that impact the size, composition, and skills of the NTSB workforce are becoming increasingly important. In focusing principally on the aviation accident investigation workforce, this chapter characterizes the current staffing posture at the NTSB, discusses factors that could influence that posture, estimates the nature and extent of the current workload, and examines the state of training at the NTSB today.

STAFFING

The NTSB's principal resource is its staff. Attracting and maintaining qualified staff people is critical to the agency's operation. To successfully fulfill the NTSB's mission and remain a standard-bearer for aircraft accident investigation, the Safety Board staff must possess exceptional skills and expertise, combining leadership in relevant technical areas with superior investigative talents and management abilities.

To assess the staffing situation at NTSB, RAND first characterized the workforce by examining its size, depth in key specialty areas, experience levels, and age distribution. We also examined the NTSB's recent experience with attrition and compared its salaries with those of the aerospace industry as a whole. To characterize the NTSB staff, we used internal NTSB records and a questionnaire designed by RAND and administered to the NTSB technical staff during the summer of 1998.[1]

[1]The questionnaire was sent to *every* professional employee at the NTSB involved in accident investigation activities, including regional and headquarters technical staff who investigate aircraft and surface transportation accidents, those who track safety recommendation compliance, and personnel who provide research and engineering support to accident investigations. Appendix D describes the administration of

The NTSB’s staff, while small, has the breadth of skills needed to cover all transportation modes and diverse equipment types, but it has only limited depth in individual specialty areas. This limited depth leaves the agency vulnerable when an employee possessing critical and unique skills leaves the agency or when accidents occur in clusters, creating multiple simultaneous demands for critical expertise. RAND did not observe any significant actions by the NTSB to compensate for this limited depth, such as strategic alliances with other organizations or cross-training. Nor does the NTSB retain a support service contractor to augment staffing capability in times of heavy workload.

The NTSB typically hires experienced mid-career professionals, many drawn from industry, who must be able to match their expertise with that of party experts in order to maintain the integrity of the party process. A by-product of hiring experienced professionals is a staff with an age distribution that is skewed toward older ages, particularly in the case of the OAS, which has a disproportionate number of staff already at or above age 55.

Replacing retiring employees in a small organization that has limited staffing depth to begin with could pose a substantial hiring challenge for the NTSB in the coming decade. Some features of the NTSB salary structure may serve to further complicate the agency’s efforts to attract and retain the experienced staff it needs to perform its investigative function.

Characteristics of the Workforce

Despite its high public profile, the NTSB is a small agency, having just a little over 400 employees. Staffing in the OAS, which encompasses employees at its headquarters and regional and field offices, grew slightly during the 1990s (see Figure 5.1). During that same period, the ORE, which supports accident investigations across transportation modes, had much more growth, with staffing up by about 57 percent.

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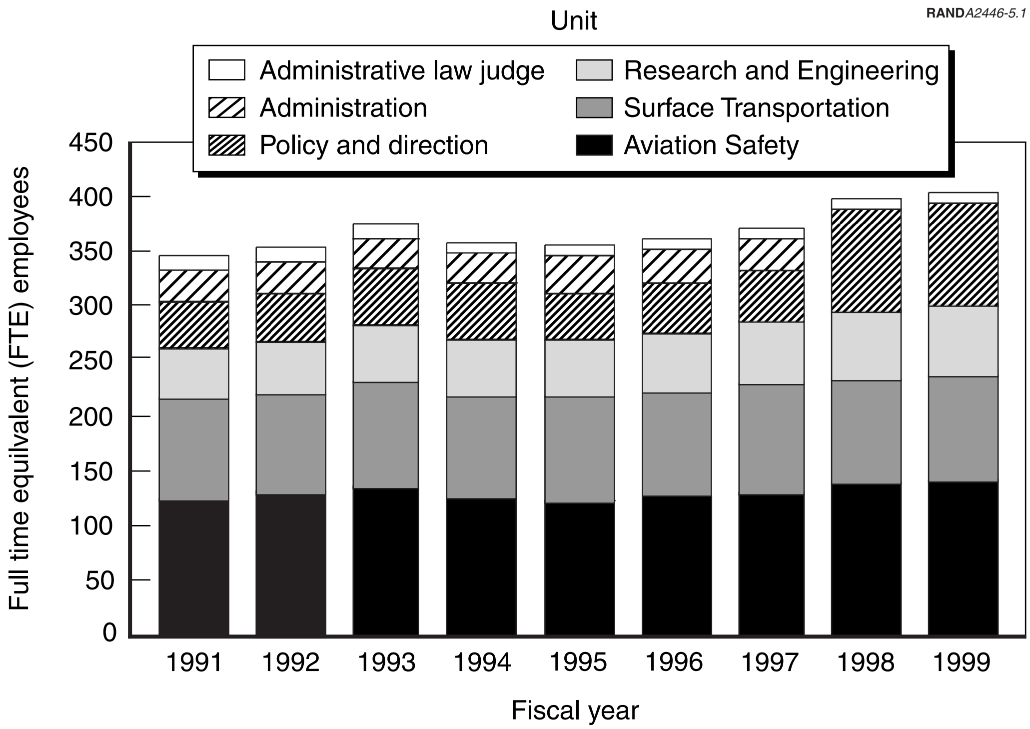
the survey, the sample, response rates, and selected results. Appendix E provides a copy of the survey questionnaire.



SOURCE: Internal NTSB staffing databases, various years.

Figure 5.1--NTSB Staffing Numbers During the 1990s

As noted earlier, the NTSB has only limited depth in many specialties because of its limited size and the breadth of specialty expertise required for accident investigation. Periodically from 1990 to 1995, the NTSB surveyed its staffing depth in various specialties, often in response to congressional inquiries or as part of its budget submittals. Although the most recent staffing depth survey made available to RAND was for fiscal year 1995, given the moderate growth in NTSB's OAS staff since then, we suspect the current depth is not very different from that shown in Tables 5.1 and 5.2.

To perform aircraft accident investigations, IICs draw on the technical skills of specialists in the OAS and ORE. However, within the specialty areas of the OAS and ORE there are seldom more than one or two staffers expert in each area. In fiscal year 1995, the median number of staff members skilled in any particular aviation specialty in the OAS was just two and in the ORE was only one. In that year, for example, the NTSB listed just one helicopter specialist (at one of the regional

Table 5.1

OAS Staffing Depth in Various Specialties
(Fiscal Year 1995)

Number of Employees[a]	OAS Specialty[b,c]
1	Air Safety Investigator (Logistics)
	Aircraft Maintenance Records
	Survival Factors: Cabin Safety
	Survival Factors: Emergency Response
	Helicopter Specialist
	Safety Recommendations
	Accident Data Specialist
2	Meteorology
	Aircraft Systems: Avionics
	Aircraft Systems: Hydraulics
	Aircraft Airworthiness
	Survival Factors: General
	Survival Factors: Crashworthiness
	Safety Recommendations
	Technical Writer
	GA Engineering
3	Aircraft Operations
	Airframe Structure
	Aircraft Power Plants
	Accident Analysis
4	Air Traffic Control
	Human Performance
7	Investigator-In-Charge
49	*Air Safety Investigator*

SOURCE: Internal NTSB records, FY 1993 to FY 1995.
[a]Staff covers Washington headquarters and nine regional locations.
[b]Major investigation specialties are shown in roman type; field investigation specialties are in italics.
[c]Excludes supervisory and administrative/clerical specialties.

locations) and one cabin safety expert (at headquarters) (see Table 5.1). At the same time, the ORE had one chemist/fire/explosions expert to cover all transportation accidents investigated by the NTSB (see Table 5.2).[2]

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[2]With fire and explosions a common occurrence in many transportation accidents, the ORE has since taken steps to add another

Table 5.2

ORE Staffing Depth in Various Specialties (Fiscal Year 1995)

Number of Employees	ORE Specialty[a]
1	Engineering Applications
	Engineering Technician
	Safety Studies: Aviation
	Safety Studies: Railroad
	Safety Studies: Highway
	Safety Studies: Marine
	Accident Data: Research Methods/Statistics
	Accident Data: Aviation Analyst
	Accident Data: Records Management Officer
	Chemist/Fire/Explosions
	Technical Writer
	Writer/Editor
	Computer Specialist (Applications)
2	Safety Studies: Cross-Modal
	Accident Data: Accident Data Specialist
	Accident Data: Records Management Specialist
	Computer Specialist (Systems)
3	Cockpit Voice Recorder
	Flight Data Recorder
	Aircraft Performance
	Investigator-In-Charge (Hazardous Materials)
	Metallurgy
	Materials Analysis

SOURCE: Internal NTSB records, FY 1993 to FY 1995.
[a]Excludes supervisory, administrative, and clerical specialties.

With a technical staff that is only one or two persons deep in critical positions, even a single retirement or resignation can materially impact the skills the NTSB can bring to bear in an accident investigation. The NTSB also encounters difficulties when accidents occur in clusters. When this happens, the NTSB typically serves the most immediate need, which can increase the time required to complete other ongoing investigations (Benzon, Summer 1998).

Although the data cannot support definitive conclusions regarding trends, analyses of accident complexity and investigation duration

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specialist in the chemist/fire/explosions category. The senior specialist in this category retired after RAND completed its research.

suggest a trend during the 1990s of growing complexity in aviation accidents and longer investigation times. These lengthy investigations work against the NTSB's ultimate aim of finding the cause of an accident and issuing safety recommendations quickly.

Aside from overall trends, RAND noted several specific examples in which limited staffing depth influenced the pace of accident investigations. In one instance, the NTSB, lacking certain in-house expertise, had to delay its investigative work until parties to the investigation completed the results of technical analyses of complex structural dynamics.[3]

RAND also observed the staffing demands posed by concurrent investigations of complex major accidents, such as the simultaneous investigations of U.S. Air Flight 427 and TWA Flight 800. Although some investigative activity continued on other air carrier accidents, the demands of bringing the U.S. Air Flight 427 accident investigation to a conclusion consumed most of the time of the NTSB headquarters aviation technical staff in the months leading to the final hearing and issuance of a final report.

Strategic alliances outside the party process might be used to augment or extend NTSB expertise at times of especially heavy workloads. Such alliances could also offer NTSB employees more opportunities for professional development. However, the NTSB uses few such formal arrangements.[4]

Some organizations use cross-training to compensate for limited staffing depth. For instance, NASA's Jet Propulsion Laboratory has used generalists to fill skill vacuums when they develop, successfully cross-training small teams to develop and operate interplanetary spacecraft (Muirhead, March 16, 1999). Although migration across organizational boundaries occurs at the NTSB in the course of some staffers' careers, RAND did not observe any extensive use of cross-training.

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[3]This instance involved the crash of Federal Express Flight 14, a MD-11 aircraft that crashed on landing on July 31, 1997, in Newark, N.J. (personal conversation with NTSB IIC for the accident, Summer 1998).

[4]See Chapter 6 of this report for a discussion of the insularity at NTSB and the need for more strategic relationships with the aviation community.

As Table 5.3 shows, the NTSB hires more of its staff from private industry than from any other single source. The Safety Board's ability to continue to attract this sort of employee will depend in part on its salaries relative to private industry.

The NTSB tends to hire very experienced professionals for aircraft accident investigation. Many OAS recruits have 10 years, and in some cases more than 20 years, of experience prior to joining the NTSB (see Figure 5.2). Survey respondents from the OAS (headquarters and regional offices) possessed an average of 11 years of experience at NTSB and 23 years overall.[5] Headquarters OAS respondents had approximately five years more experience overall than regional OAS respondents, and about two years more time at NTSB.[6] Respondents from offices representing other transportation modes reported an average of four years less experience than their OAS counterparts.

Table 5.3

Prior Employment of NTSB Employees

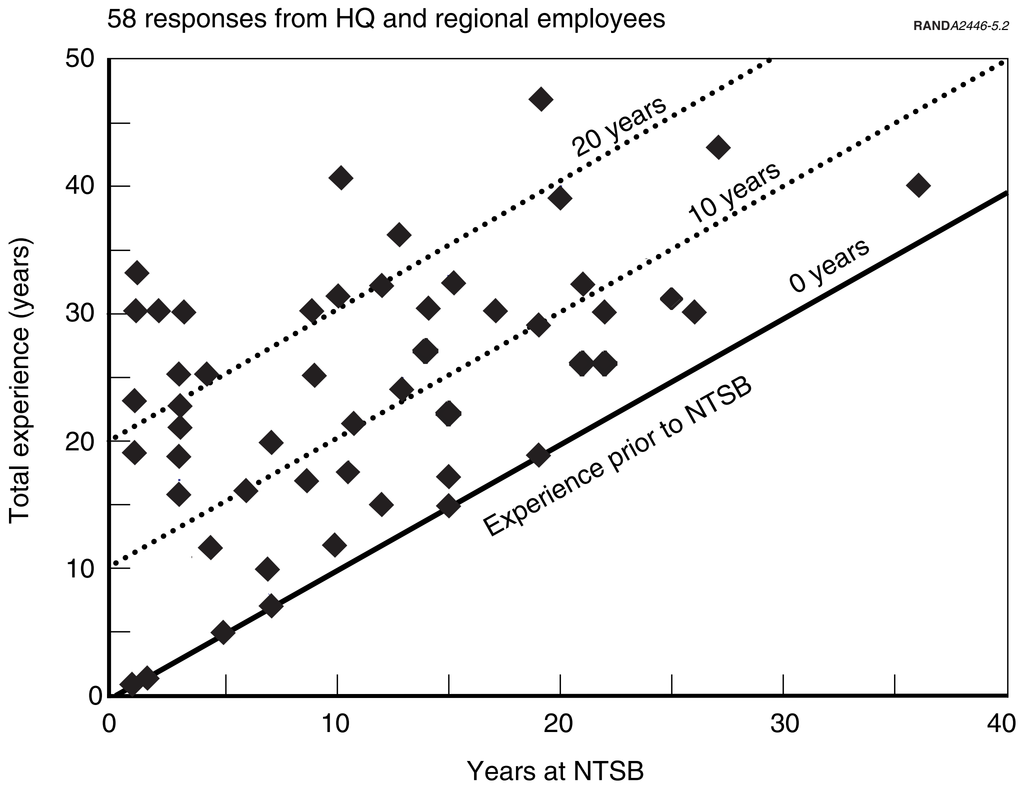
	Percentage of Respondents[a]	
Prior Employment	OAS (all)	All NTSB Respondents
Industry	55	41
Government agency	17	29
Military	17	12
Academia	5	10
Other	5	9

SOURCE: RAND Skills and Experience Questionnaire, Summer 1998.

[a]58 respondents from the OAS; 147 overall for NTSB.

[5]The 95 percent confidence intervals on these results were ±2.1 years and ±2.7 years, respectively. Late in the study, RAND acquired staffing records for the OAS for a larger sample of employees. Average tenure at NTSB for this sample was approximately one year less than that reported from the respondents to the RAND questionnaire, well within the confidence interval of the questionnaire sample.

[6]Fifty-eight of 112 OAS headquarters and regional staff answered the question regarding years of experience, a 52 percent response rate.



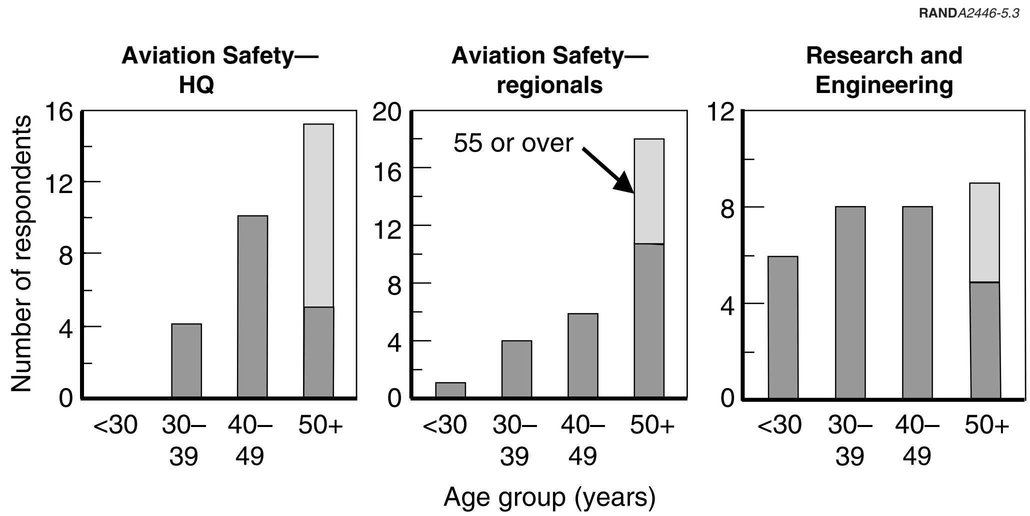
SOURCE: RAND Skills and Experience Questionnaire, administered to the NTSB staff, Summer 1998.

Figure 5.2--Experience Level of OAS Employees

The pattern of hiring highly experienced staff impacts the age distribution of the NTSB workforce and the niche within the aerospace industry salary structure in which the NTSB must compete.

As Figure 5.3 shows, the NTSB's experienced aviation workforce is skewed toward an older age distribution. Seventeen members (29 percent) of the OAS regional and headquarters staff responding to the RAND questionnaire reported being at least 55 years of age. This represents about 13 percent of the OAS technical staff and supervisory workforce as a whole, including those who did not respond to the survey. ORE staff had a more balanced age distribution.

Whereas age 55 represents an initial threshold for retirement, the Office of Personnel Management (OPM) has reported that federal workers on average retire at age 61 (Adelsberger, January 1998, p. 2). Twelve NTSB survey respondents were 61 or older, including six from the OAS and one from ORE. Because many NTSB staff join the agency in mid-career,



SOURCE: RAND Skills and Experience Questionnaire, administered to the NTSB staff, Summer 1998.

Figure 5.3--Age Distribution of Aviation Office Staff

they may tend to stay beyond age 55 to accrue full federal retirement benefits.

As the leading edge of the baby boom generation approaches retirement eligibility in 2001, the "graying" of the American workforce has been well documented. However, as Table 5.4 shows, the NTSB's aviation workforce age distribution appears to be more skewed than the distribution of the general working population in the United States in terms of both those at or above first retirement age and those who will reach that age within a decade.

"Block retirements" might create significant staffing problems at the NTSB, given the Safety Board's limited size and depth of staff. It has already faced this problem to some extent, and has used retention bonuses to encourage several employees to postpone their planned retirements (Case-Jacky, April 1999).[7]

The NTSB has also implemented accelerated hiring and mentoring programs to offset the impact of retirements. With a large fraction of its workforce in the 45-to-54 age group, NTSB managers will have to

[7]Retirements between fiscal years 1994 and 1998 ranged from four to nine per year. In the first three months of fiscal year 1999, the NTSB had already recorded six retirements (National Transportation Safety Board, 1999c).

Table 5.4

Surveyed Age Distribution of Selected NTSB Workers

Organization	Average Age (years)	Percentage of Respondents by Age		Number of Responses	Response rate (%)
		45–54	55+		
OAS--all	50	45	29	58	52
ORE	41	32	13	31	51
All NTSB	47[a]	43	21	147	55
U.S workforce[b]	—	21	12	—	—

[a]As a point of reference, the DOD civilian workforce has an average age around 45 while the average age for NASA's workforce is 44 (Adelsberger, January 1998, pp. 2–3).

[b]Employed civilians (Jacobs and Zhang, 1998, p. 49).

devote considerable attention to the issue of its aging workforce in the coming decade in order to ensure that it maintains critical workforce skills.

Attrition has been moderate in recent years. From fiscal year 1995 through fiscal year 1998, voluntary resignations ranged from 6 to 8 percent of the workforce annually.[8] Other than fiscal year 1995, when five air safety investigators from field offices resigned, no year stands out from the rest.[9]

The positive attitude of NTSB employees regarding the mission of the agency probably contributes to the low attrition rate. In interviews with RAND, NTSB employees frequently expressed concern about their workloads. However, they also repeatedly mentioned the interesting nature of their work and indicated a strong belief in the importance of their work to the traveling public.

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[8]RAND tabulated all work separations from December 31, 1993, through January 5, 1999. Attrition calculations were based on voluntary resignations (NTSB personnel action 317) and the average size of the workforce in full-time equivalents during each fiscal year (National Transportation Safety Board, 1999c).

[9]Regional Air Safety Investigators communicated concerns about their working environment, career path, salary structure, and other issues to the chairman of the NTSB in 1997 (National Transportation Safety Board, October 1, 1997).

Salary Comparisons with Industry

During the next decade, the NTSB may need to accelerate the hiring of new staff in order to reduce the workload of individual staff members and offset coming retirements in its workforce. A central question then is whether the NTSB can attract and retain the class of experienced employees that it uses as accident investigators. Although a comprehensive examination of all the factors influencing the NTSB's ability to attract and retain employees was beyond the scope of this analysis, RAND performed a first-order assessment.

Because the NTSB recruits more employees from industry than from any other sector, RAND compared typical salaries of NTSB engineers with engineering salaries in the aerospace industry. The results showed that salaries for mid-career NTSB staff tend to lag behind those offered by the aerospace industry.

Figure 5.4 shows typical salary ranges in the aerospace industry for four experience levels, ranging from an entry-level new hire to an experienced middle-management employee.[10] It also shows the premium the aerospace industry pays to program and project managers.

To compare aerospace industry salaries with those at the NTSB, RAND asked NTSB administrative officers from the ORE and OAS which government service (GS) grade is typically held by employees in each experience category (Francis, March 1999; Case-Jacky, April 1999). The salary ranges for the various GS grade levels are shown in Figure 5.4, along with examples of actual salaries of some NTSB employees.[11]

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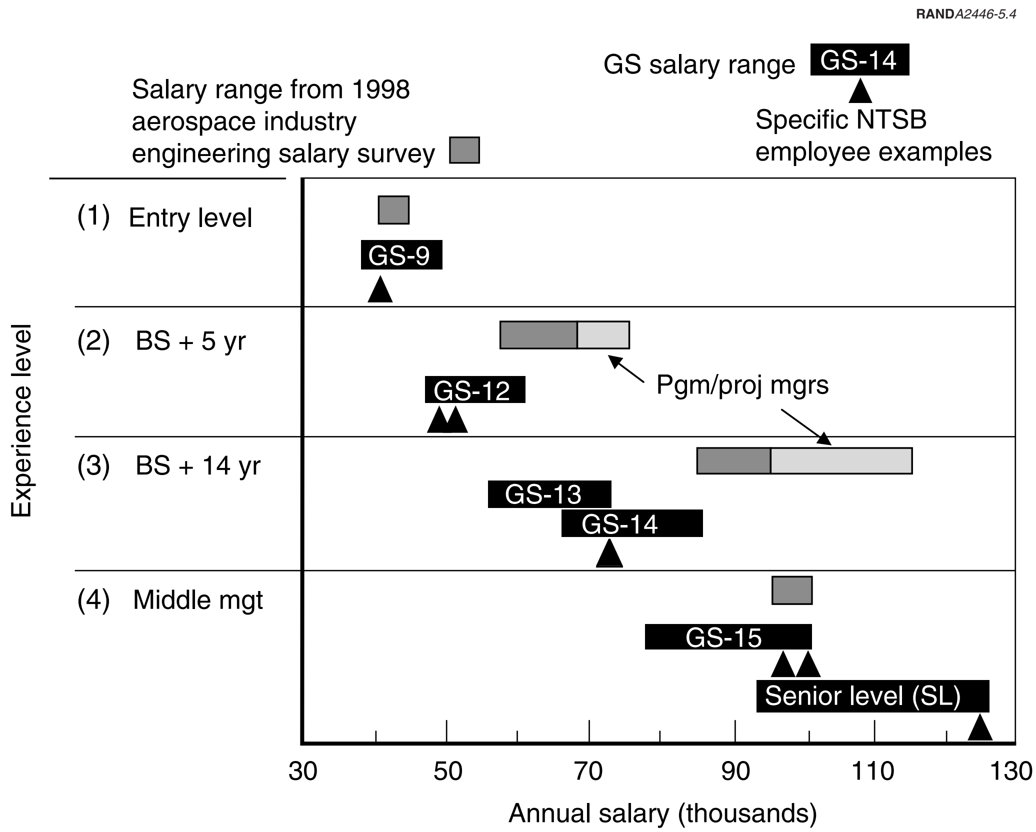
[10]In 1998, Organization Resources Counselors Inc. compiled data on compensation and employment trends for more than 700 U.S. companies. They then developed a separate tabulation for 144 aerospace-related concerns, publicly and privately held, as well as some federally funded firms. Personal interviews and discussions with executives from 30 aerospace and aviation companies supplemented the survey results. ("Despite Consolidation, Aerospace Offers Attractive Employment Opportunities and Salaries," February 8, 1999, p. 83).

[11]RAND used the Special Salary Rate Table 0414 for engineers through GS-12. For higher grades, the *1998 General Schedule* for the Washington-Baltimore, DC-MD-VA-WV, area was used. The year 1998 was selected for comparison because the industry survey covered 1998 (U.S. Office of Personnel Management, 1998).



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

Figure 5.4--Comparison of NTSB and Aerospace Industry Salaries

Engineers joining the NTSB as a GS-9 Step 1 fall at the low end of the salary range for entry-level aerospace industry employees. These engineers do benefit from special civil service salary schedules for engineering occupations that exceed salaries in the General Schedule.

The disparity between NTSB and industry salaries increases for the more-experienced employees. The median grade for OAS employees is GS-13.[12] The salaries for these mid-career NTSB employees appear to lag behind typical aerospace industry salaries by the equivalent of at least one GS grade.

The disparity in salary levels is reduced for senior middle-management employees at the NTSB. Those in the upper levels of the GS-15

[12]From data provided by NTSB's Human Resources division, Fall 1998.

pay scale appear to have salaries broadly comparable with those in the aerospace industry survey.

The federal pay schedule also includes senior-level and scientific or professional positions. These positions, designed to compensate valuable senior employees who have reached the top step of the GS-15 scale, can provide a sizable premium over a GS-15 salary. The NTSB has rarely used these positions, although within the past several years one employee in the ORE was put on this salary schedule.

Federal agencies can use other types of incentive compensation, including hiring bonuses, retention bonuses, and the National Resource Specialist designations.[13,14] The NTSB also has positions for three senior executive service people in the OAS at the director and deputy director levels, and two similar positions in ORE. These options provide some leverage for attracting or retaining key employees on a case by case basis, but they are not designed to address inherent competitive inequities in federal pay schedules.[15]

The NTSB must also measure its salary levels against those of other agencies of the federal government. The FAA, for example, is adopting a wide-ranging reform of its compensation system, replacing the traditional "grade-and-step" base pay method with a simplified structure of "pay bands," the value of which is determined by comparison with

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[13]As of Spring 1999, the NTSB had recently used retention bonuses for five employees, three of whom were poised to retire, and two of whom were considering leaving the agency. Such bonuses are renewable; however, the additional compensation is not counted in the calculation of an employee's retirement pay (personal communication with administrative officer of the OAS, April 1999).

[14]Created by the OPM, the research specialist designation was designed to better compensate nonmanagerial employees who possess critical technical skills. Examples of NTSB staff who have held such positions include a structures and systems engineer, a meteorologist, and an ATC specialist (personal communication with administrative officer of the OAS, April 1999; internal NTSB staffing report, March 18, 1997).

[15]Another compensation challenge facing NTSB is that its headquarters and most of its regional and field offices are located in regions that most salary survey organizations classify as the "hottest" geographic areas for engineers. Anchorage, Miami, and Los Angeles are the only NTSB locations absent from those organizations' lists.

similar jobs in government and private industry (Federal Aviation Administration, June 17, 1998).

The new negotiated agreement with air traffic controllers abandons traditional GS grades and replaces them with air traffic control (ATC) levels. Under this plan, one-time increases in salary levels will be introduced over three years. They will range from a minimum of 5 percent to a maximum of 23 percent, and will average 12 percent nationwide (Haines, May 21, 1999).

Some FAA employees who are not covered by negotiated agreements, and whose functions may be considered analogous to some NTSB employees, are now involved in pilot programs of the FAA’s Core Compensation System (Garvey, October 1, 1998). These programs are more flexible than the GS system under which NTSB currently operates.

The changes evolving at the FAA have not gone unnoticed by NTSB staff. Perceived compensation disparities between the FAA and the NTSB were noted in many survey responses and also in interviews. However, it is too soon to assess the long-term effects of these disparities on the ability of the NTSB to hire or retain qualified staff.

RAND did find anecdotal evidence that disparities in salary between private industry and the NTSB, and between the NTSB and other federal agencies, seem to adversely affect the NTSB’s ability to hire the employees it needs. The director of OAS indicated that he has experienced difficulties in attracting experienced staff with skills (such as software engineering) that are in large demand in the general employment sector because of deficiencies in the NTSB salary structure. Key managerial positions have also been difficult to fill.

More research is needed to fully assess whether salary disparities will prevent the NTSB from attracting the high-caliber employees it needs to fulfill its mission. RAND’s assessment compared only the salary dimension of compensation, and only for engineering disciplines. Future research should compare other elements of compensation for engineers and professionals from other disciplines, including psychologists, pilots, physical scientists, and others. Other nonmonetary factors affecting success in recruiting and retention also need to be considered.

WORKLOAD

RAND assessed the current workload at the NTSB to determine whether the size of its staff is adequate to meet accident investigation demands and whether it leaves time for staff to participate in training while away from daily accident investigation duties. The magnitude of the current workload also provides an indication of the ease or difficulty with which NTSB might expand into new activities consistent with its mission.

RAND measured workloads in terms of the hours NTSB investigators worked in aggregate as well as more disaggregated examinations of how they spent their time. Average workloads at the NTSB are quite heavy across all transportation modes. RAND's examination of how employees spent their time also raised some issues about work priorities at the NTSB.

The NTSB's lack of a project-oriented management information system significantly hampers its ability to measure the workloads of its employees. Expenditures for goods and services are tracked by project (or accident investigation), but employee work time is not. This makes it virtually impossible to develop a breakdown of the human resources devoted to specific accident investigations.[16] As a consequence, RAND used a variety of methods to measure workloads, including employee interviews, the structured survey, and data assembled from multiple internal NTSB data systems.

Aggregate Workloads

To estimate aggregate workloads at the NTSB, RAND reviewed (1) normal timekeeping data that recorded the typical 40-hour workweek, (2) budget data and personnel records to estimate overtime typically clocked by employees, (3) a prototype data system used by NTSB to track compensatory time,[17] and (4) the survey results. Figure 5.5 presents a summary of these data.

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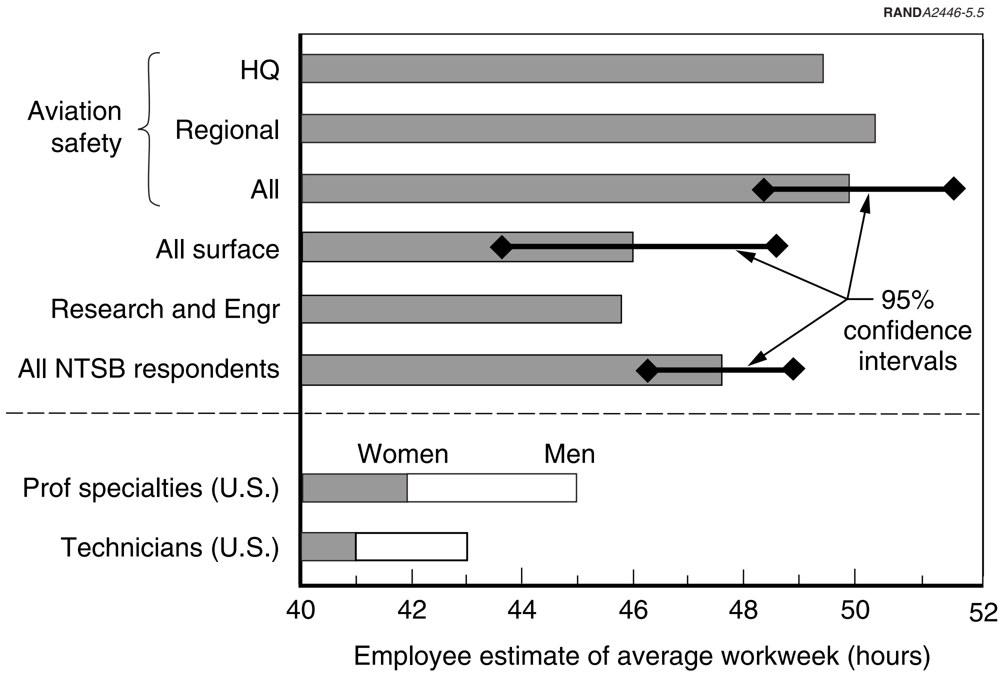
[16]This issue is discussed further in Chapter 6.

[17]In lieu of overtime compensation, which is granted rather sparingly by the NTSB, employees often work excess hours and then are granted compensatory time off. The Budget Division of the Office of the Chief Financial Officer developed a prototype system for tracking



SOURCE: Developed from internal NTSB databases and RAND Skills and Experience Questionnaire; Hecker, October 1998, pp. 8–18.

Figure 5.5--Estimated Average Workweek Hours

The OAS staff at headquarters and in field offices reported an *average steady-state workweek* of approximately 50 hours. More than 8 out of 10 OAS investigators reported workweeks exceeding 44 hours.[18] Like many other managerial and professional workers, NTSB staff are not compensated for all time worked in excess of 40 hours, although overtime and compensatory time arrangements do provide compensation for some of the extra hours worked.[19]

compensatory time accounts, both time used and unused (Libera, Fall 1998).

[18]Questionnaires were sent to 112 members of the OAS at headquarters and in the field. Replies answering the workweek question and noting organizational affiliation numbered 55, a 49 percent response rate. The standard deviation in the average workweek estimate was 6.3 hours and the 95 percent confidence interval was ±1.7 hours. Eighty-one percent of headquarters OAS investigators and 89 percent of regional OAS investigators reported workweeks exceeding 44 hours.

[19]The internal NTSB timekeeping and budget records RAND reviewed indicated that aviation investigators usually recorded about two hours per week of overtime.

Periods of high overtime usage coincided with particularly intense activity during investigations of the TWA Flight 800 and the ValuJet Flight 592 accidents. During this time, the estimated continuous average workweek for senior investigators in the OAS approached 60 hours per week. Peak workloads can be substantially higher.

OAS personnel are not unique in working long hours, but their estimated workweek appears greater than that reported by surface transportation mode accident investigators at the NTSB.[20] As shown in the bottom portion of Figure 5.5, the estimated workweek of OAS personnel also appears to exceed that reported by other populations of full-time wage and salary workers, such as the professional specialty and technician occupational groups (Hecker, October 1998, p. 11).[21] Table 5.5 more fully illustrates the differences in workweeks reported by NTSB personnel and other U.S. workers.

As the right-hand column of Table 5.5 indicates, a greater proportion of NTSB investigators report workweeks exceeding 44 hours (so-called *extended workweeks)* than do salaried U.S. workers as a whole and professional and technical workers. Of the major occupational groups tracked by the Consumer Population Survey, workers in the "executives, officials, and managers" group are most likely to work extended workweeks. However, the proportion of workers in this category who report working more than 44 hours per week (5 of 10 men and 3 of 10 women) is less than the proportion of NTSB investigators who report working extended hours (Hecker, October 1998, p. 9).

Assessments of the magnitude of the NTSB workweek should consider not only quantitative measures of workload but also the nature of the job of NTSB investigators. Although the NTSB is a small agency, its

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[20]Differences in workweeks reported by OAS respondents and the rest of NTSB respondents were statistically significant at the 99 percent confidence level. See Appendix D.

[21]Males in the occupational groups "clergy," "physicians," and "firefighters" report the highest typical weekly work hours among full-time wage and salary U.S. workers, in excess of 50 hours. Data derived from the 1977 Current Population Survey conducted by the Bureau of the Census for the Bureau of Labor Statistics. The Current Population Survey is a monthly survey of 50,000 households conducted by the Bureau of the Census for the Bureau of Labor Statistics.

Table 5.5

Comparison of Reported Workweeks

Sample	Average Weekly Hours	Percentage Reporting More Than 44 Hours
NTSB OAS personnel (HQ and regional)	50[a]	85
NTSB surface transportation personnel (HQ and regional)	44-48[b]	72
Full-time wage and salaried U.S. workers (men/women)	44/41[c]	29/14
Professional specialty occupations, U.S. (men/women)	45/42	36/23
Technicians, U.S. (men/women)	43/41	21/9

[a]Survey data.

[b]Questionnaires were sent to 83 surface transportation investigators at headquarters and in the field. Replies answering the workweek question and noting organizational affiliation numbered 46, a 55 percent response rate. The standard deviation in the average workweek estimate was 8.5 hours and the 95 percent confidence interval was ±2.5 hours.

[c]U.S. workforce workweeks are based on data from the 1997 Current Population Survey, as summarized in Hecker, October 1998, pp. 8–18.

findings and recommendations can have multibillion-dollar implications and impact the safety of millions of travelers.

The size and timing of the investigators' workloads are largely determined by accident occurrences over which they have no control. Almost all NTSB employees wear pagers and to varying degrees are "on call" much of the time. When they reach an accident scene, which can be in just about any type of environment, they may be faced with dead or dying people, pathogens, toxic materials, and other physical hazards. They may also have to deal with jurisdictional disputes, intense media scrutiny, and concerned family members. In the midst of all this, they must act as managers, technologists, and investigators in order to collect and assess evidence to support subsequent efforts to identify the cause of an accident.

Pressure to avoid mistakes during an investigation and to avoid overlooking anything of significance is high because of the prominence of the NTSB as the nation's independent safety examiner. The intense scrutiny that accident investigations receive from Congress, the media, the public, academia, companies, associations, states, foreign governments, regulatory agencies, private accident investigators, lawyers, and victims' families creates internal pressures at the NTSB to produce extremely complete and totally defensible analyses (Coarsey-Rader, January 22, 1998). In this respect, the qualitative demands of the accident investigation job can compound the quantitative impact of the long hours worked.

It is also important to assess whether their workloads prevent investigators from performing other tasks essential to the NTSB's mission, and whether the workloads impede investigators' ability to receive training to keep their skills current. NTSB staff repeatedly mentioned to RAND researchers that excessive workload was the single largest factor limiting their ability to participate in training they felt they should have.

More than half of the respondents to the RAND questionnaire indicated that they did not have adequate time to maintain and improve their professional skills. NTSB staff indicated that even if training budgets doubled or tripled, they would not be able to take advantage of additional training opportunities without first getting some workload relief. Addressing this issue appears to be a necessary prerequisite to improving staff training opportunities at the NTSB.

Workweek estimates that suggest NTSB investigators have an especially demanding workload are consistent with insights gained through interviews with people inside and outside the NTSB and from past results of other surveys and focus groups conducted at the NTSB (Coarsey-Rader, January 22, 1998; National Transportation Safety Board, October 1, 1997). RAND's results were also indirectly confirmed by observing the limited amount of time investigators spent on activities outside of day-to-day accident investigations, including formal training.

Notwithstanding the positive indications regarding the overall accuracy of the workload estimates, the fact that these estimates rely at least in part on self-reported workweeks introduces an element of uncertainty.[22]

The confidential questionnaire was distributed to every accident investigator at the NTSB across many geographic locations. The response rate on the workweek question was approximately 50 percent. The largest sample of data was collected from aviation safety investigators, the principal focus of the RAND analysis, and the resulting 95 percent confidence interval on their workweek results was ±1.7 hours.

The survey results suggest that NTSB employees tend to work long workweeks. However, these results should be regarded as indicators rather than precise measurements. In the RAND assessment, the results were used as a departure point, prompting examinations of other indicators of workload levels, such as overtime payments.

Trends in Overtime Payments

Figure 5.6 shows that trends in NTSB overtime pay also suggest a growing workload, particularly for the OAS, which shows a steady increase in overtime payments since 1993. Between fiscal year 1992 and fiscal year 1997, the OAS accounted for a disproportionate share of overtime payments (49 percent), relative to both its proportion of the NTSB workforce (37 percent) and the growth in its staff.[23]

Collectively, the quantitative and qualitative measurements assembled during the RAND study all suggest a continued heavy workload for the NTSB staff that, if left unaddressed, will continue to impede NTSB efforts to provide training opportunities to its employees.

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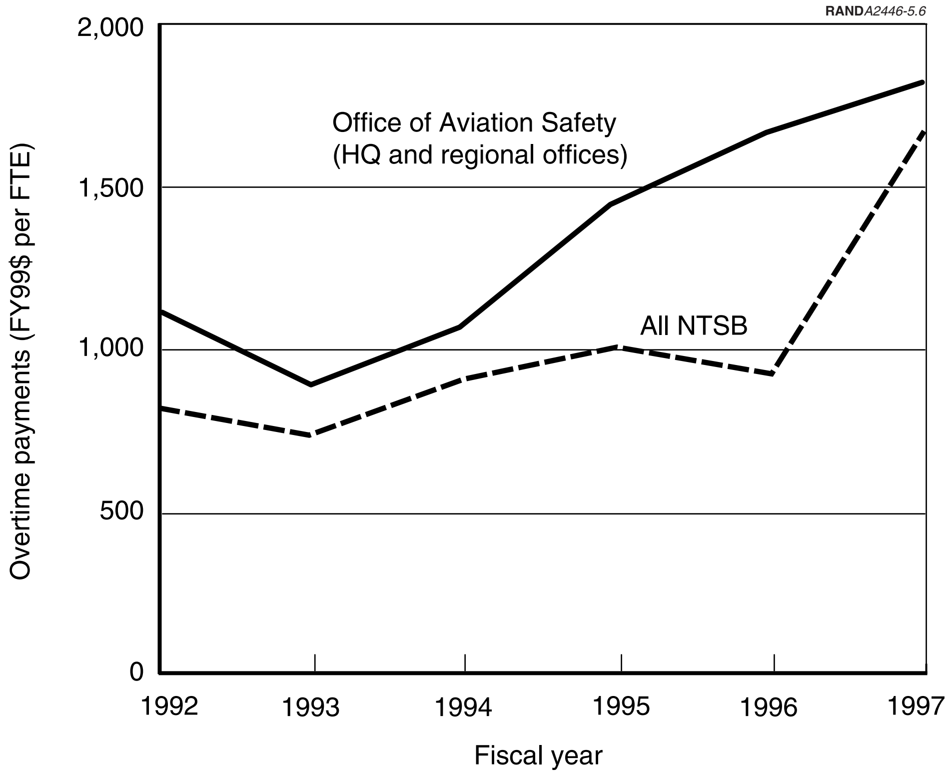
[22]The accuracy of self-reported workweeks is the subject of considerable research, as investigators try to measure trends in working hours and more generally how working Americans spend their time. Appendix D discusses views on the efficacy of various approaches for measuring workweeks.

[23]Overtime is used rather sparingly at the NTSB, and when used, is not paid at a rate commensurate with the GS grade of typical investigators. Because Air Safety Investigators are exempt from the Fair Labor Standards Act, they are entitled to a maximum of 1.5 times the GS-10 step 1 hourly rate. This frequently results in investigators being paid less than their regular hourly rate when working overtime (National Transportation Safety Board, October 1, 1997, pp. 4,5). In May 1999, the NTSB asked Congress for more flexibility in prescribing reasonable rates of overtime pay (Hall, May 6, 1999).



SOURCE: Developed from internal NTSB timekeeping and budget records.

Figure 5.6--NTSB Overtime Payments, 1992 to 1997

Headquarters Investigative Activities

To better understand what type of activities NTSB employees perform during their extended workweeks, we examined the specific kinds of aircraft accident investigations typically performed by headquarters and regional office investigators. Handling major airline accidents and incidents is the job of the headquarters-based OAS Major Investigations Division. A breakdown of that division's investigative activity for the last decade is shown in Figure 5.7. NTSB headquarters has dealt with an average of seven major accidents per year, a number that has not shown a downward trend. As previously mentioned, these accidents have tended to involve increasingly complex investigations; RAND expects this trend to continue.

Because support to foreign accident investigations is an important element of NTSB's responsibilities, one must look beyond the

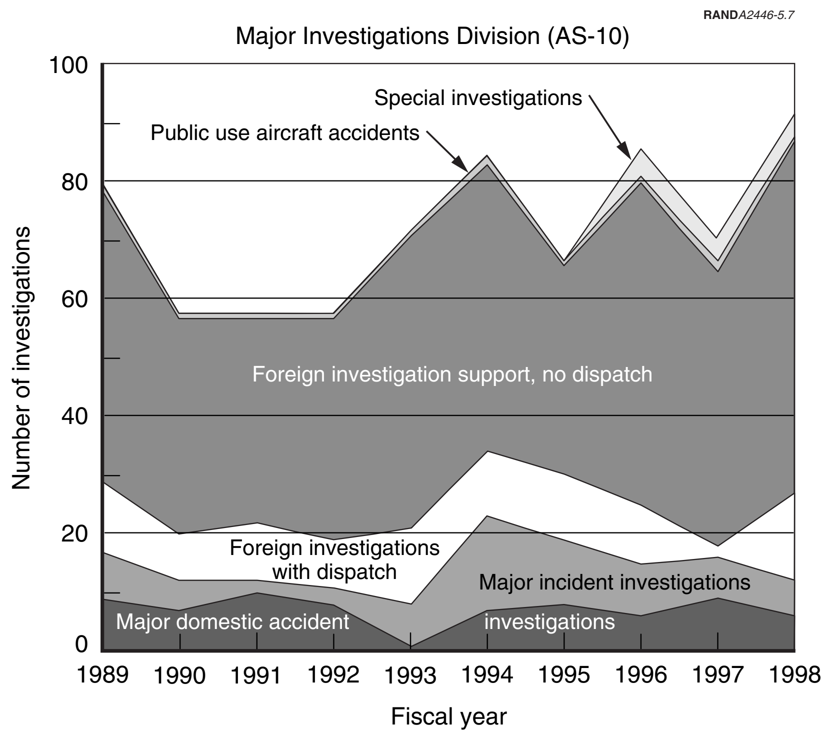


Figure 5.7--Investigative Activity, Major Investigations Division, 1989 to 1998

investigation of major U.S. air carrier accidents to get a complete picture of the OAS workload (see Figure 5.7). During the past decade,the OAS Major Investigations Division supported an average of 46 foreign accident investigations per year without dispatching investigators,[24] and on average dispatched personnel to another 10 foreign investigations per year.[25] This highlights the fact that a significant residual workload could remain even with progress in reducing accident rates of U.S. air carriers.

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[24] For example, NTSB support often takes the form of reading and interpreting the contents of voice and flight data recorders recovered from overseas accidents. The OAS would normally do this in concert with the Vehicle Recorders branch of ORE.

[25]Work hours devoted to each dispatch would provide a more informative picture of the distribution of effort at the NTSB. Unfortunately, because the personnel timekeeping system used by the NTSB does not track efforts by project (or accident), such information is not available. See Chapter 6 for more details about the NTSB's timekeeping system.

Support to foreign accident investigations can be relatively minor or can represent a major effort, as exemplified by the NTSB's support of Canadian investigators in the MD-11 Swissair 111 accident in 1998 and support of Colombian investigators in the 1995 crash of an American Airlines Boeing 757 in Cali, Colombia. In the case of a foreign accident involving a U.S.-manufactured aircraft, NTSB personnel from regional offices may also be dispatched to the manufacturer's facilities to support investigations being managed by NTSB headquarters or by a foreign accident investigation organization.[26]

Ten percent of the investigations shown in Figure 5.7 involve U.S. air carrier incidents. Although the number of incidents the NTSB investigated during the 1990s increased, the bulk of the NTSB's resources remains dedicated to accident investigations. RAND interviews with the NTSB staff and examination of NTSB investigative activities reports confirmed that the NTSB is organizationally focused and expends far more resources on investigating accidents than incidents.

Chapter 6 examines the implications of taking a more proactive stance with respect to accident prevention through expanded examination of aircraft incidents. These proactive efforts could help the NTSB better meet its mission objectives and support nationwide goals for continued reductions in aviation accident fatalities. However, absent any augmentation to the workforce or a change in NTSB priorities, such a policy change could increase workloads beyond what the NTSB staff is experiencing today.

Looking to the future, the mix of accident investigation activities performed by NTSB headquarters personnel may change, while demands for their investigative services will likely remain strong because of projected robust air traffic growth worldwide. Absolute numbers of accidents may decline, but the complex systems involved in the remaining accidents could make those accidents much harder to

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[26]During the early stages of the Swissair 111 investigation, personnel from the NTSB's Seattle and Los Angeles regional offices were dispatched to Boeing facilities in Seattle and Long Beach (Mucho, March 1999; McGuire, Fall 1998).

diagnose. Additionally, the need to support foreign investigations will place a continuous demand on NTSB resources.

Regional Investigative Activities

Six regional NTSB offices and four smaller field offices across the contiguous 48 states and Alaska collectively investigate approximately 2,000 GA accidents per year.[27] In addition, field personnel often participate in, and in some cases lead, major accident investigations.[28]

Although there are many more GA investigations than major air carrier accident investigations, they are normally of much shorter duration. A typical regional office investigates approximately 300 accidents per year. At one regional office visited by RAND researchers, the average investigator was carrying more than 20 open investigations (National Transportation Safety Board, September 30, 1998). Because of the volume of accidents, regional offices apply their own criteria to determine the depth of each investigation. While some offices apply similar criteria, there is no NTSB-wide set of standards. This variability impacts the workload at various regional offices and the resources needed for investigations.

As explained in Chapter 2, GA accident investigations fall into two of the five major categories of aviation accident investigations: "limited investigations," which are accomplished by gathering facts over the telephone about the circumstances of an accident, and "field investigations," in which investigators go to the accident site.

Limited investigations typically consume 10 to 12 investigator hours, whereas field investigations might consume 10 times that number of investigator hours. Figure 5.8 shows that more than 80 percent of

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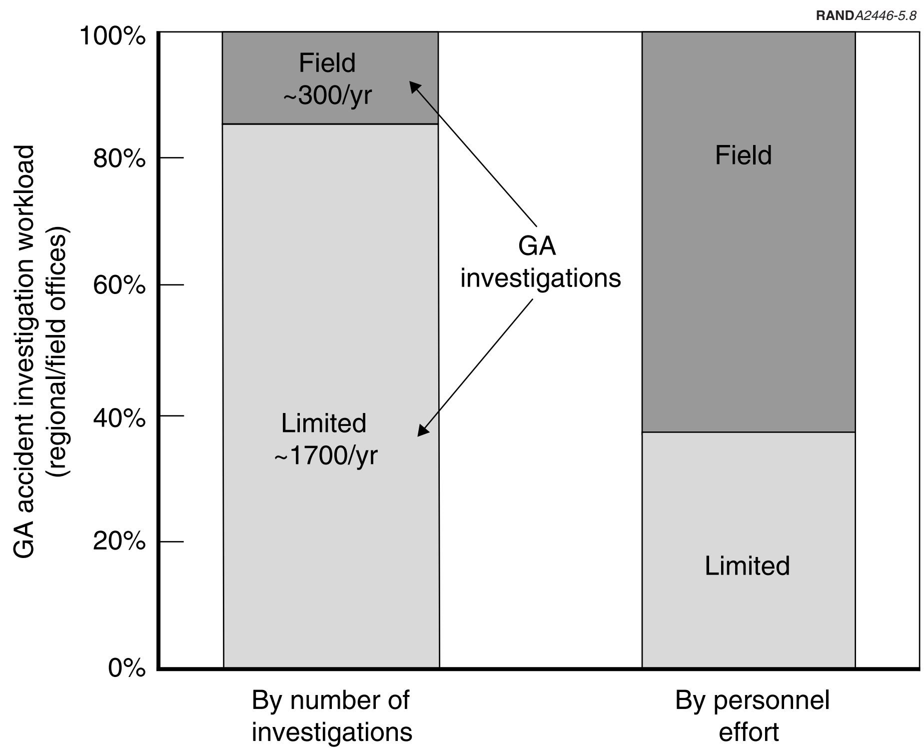
[27]General aviation encompasses companies using their own airplanes for business transportation, air charters, air taxis, personal and recreational flying, emergency medical evacuation, agricultural flying, traffic and aerial observation, and flight training. After a long decline, activity in this aviation sector has begun to grow again (see Figure 3.13 in Chapter 3).

[28]Because more than half the personnel in the OAS are assigned to regional and field offices, GA accident investigation represents a significant resource expenditure for the NTSB.



SOURCE: Mucho, 1999; McGuire, Fall 1998.

Figure 5.8--General Aviation Accident Workload, Field vs. Limited Investigations

accident investigations are in the limited category, but the extra effort required for field investigations means that they end up accounting for about 62 percent of the effort.

Most, but not all, fatal GA accidents are treated as field investigations. Four regional offices reportedly treat some fatal accidents as limited investigations if after collecting the facts by telephone they are reasonably assured of the cause of the accident.

Comparisons of GA and air carrier accident statistics do not provide a clear indication of appropriate resource allocations for accident investigations. GA accident investigation accounts for a substantial fraction of NTSB resources, and indeed, many more accidents and typically five times more fatalities occur annually in the GA sector than in the air carrier sector. Conversely, a single air carrier accident can have far broader implications for the traveling public than

Table 5.6

General Aviation and Air Carrier Comparisons

Metric	General Aviation	Air Carrier
Staff FTE (FY98)	86 (OAS regions)	63 (OAS HQ)
Budget (FY98)	$6.7M (OAS regions)	$9.2M (OAS HQ)
Accidents/year	~2,000	~14 major domestic accidents/incidents
Average fatalities/year (88-97)	746	149
Exposure-domestic operations (FY96) (million passenger hours)	79	1,050

SOURCE: Internal NTSB staffing databases; Internal NTSB budget records; NTSB Aviation Accident Database, 1999; Department of Transportation, 1998, Chapter 1 and Appendix A.

a single GA accident. Further, as Table 5.6 indicates, in terms of passenger hours, the U.S.traveling public uses air carrier transportation 13 times more than GA transportation on an annual basis.

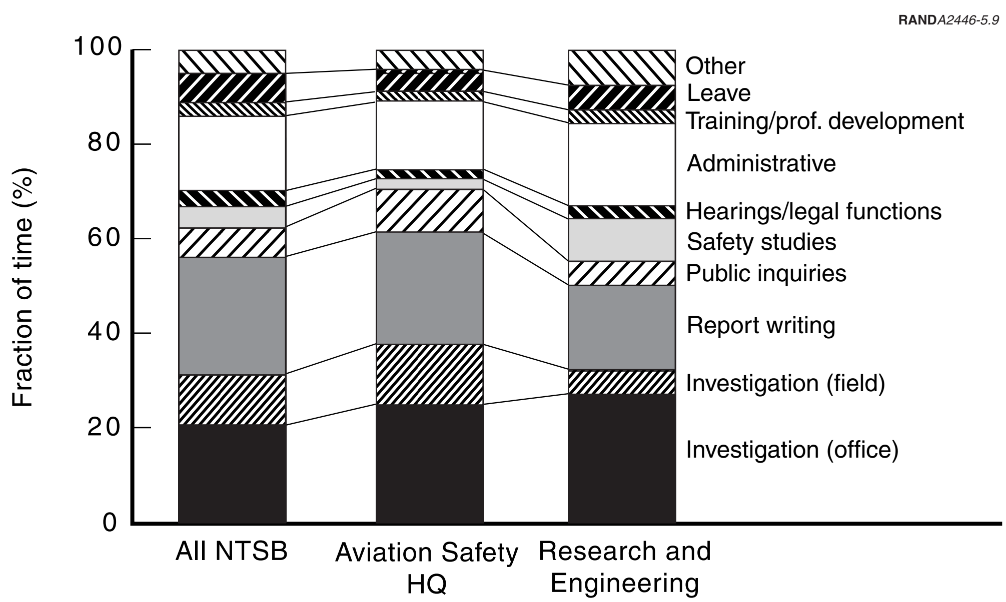
In interviews, many members of the aviation community expressed dissatisfaction with the current NTSB approach to resource allocation for GA accident investigations. Several salient observations emerged in these discussions. One frequent comment was that the NTSB should either hire more investigators so they can do more thorough GA accident investigations, or alternatively, be more selective in choosing which accidents to investigate so investigators can devote more time to a smaller set of accidents. Others within the NTSB argue that all accidents should receive at least limited investigations to prevent safety issues with potentially broad implications from going unnoticed, and to maintain the integrity of the unique GA accident database that the NTSB maintains.

In citing the value of GA investigations, NTSB staff members noted that safety recommendations drawn from GA investigations often have important implications for air carrier operations. However, a more direct approach--such as expanding the analysis of air carrier incidents--might increase the yield of safety recommendations relevant to air carrier operations. To ensure appropriate resource allocations, the NTSB must weigh its resource expenditures for air carrier and GA accident investigations against the benefits the traveling public derives from each of these two categories of investigations.

How NTSB Personnel Spend Their Work Time

RAND also examined how NTSB investigators allocated their work time. The questionnaire used to query NTSB personnel about their workweek asked respondents about the relative percentage of time they spent on various activities. Respondents were offered a structured set of choices, including "other," as well as space to enter text freely.[29]

The results helped RAND identify how NTSB investigators prioritize their activities and it provided self-reported estimates of how much time they spent in training. RAND used these estimates to gain a first-order assessment of the training situation at NTSB. Figure 5.9 shows that for the NTSB as a whole, and for OAS and ORE at NTSB headquarters, investigators on average spend more than half their time investigating accidents and writing reports.



SOURCE: RAND Skills and Experience Questionnaire.

Figure 5.9--Fraction of Time NTSB Staff Spend in Work Activities

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[29]This question drew 149 responses across the NTSB from 269 distributed questionnaires. See Appendix E for the specific format of the question on the distribution of activities.

The questionnaire specifically included a category to quantify how much time NTSB staff spent answering public inquiries. In interviews with RAND, NTSB staff expressed concern regarding the priority NTSB management attached to this activity relative to investigators' other duties. Given NTSB management's expressed desire to improve the quality and quantity of training at the agency, it is of considerable interest that their employees estimate they spend significantly more time answering public inquiries than they do in training.

As a public agency, the NTSB's mission includes informing the public of its accident investigation findings. It uses many techniques to disseminate this information, including holding public hearings and press conferences, issuing accident reports and safety studies, conducting public outreach activities, and publishing material on its Internet site. By congressional direction, the NTSB has also established an office of family affairs to provide information and support to the families of accident victims. In addition, NTSB staff also communicate directly with the public by answering letters or responding to other communications regarding accident theories, safety ideas, and other topics.

RAND survey respondents estimated spending an average of more than 6 percent of their time answering public inquiries and only 3.4 percent of their time in training activities. Respondents from the OAS at headquarters estimated spending almost 9 percent of their time answering public inquiries and only 2 percent of their time in training (about one week a year).

Some extreme values reported by individual respondents skewed the averages. The median values depicted in Table 5.7 provide a more representative picture of the time the NTSB staff estimates it typically spends answering public inquiries relative to time spent in training.[30] As Table 5.7 shows, personnel from OAS headquarters and regional offices (labeled "All OAS") typically reported spending 2.5 times more time

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[30]The median, the value above or below which lies an equal number of observations, generally provides a better measure of central tendency than the mean when there are some extremely large or small observations (Lapin, 1975, pp. 43-45).

Table 5.7

Time Spent Answering Public Inquiries and in Training (Percentage of Respondent's Time)

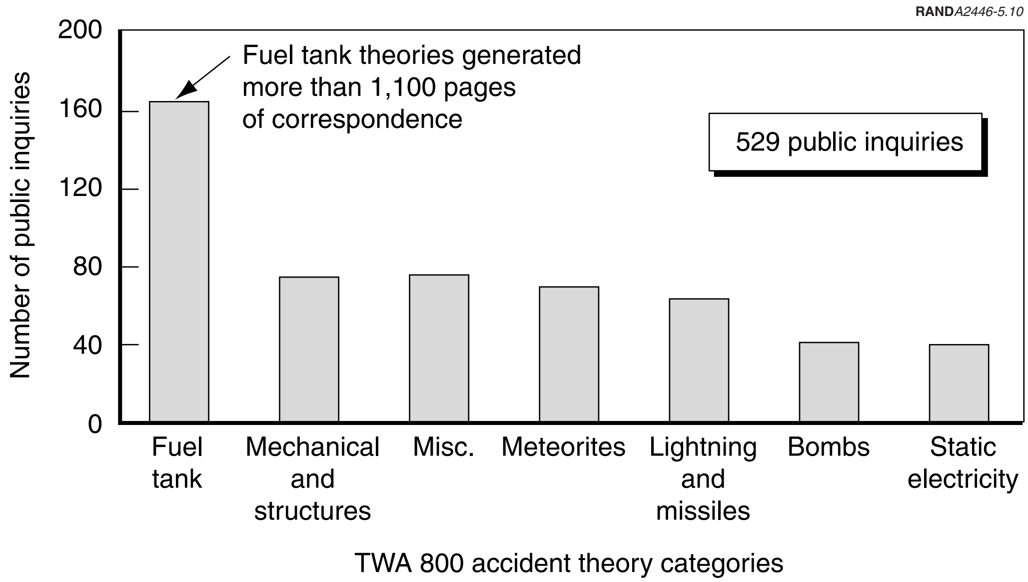
	Answering Public Inquiries		In Training		Survey	
Office	Mean	Median	Mean	Median	Response	Population
OAS-HQ	8.8	5.0	2.0	2.0	29	56
OAS-Regional	6.2	5.0	2.8	3.0	29	56
All OAS	7.5	5.0	2.4	2.0	58	112
ORE	5.0	2.0	3.5	3.0	31	61
All NTSB	6.2	5.0	3.4	3.0	150	269

answering public inquiries than in training (5 percent versus 2 percent). Overall, the estimates indicate the typical NTSB respondent across all organizations spent more time answering public inquiries than in training.

NTSB staff members' experience answering public inquiries about the crash and investigation of TWA Flight 800 puts these statistics into sharper focus. During that investigation, the NTSB staff were inundated with public inquiries about accident theories. Through its "mail control" process, the NTSB date-stamped, sorted, catalogued, and routed hundreds of pieces of correspondence received during the course of the investigation. As Figure 5.10 shows, 529 separate public inquiries offered theories about accident causes. Letters from the public and the NTSB's replies concerning fuel tank theories alone amounted to more than 1,100 pages of correspondence. Although not all inquiries received a reply, and some received only a brief courtesy reply, investigators were asked to prepare technical replies to a number of inquiries.[31]

The burden of replying to public inquiries was not unique to the TWA Flight 800 investigation, and many NTSB staff members in interviews with RAND, without being prompted, mentioned the time commitment to

[31]Inquiries were sorted into seven categories: missiles and lightning strikes, fuel tank (two volumes), mechanical malfunctions and structural failures, bombs, meteorites, static electricity, and miscellaneous (letters to NTSB from the public regarding the TWA Flight 800 accident, 1996-1998). Letters addressing accident theories from attorneys representing various parties in the accident were another major source of correspondence.



SOURCE: Tabulation of letters to the NTSB from the public regarding the TWA flight 800 accident, 1996-1998.

Figure 5.10--Public Inquiries Following Crash of TWA Flight 800

public inquiries. Investigators expect the level of public inquiries to remain high in the future because the NTSB posts the factual record of its accident investigations on the Safety Board's Web site. The speed and breadth of Internet communication have facilitated interaction among accident theorists. Following a major accident, the number and intensity of news group postings multiply.

Given the heavy workload in all transportation modes, the degree of staff time devoted to answering public inquiries deserves careful examination, particularly because the NTSB already uses many other channels to disseminate information to the public. Furthermore, senior investigators could recall no instance in which an accident theory proposed by a member of the public contributed materially to an NTSB air carrier accident investigation.

TRAINING

NTSB investigators draw on their management, investigative, and technical skills to investigate accidents. Management skills are needed to coordinate the activities of the myriad entities involved in an accident investigation so that an objective assessment of the accident cause can be reached. Investigative skills are needed to collect, catalog, and evaluate all the facts associated with an accident. Technical skills are needed to understand the functioning of the aircraft, and the airport and airways system within which it operates. Rapid advances in aircraft technology and other elements of the aviation environment make technical skills more "perishable" than management or investigative skills, which are less likely to become outdated.

The party process can work effectively only if investigators (1) possess sufficient skills and experience to command the trust and respect of the parties, and (2) ask the right questions, critically evaluate input from parties, and correctly assemble the facts. NTSB personnel must quickly and unequivocally demonstrate leadership and command of an investigation. Training helps investigators renew technical skills and keep abreast of new developments in aviation that they need to accomplish their investigative tasks.

To keep their skills current, NTSB investigators undertake various training activities. RAND examined the following aspects of training at the NTSB:

- Rationale for training
- Amount of training
- Sources of training
- Administration of the training process
- Training content.

RAND's assessment indicates that training opportunities for NTSB investigators are constrained by heavy workload, inadequate funding, and other factors, particularly when measured against the amount of training other members of the aviation community receive. Much of the training that is offered takes place in-house because the NTSB utilizes outside training resources to only a limited degree. The training that does occur is balanced across management, investigative, and technical areas. However, the emerging aviation environment (discussed in Chapter 3) will pose new challenges that may require some changes in the emphasis among these areas.

Rationale for Training

Interviews with NTSB managers and technical staff, and other members of the aviation community, revealed consistent views on the need for enhanced training at the NTSB. These interviews also outlined the typical pattern of training at the NTSB. They complement quantitative assessments of the current state of training at the NTSB.

Aircraft operators recognize the importance of on-the-job and supplemental off-the-job training to maintain the skills of their workforce. Table 5.8 shows that sharp distinctions exist between the airline training experience and the training environment at the NTSB.

Because airline officials know which equipment their personnel must operate and maintain, they can gauge the diversity of skills required to maintain and operate their fleets. The NTSB is in a more reactive posture, driven by the stochastic nature of accident events. Any kind of airplane can crash at any time, from the newest airliner to a vintage transport. The skill set required for investigations varies unpredictably from accident to accident.

Airline personnel receive both formal and informal on-the-job training that usually occurs on a regular basis. In contrast, NTSB

Table 5.8

Airline vs. NTSB Training Factors

Factor	Airline	NTSB
Predictability of skill needs	High	Low
Diversity of skill needs	Moderate[32]	High
Diversity of equipment	Moderate	High
On-the-job professional training	Extensive	Limited
Predictability of on-the-job training experience	High	Low
Off the job training	Extensive	Limited
Predictability of off-the-job training experience	High	Low

SOURCE: Based on RAND interviews with airline operators and NTSB personnel, 1998-1999.

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[32]This rating is not meant to underrate the skills needed by airline employees, but only to indicate that NTSB investigators must possess project management and investigative skills in addition to technical knowledge about flying and maintaining aircraft.

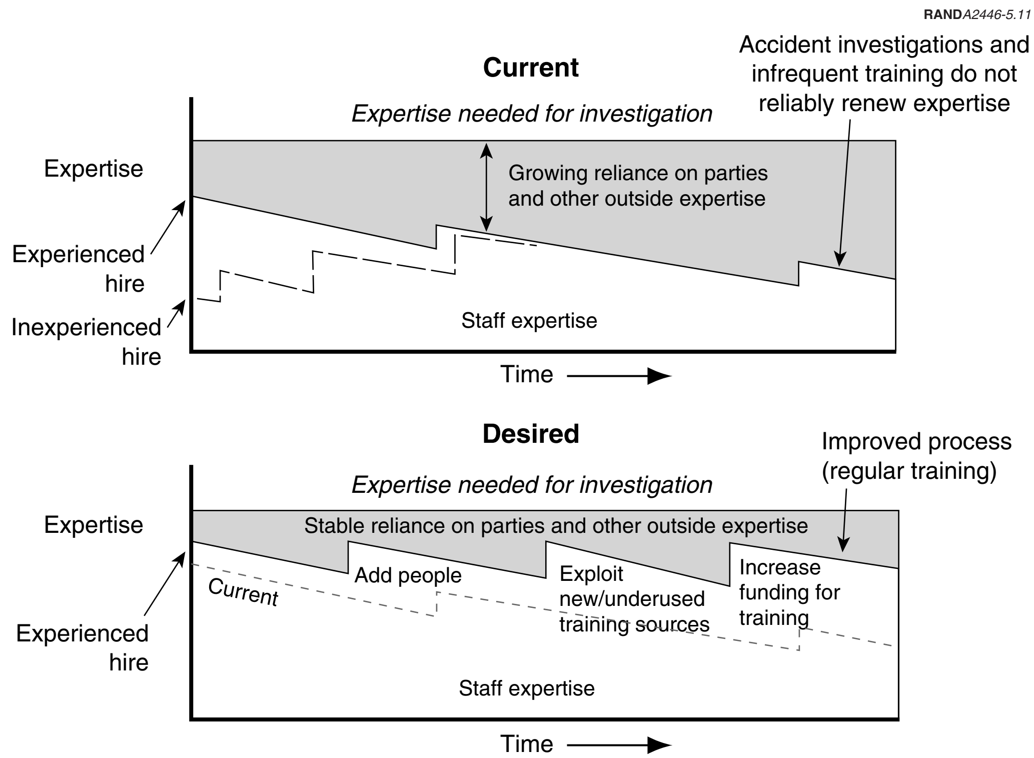
investigators do not fly or maintain airplanes on a regular basis; therefore, they do not have comparable opportunities to become familiar with equipment and operational procedures, although the on-the-job experience they do receive can develop accident investigation skills.

Because of the unpredictability of accident events, NTSB investigators may only become familiar with new equipment as a by-product of their daily activities if such an aircraft is involved in an accident. There is no guarantee that investigating an accident involving an older aircraft, such as a Boeing 747-100, will prepare an investigator for a subsequent investigation involving a more modern airliner, such as an Airbus or a Boeing 777.

To supplement on-the-job training, airlines provide extensive, regularly scheduled, formal off-the-job training to meet their own internal training requirements and those of the FAA. In the case of flight training, the type and amount of this formal annual training is determined by the employee’s job duties rather than by his or her age or experience. For instance, every pilot, irrespective of experience, must undergo a specified amount of formal training every year. The amount of training varies according to whether the pilot is keeping the same duties on the same type of aircraft, or is transitioning to new duties or moving to another aircraft type (Landry, June 1999). In contrast, the typical NTSB employee receives much less formal training, and the demands of accident investigation can disrupt scheduled training.

This contrast between the level of formal training received by airline personnel and NTSB staff underscores one of the reasons the NTSB relies on the party system: Its investigators cannot be expected to possess intimate design or operational knowledge on the entire scope of equipment every airline operates. Significantly, while airlines offer appreciable on-the-job training opportunities, air carriers also augment that learning with extensive outside training. NTSB personnel, on the other hand, have limited opportunities for systematically and regularly updating their technical knowledge of aircraft while on the job and, for a variety of reasons, undergo little formal off-the-job training.

The potential consequences of this limited technical training are depicted at the top of Figure 5.11. As illustrated earlier in this



SOURCE: Notional depiction based on interviews with NTSB staff and other members of the aviation community, 1998–1999.

Figure 5.11--Two Notional Views of the NTSB Training Cycle

chapter, the NTSB often hires experienced personnel who enter the agency at a high skill level. Over time, however, as workload demands limit the frequency and extent of training, technical skills diminish, forcing the NTSB to rely increasingly on the party process to supply the technical expertise needed for accident investigations. The NTSB tries to manage the level of party participation so that party involvement does not threaten the independence of its investigations.

At times, the NTSB hires relatively inexperienced individuals and devotes comparatively greater resources to training them to acquire the skills needed to become productive investigators. Whether this sort of employee development path is in fact effective is somewhat unclear. Some respondents to the RAND questionnaire asserted that the NTSB cannot successfully train an inexperienced person in such a manner. Other respondents expressed concern that the high cost of training inexperienced employees leaves limited resources for training other employees.

Frustration was also expressed about newly hired employees who may not be able to immediately shoulder a part of the investigative burden, thereby creating even more work for experienced employees. Seemingly, with its limited staffing depth and heavy workload, the NTSB is not in a good position to divert senior personnel from their regular work to engage in mentoring duties.

The current state of training at the NTSB, depicted in Figure 5.11, implies a steady degradation of staff skills, a matter of concern for an agency with a national safety role. The current situation is of particular concern because, as detailed in Chapter 3, the NTSB is facing more complex accident investigations that increasingly involve design-related issues associated with high-level systems integration.

Because aircraft safety is a complex function involving the actions of many entities, including airlines, the FAA, manufacturers, and the NTSB, it would be difficult to directly attribute any change in aircraft safety to the training situation at the NTSB. The impact of insufficient training is much more subtle, such as the technical question that goes unasked or the possible accident cause that goes unexplored because the investigator does not possess adequate technical knowledge of a particular system.

Investigators have related instances of misrepresentation by parties that were uncovered only because of the technical knowledge of the NTSB staff,[33] underscoring the need to maintain a skilled staff through a combination of hiring and training.

One party representative from the aviation community privately stated to RAND researchers that information would be given to the NTSB investigators only if “they [the investigators] knew to ask the right question[s].” There is no definitive way to determine how pervasive this attitude is, but it illustrates how important it is for investigators to have enough technical knowledge to elicit needed information from parties.

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[33]Chapter 4 discusses the relationship between parties and the NTSB, and the pressures that can shape that relationship.

Many individuals interviewed by RAND felt that a training cycle, such as in the one shown at the bottom of Figure 5.11, could address many of the shortcomings of the current situation. In this desired scenario, the NTSB hires experienced employees who would be trained more frequently and to a greater extent, renewing their skills on a regular basis. Consequently, the NTSB’s dependence on parties and outside expertise would stabilize, thereby safeguarding the integrity of the accident investigation process.

Because of the nature of career paths at the NTSB, this skill renewal process should, in principle, occur throughout an investigator’s career. In the words of the NTSB chairman, “[b]ecause of the small size of the NTSB workforce, investigators tend to stay on the front lines of accident investigation throughout their careers, with few options for alternative office positions (Hall, May 6, 1999).”

We now turn from a qualitative description to more quantitative measures of training at the NTSB.

Amount of Training

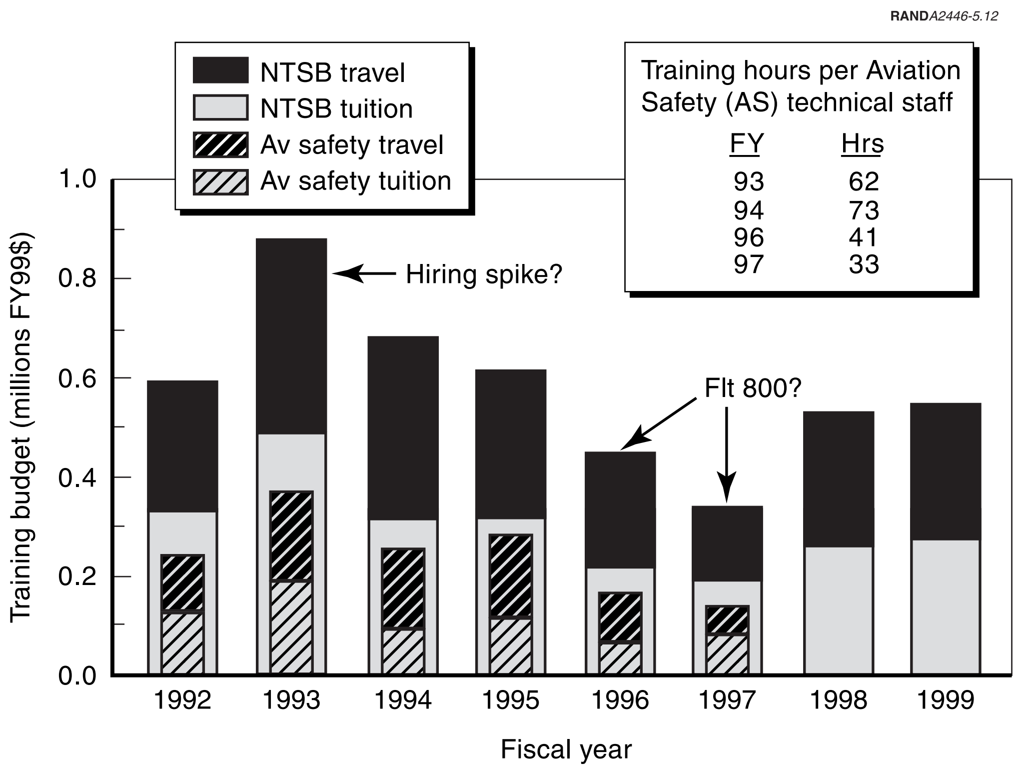
RAND used three metrics to characterize the amount of training activity at NTSB:

- tuition and travel expenditures for training derived from NTSB fiscal records
- technical staff training hours as recorded by administrative officers at the NTSB
- self-reported estimates of training activity from the RAND questionnaire.

Tuition and travel expenditures are routinely tracked in the NTSB’s accounting system. Administrative officers prepare tabulations of training hours for submittal in response to congressional inquiries. Respondents to the RAND questionnaire estimated the fraction of their work time spent in training, usually expressing the estimate to the nearest percent (equivalent to approximately 2.5 days) and occasionally to a half percent (equivalent to approximately 1.3 days).

Figure 5.12 shows that NTSB expenditures for training OAS employees fluctuated significantly during the 1990s.[34] The 1999 NTSB training budget, adjusted for inflation, approaches levels achieved during several fiscal years earlier in the 1990s; however, because of growth in the NTSB staff, the budgeted $1,400 per employee for training in fiscal year 1999 is approximately 81 percent of the fiscal year 1992 level.[35]

The NTSB does not have historical records that would explain with certainty the cause of fluctuations in training expenditures. An influx of new employees may account partially for the high expenditures for



SOURCE: Internal NTSB budget records, various years; Congressional submittals of training hours, various years.

Figure 5.12--NTSB Travel and Tuition Budgets for Training, 1992 to 1999

[34]Tuition and travel costs comprise incremental training expenses. Salary is not an incremental cost because employees are already on the NTSB payroll. An opportunity cost is associated with having employees away from the job while attending formal training.

[35]Data drawn from internal NTSB staffing and budget records.

training in 1993.[36] The time demands placed on investigators following the crash of TWA Flight 800 and ValuJet Flight 592 in the same year may have contributed to the decrease in training expenditures in the OAS in 1996 and 1997.

The NTSB's response to congressional inquiries regarding the training hours expended by the NTSB technical staff is a better measure of training activity than tuition and travel expenditures. For the years shown in Figure 5.12, OAS personnel averaged four to nine days of formal training per year, with appreciably less training in recent years.[37]

In interviews with RAND researchers, NTSB employees repeatedly asserted that heavy workloads prevented them from receiving the training they needed. We tested the relationship between the amount of training (measured in terms of hours per full-time employee for the OAS and in terms of expenditures per full-time employee for the NTSB as a whole) and workload (represented by overtime expenditures per full-time employee). Both measures of training were negatively correlated with increased workload; that is, as workload increased, training tended to decrease.[38] As has been frequently noted in this report, resolving the workload issue is an important part of any integrated effort to improve training at NTSB.

Using results from the RAND questionnaire, we tested for differences in the amount of training reported by investigators having varying experience levels and who were from different NTSB organizations. Figure 5.13 shows that employees with less experience

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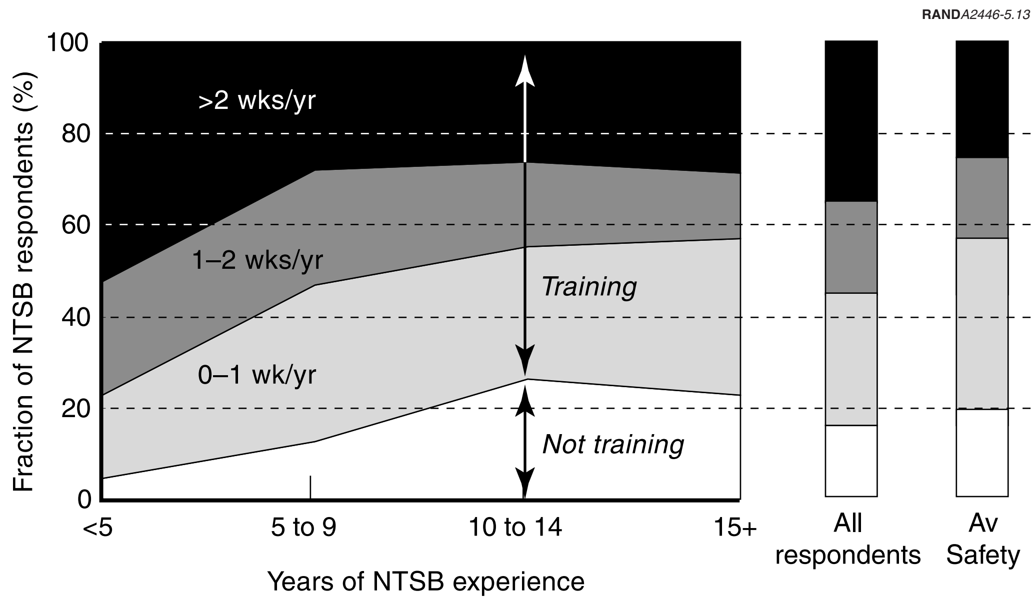
[36]Each new employee attends a basic accident investigation course taught by the NTSB.

[37]Drawn from NTSB congressional submittals for fiscal years 1993, 1994, 1996, and 1997. These submittals describe the kind of training, hours, and job classification of employees receiving the training. This measurement of training hours brackets the self-reported level of training activity--roughly six days per year--estimated by OAS personnel who responded to the RAND Skills and Experience Questionnaire in Summer 1998.

[38]Training hours and training expenditures comparisons included only four and six years of data, respectively. Both measures were negatively correlated with increases in overtime expenditures, having coefficients of determination (R-squared) of .90 and .62, respectively.



SOURCE: RAND Skills and Experience Questionnaire. Respondents numbered 149 overall and 58 OAS staff members.

Figure 5.13--Days Spent in Training per Year by NTSB Respondents According to Years of Experience

reported greater levels of training activity than those with more experience. A statistically significant difference existed between training time reported by the least experienced employees and other employees.[39]

Approximately 25 percent of the most experienced employees reported that they participate in no training whatsoever, while more than half of this group reported participating in training for a week or less per year. These more experienced employees also reported working a somewhat longer workweek.

Levels of reported training activity also varied across organizations. OAS respondents reported less training than staff in other NTSB organizations.[40] The most pronounced differences were between headquarters-based OAS personnel and all other NTSB employees.

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[39]Differences were statistically significant at the 90 percent confidence level or greater. See Appendix D for a more complete description of these statistical tests.

[40]Differences in reported training activity in the OAS and the rest of NTSB were significant at the 99 percent confidence level.

Data about training activity levels at the NTSB are more meaningful when viewed in a broader context. Table 5.9 compares typical training levels for the airlines and the NTSB. Over time, the airline industry has developed a level of training activity for its personnel that satisfies internal requirements as well as the requirements of the FAA.

Because airline personnel regularly operate flight equipment (70 to 85 hours of flying per month), they acquire a high degree of familiarity with their equipment on the job, which they supplement with formal training. They do not, however, need the accident investigation and project management skills that NTSB investigators require. Therefore, the full spectrum of training necessary for NTSB investigators is not captured by comparisons with the training received by airline personnel. Nonetheless, airline training activities provide useful indicators of the sort of training needed in order to become familiar with aircraft systems and their operation.

Table 5.9

NTSB and Airline Training Activities

Training	Description	Amount of Training
NTSB OAS	Measured, FY93-94	7-9 days/year
	FY96-97[a]	4-5 days/year
	Self-reported estimates	~6 days/year
Airline flight training[b]	Recurrent	4-6 days/year
	Type rating	20-26 days
	Home study	0.6 days/year
	Flying time	70-85 hours/mo
	Duty time	100+ hours/mo
Airline maintenance training[c]	Senior mechanic	10-12 days/year
	Junior mechanic	20-40 days/year
	On-the-job training	1.5-2 times formal

[a]Based on NTSB congressional submittals, various years.
[b]Landry, June 1999; Federal Aviation Administration, 1998b.
[c]Culhane, June 1999; Utecht, May 1999.

Conversations with flight and maintenance training managers confirm that airlines typically engage in considerably higher levels of formal training than does the NTSB. Characteristically, airlines also offer broad opportunities for on-the-job training, both in the form of day-to-day work experience and through structured training activities.

Flight crew members staying with the same airplane type and crew position typically perform recurrent training once a year for a minimum of four days, with the training split evenly between ground school and simulator training. Crews that fly long haul over water routes and fly low-cycle routes (with fewer takeoff and landing opportunities) may train several additional days per year to satisfy their training requirements.

Flight crew members who are switching to a new airplane type or upgrading from one crew position to another undergo more extensive training. This training lasts at least four weeks and is split evenly between ground school and simulator training. Other training requirements can add slightly more than a week to these totals.

Although accident investigators do not require the same level of flying proficiency as airline pilots, much of the airline training is nevertheless applicable to NTSB needs, including knowledge of flight crew procedures, piloting techniques, aircraft systems operation, interactions with air traffic control, and aircraft flight characteristics. Yet, the *minimum* annual formal training time for an air carrier crew member--four days--is approximately equivalent to the *average* amount of training OAS investigators underwent in fiscal year 1997, including management, investigative, and technical training. Airline crew members moving to a new airplane type or crew position log at least four times more training days than the average OAS staff member logged in fiscal year 1997.

Senior airline maintenance personnel typically undergo two to two-and-one-half weeks of formal training per year, while junior personnel may train two to three times that amount per year. This training includes familiarizing mechanics with aircraft systems and their operation, a subject area that is also of interest to NTSB investigators.[41]

Airlines also use a “buddy system” for structured on-the-job training. Experienced mentors accompany junior mechanics on the job, helping them learn new tasks. The number of hours spent in this type of informal training can be several times that spent in formal training (Utecht, May 1999; Culhane, June 1999).

Collectively, the comparison of training by the NTSB and the airlines suggests that the amount of formal technical training received by the NTSB’s OAS staff falls short of industry standards for acquiring and maintaining familiarity with aircraft systems and their operation. In addition, NTSB staff members do not enjoy as rich a set of on-the-job training opportunities as do airline personnel, reinforcing the need for formal training to supplement experience on the job.

Sources of Training

Most OAS staff training is provided by the NTSB and, to a lesser extent, by aircraft manufacturers.[42] Respondents to the RAND questionnaire also cited professional societies as a common source for acquiring technical knowledge. Other U.S. government agencies, temporary personnel exchanges, and aviation operators were infrequently cited as sources of training opportunities. Figure 5.14 depicts the fraction of respondents that mentioned each training source.

RAND researchers questioned aircraft manufacturers and airline operators about offering training opportunities to NTSB personnel. Virtually all of these organizations expressed a willingness to allow NTSB participation in the training courses they sponsor for their own

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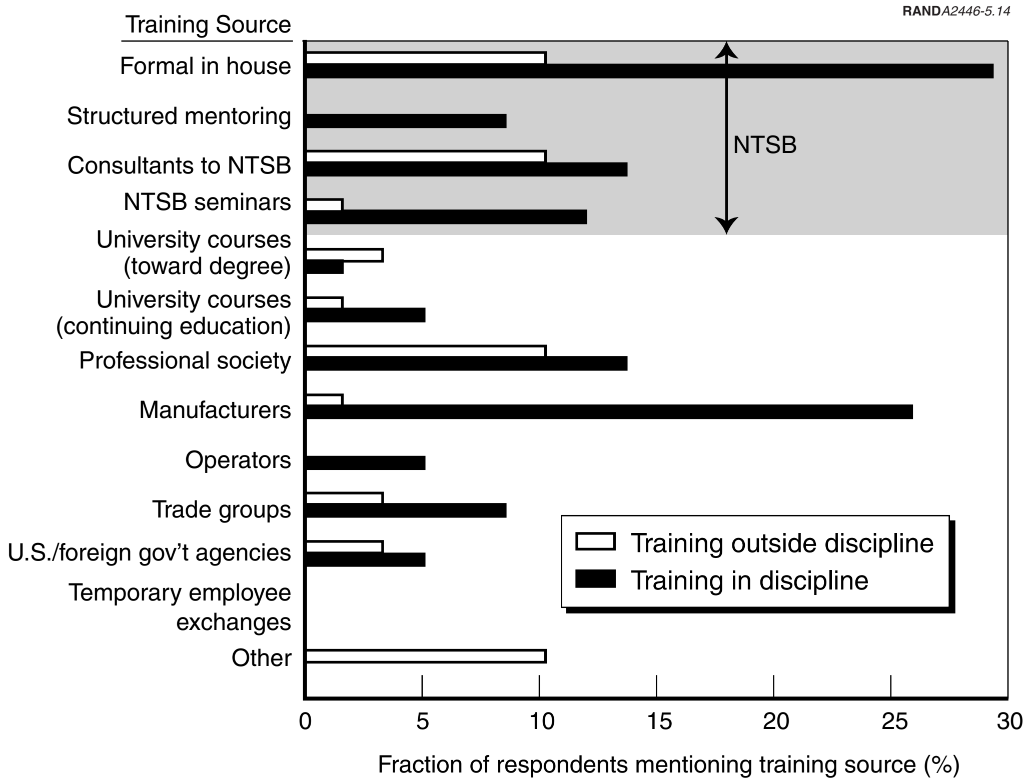
[41]Other aspects of maintenance training, such as process training (for instance, learning how to prepare a metal surface for painting), may have less applicability to the skill set needed by NTSB investigators.

[42]The RAND questionnaire asked employees to identify sources of training beyond their everyday on-the-job experience. According to NTSB staff interviewed by RAND, on-the-job experience is particularly useful in acquiring accident investigation skills; the NTSB also requires that its staff participate in a formal in-house course in basic accident investigation.



SOURCE: RAND Skills and Experience Questionnaire. 58 people responded from OAS Headquarters and Regional Aviation Offices.

Figure 5.14--Training Sources Used for Professional Development by OAS Staff

employees and customers, and a willingness to offer those courses at a reasonable cost.[43] The manufacturers and operators interviewed by RAND suggested that their interests are better served when investigations are conducted by informed and skilled investigators. According to the manufacturers and operators, the NTSB rarely takes advantage of these training opportunities.

Manufacturers frequently offer their customers computer-based training (CBT) in operations and maintenance. CBT, which is being widely adopted by the aviation community, may permit some training to be accomplished in home offices without incurring travel expenses.

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[43]One airline manager mentioned that many FAA employees participated in his company's courses at no charge. He believed the same policy could be applied to NTSB employees, but was not aware of any NTSB participation to date.

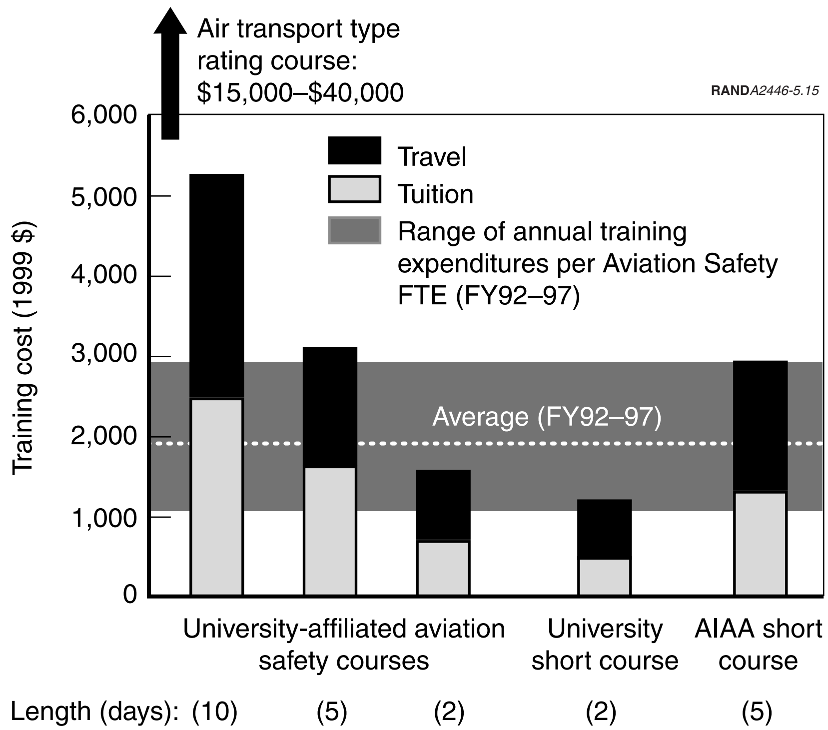
Manufacturers also suggested other possible settings for deriving knowledge about aircraft systems, such as certification review meetings for new aircraft systems (McWha, November 1998).

NTSB staff identified several factors inhibiting the fuller exploitation of training opportunities outside the NTSB. In addition to the most common impediment--heavy workload--employees mentioned the lack of an effective system for communicating the availability of training opportunities, the absence of a clearly articulated policy regarding accepting training from the private sector, limited tuition funding, and course length. No single NTSB organization is responsible for developing an integrated set of information about training opportunities (this issue is discussed in more detail later in this chapter). Because the process is neither centralized nor uniform across offices, training opportunities are undoubtedly missed, as are opportunities to coordinate training across regional and headquarters offices.

NTSB staff members also expressed uncertainty about the rules regarding accepting training opportunities from the private sector, citing the importance of maintaining public confidence in the NTSB's independent status.[44] RAND discovered that no written policy exists regarding the propriety of accepting private-sector training opportunities. Rather, these situations are resolved on a case-by-case basis by the NTSB General Counsel (Campbell, March 1999). While many staff members expressed no reservations about taking advantage of such training opportunities, staff interviews suggest that the lack of an articulated policy on the matter may contribute to a reluctance on the part of some staff members to explore using outside training.

The NTSB relies principally on its own internal training course to educate new employees in accident investigation techniques, rather than relying on courses offered by several private and university-affiliated schools. As Figure 5.15 shows, tuition and travel costs for these

[44]The Independent Safety Board Act exempts NTSB from rules on receiving gifts in order to assure operating flexibility in the emergency situations in which NTSB operates; 49 U.S.C. §1113.



SOURCE: University of Southern California, Aviation Safety Program; Embry-Riddle Professional Program in Aviation Safety; American Institute of Aeronautics and Astronautics; internal NTSB budgetary records on tuition and travel budgets for training, various years; personal communications with NTSB aviation safety investigators, Summer, 1998.

NOTE: The figure depicts the cost (actual tuition and estimated travel costs) for 10-, 5-, and 2-day accident investigation courses offered by the University of Southern California, a 2-day course on human factors in aircraft maintenance offered by Embry-Riddle, and a 5-day course in conceptual aircraft design offered by the AIAA.

Figure 5.15--Costs of Private-Sector Aviation Training Courses vs. NTSB Funding for Training

outside courses often exceed the NTSB's training budget allocated annually per full-time employee.[45] Greater participation in outside

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[45]Average expenditures for tuition and travel associated with training amounted to about $1,900 per full-time employee in the OAS between FY 1992 and FY 1997, when expenditures are normalized across all employees in that organization. Aggregate budget records did not permit us to distinguish between tuition and travel expenses for clerical and technical staff. We would expect the technical staff accounted for most of the training expenses. If budgets are normalized excluding clerical workers, the average expenditure per staff member increases by 21 percent, to about $2,300 per year between FY 1992 and FY 1997. Source: internal NTSB staffing and budget records.

training opportunities would require increases in the NTSB’s tuition and travel budgets.

Although additional investments in training are needed, such investments only make sense after the NTSB adopts measures to mitigate its workload problems so that employees will have time to take advantage of expanded training opportunities.

Administration of the Training Process

The NTSB has improved some aspects of its training process since RAND began its study. However, the process still remains largely decentralized and it suffers from a lack of coordination. A brief description of the process illustrates some shortcomings and also some recent improvements.

Training budgets are given to the individual regional offices and headquarters office.[46] Office directors, in consultation with individual employees, identify training opportunities and decide what course of training is appropriate. While some training opportunities are common knowledge, many are not. There is no agency-wide focal point to identify and catalog training opportunities.

NTSB policy stipulates that new investigators must take certain required courses, such as the basic accident investigation course.[47] Employees are also required to take courses covering a range of management and administrative topics, including government ethics, sexual harassment, procurement procedures, and other subjects.

Beyond these basic training requirements, however, RAND found no agency-wide standards for training personnel within each job title, although some individual regional offices have laid out course needs for various job titles.[48] Moreover, training program formats and time

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[46]Actual budgets are often not available until several months after the beginning of the fiscal year; therefore, directors estimate available funds from the prior year’s budget (Mucho, March 1999).

[47]The chief of human performance in the OAS is also responsible for administering NTSB’s basic accident investigation course. This course is generally held off-site because the NTSB’s headquarters facilities have traditionally been limited in size.

[48]Mr. Gene Sundeen, Deputy Director, Regional Technical/ Investigative Operations, provided course lists, called “Individual Development Plans” or IDPs, which were developed by one regional office

horizons differ from office to office, making it more difficult to conduct strategic planning on training for the agency as a whole.

A new computerized tool that tracks the training activities of individual employees was introduced at the beginning of fiscal year 1999 to replace the tedious manual record-keeping. This tool records an employee’s training activities and schedule, but does not serve as an agency-wide repository of information about training opportunities. After each training activity, the employee is required to evaluate the training received. This material is compiled in book form for the NTSB chairman’s review.[49]

If fully implemented, the aforementioned tracking tool will help keep tabs on the training activities pursued by individual employees. Nevertheless, the NTSB training process will still have its shortcomings, including the following:

- absence of an individual or department to serve as the NTSB advocate for training, and who will manage the NTSB training program, assist in formulating training policy, and serve as the NTSB’s main point of contact on training to the aviation (or broader transportation) community domestically and overseas
- lack of an agency-wide database that catalogs training opportunities
- lack of consistent training plans and training standards across offices
- absence of a clearly articulated policy regarding participation in private-sector training opportunities.

By addressing these shortcomings, the NTSB could materially enhance its training processes and support improvements already being implemented.

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for several air safety investigator positions. Periodically, regional offices have tried to coordinate efforts to identify training standards for their staffs, but we found no agency-wide articulation of standards.

[49]As of this writing, this tool is being used by the administrative officer within the OAS. Plans call for it to be used throughout the agency (Case-Jacky, April 1999).

Training Content

As discussed earlier in this chapter, members of the aviation safety community divide the skills needed by accident investigators into three general categories: management, investigative, and technical.

The NTSB views management training as particularly important because of the increasing complexity of organizing and controlling a modern accident investigation. Management training is especially important for IICs because these individuals must coordinate the work of all the parties at the accident scene. As a result, management training has been emphasized in recent years.

Nevertheless, technical training remains critically important at the NTSB. Because investigators must be familiar with the full range of technology associated with modern aircraft operations in order to elicit information about an accident's cause from party experts, technical training is given high priority for investigators who manage party subsets, such as a group chairman for propulsion.

Within the management, investigative, and technical training categories is a wide variety of subjects of interest to the NTSB. In 1997 and 1998, a team from two NTSB regional offices compiled a list of subjects.[50] This list, provided in Table 5.10, contains both current and proposed new subjects.[51] While some of these courses can be completed in hours or a single day, others require days or weeks of instructional time. Although managers and employees would undoubtedly select a subset of these courses commensurate with an employee's specific skill needs and position, the total list (and the potential instructional time it represents) would dwarf the limited training time currently available to aviation investigators.

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[50]This subject list was compiled by Mr. Gene Sundeen, 1999, and Dr. Gary Mucho, Regional Director, Southwest Regional Office (retired). The study topics listed in Table 5.10 reflect a systematic approach to identifying the range of skills and course needs of the NTSB's aviation technical staff. Senior managers can use a similar compilation (updated as needed) as a point of departure for reviewing staff capabilities and designing a set of classes to ensure professional skill development and maintenance.

[51]Training in basic and advanced computer skills (not shown) is also provided to NTSB technical staff.

Using the four years of NTSB records assembled for Congress, RAND examined the comparative amount of training that OAS staff received in each of the three major skill areas listed in Table 5.10. Figure 5.16 portrays the results. Technical subjects (which includes the technical, flight training, and operations categories) accounted for more than half of the training. This is not surprising, given that technical knowledge tends to be more "perishable" than management skills or accident investigation skills.[52] It is surprising that "human factors" training accounted for only 1 percent of all training hours. Given the critical position human factors occupies in many accident investigations, RAND expected this subject area to account for a larger proportion of NTSB training.[53,54]

As Figure 5.16 shows, OAS investigators devote about 10 percent of their training time to maintaining pilot proficiency (currency) and qualifying pilots to fly new types of aircraft (type rating). Depending on the arrangements with the training provider, training for a type rating can be one of the most expensive and time-consuming kinds of training. Airline training managers suggested that in less than a week,

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[52]Conceptually, technical training might be further subdivided into training required for skill acquisition and that required for skill renewal. In the former case, gaps in knowledge or the introduction of new technology can create a need for skill acquisition. In the latter case, because accidents occur infrequently, the equipment involved varies from accident to accident, and each accident cause can drive an investigation in a different direction, knowledge retention can be a challenge for accident investigators. Aircraft maintenance managers we interviewed emphasized the constant turnover of technology. For example, the Boeing 777 makes extensive use of digital systems and features a high degree of integration, making it extremely different from many of the older aircraft in the air transport fleet. This kind of turnover in technology creates new training requirements for the airlines (Utecht, May 1999).

[53]Human factors scientists at the NASA Ames Research Center suggested to RAND that greater interaction between their research staff and NTSB investigators could benefit both organizations (Connors and Statler, September 1998).

[54]Accidents traditionally labeled as being caused by "pilot error" are increasingly viewed as being caused by design flaws or problems in the human-machine interface. An accurate diagnosis of accidents caused by system error rather than operator error nevertheless requires human factors expertise. See Chapter 3 of this report.

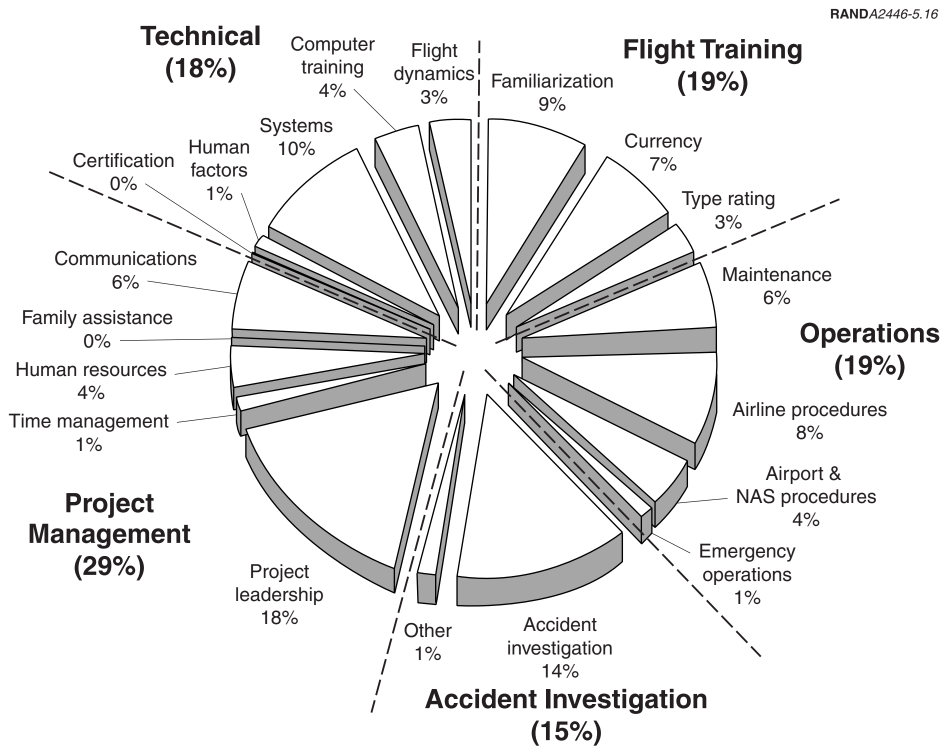
Table 5.10

Suggested Study Courses Identified by Regional Offices

Accident Investigation	Management, Administrative	Technical
Basic accident investigation	NTSB orientation*	Basic aircraft engines
Basic helicopter investigation	Procurement procedures*	Basic aircraft systems
Underwater investigation	Government ethics briefing*	Basic aerodynamics
Accident investigation photography	Office budget procedures*	Glass cockpit technology
Mid-air collisions	Time management*	Composite analysis tech
In-flight fires	Board orders*	Human performance
In-flight breakups	Equal Employment Opportunity (EEO)*	Biohazards
Air carrier incidents	Sexual harassment*	Basic failure analysis
Group chairman training	OPM regulations	Air traffic control procedures
IIC go-team training	Time and attendance	Jumpseat procedures
Tech review panel participation	Budget/accounting practices	FAA regulations
Accredited representative training	Technical conference	FAA refresher course
Board hearing participation	Technical writing	Aircraft operations
Board meeting participation	Project management	Radar plot program
Report writing	Leadership courses	Global Positioning Satellite systems introduction
Media interaction	Conflict management	New aircraft technology
Advanced course	Decisionmaking	Aircraft manufacturing processes
	OPM supervisor's course	Foreign aircraft manufacturing processes
	Problem employees	

*Identified by regional offices as required NTSB training.

SOURCES: Individual Development Plan course lists, NTSB Southwest Regional Office, 1997 and 1998.



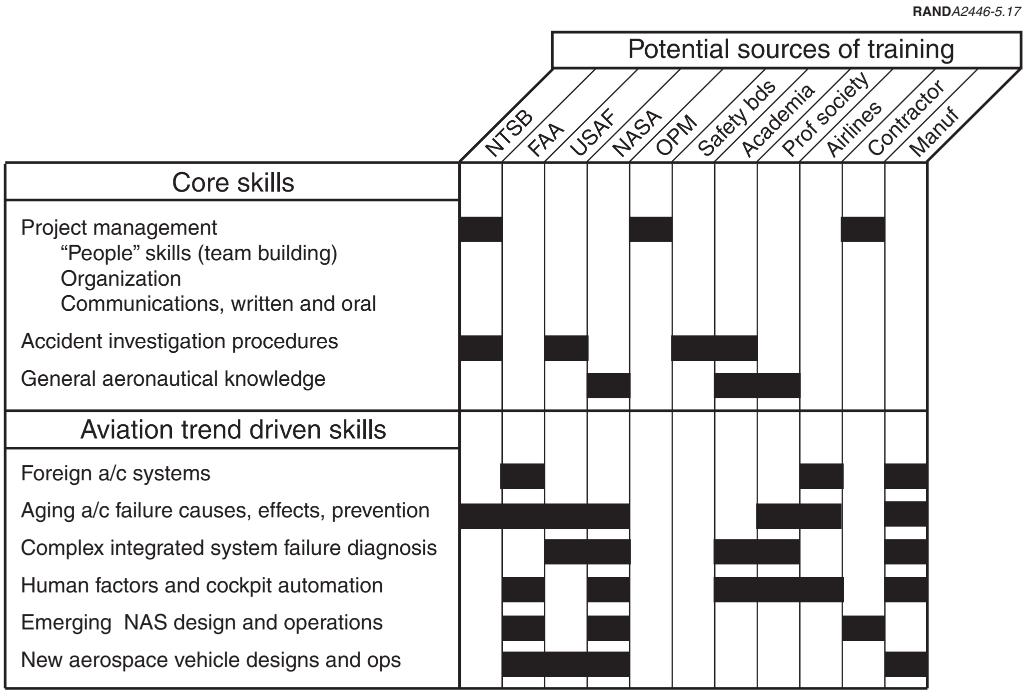
SOURCE: NTSB submissions to Congress of training activity, 1993–1994, 1996–1997.

Figure 5.16--Training Hours, OAS Technical Staff (Headquarters and Regional Offices), 1993 to 1994

an individual can get a strong foundation in aircraft systems by using CBT, attending two sessions in a full-motion flight simulator, and occupying the jump seat on operational flights with a line crew for a day (Landry, June 1999).

In the same four-week period now required to obtain a type rating in just one type of airplane, this alternative training approach could familiarize an NTSB investigator with four airplane types. The multiplicity of aircraft types an accident investigator may encounter suggests that the NTSB may want to carefully reassess the current allocation of training hours among the familiarization, currency, and type rating training components.

RAND’s review of NTSB operations in light of the emerging aviation environment suggests there will be no diminution in the need for project management and accident investigation skills or general aeronautical knowledge in the foreseeable future. Figure 5.17 presents a notional



SOURCE: Interviews with NTSB accident investigators at headquarters and regional offices; survey of emerging aviation trends.

Figure 5.17--Continuing and Emerging Skill Areas for Investigators

summary of the sources of government and private sector training the NTSB could consider if it elects to expand its training curricula. This figure suggests that new alliances with the DOD and NASA could offer extensive training opportunities.

Beyond providing training in the core skills listed in Figure 5.17, the NTSB will need to prepare its staff for the emerging aviation environment (discussed in more depth in Chapter 3). Some amount of training may simply involve expanding upon current knowledge, such as familiarity with foreign aircraft systems and aging aircraft, both of which the NTSB has dealt with to some degree in the past. In other cases, instruction in new systems and operational procedures, such as the NAS architecture and the design and operation of reusable launch vehicles, may require a more substantial investment in training. Potential sources of training on these leading-edge skills cut across virtually every segment of the aviation community.

A workforce possessing the skills listed in Figure 5.17 can help the NTSB meet aircraft accident investigation challenges well into the next century. However, because of its limited staffing depth, the NTSB will need to determine how its workforce can best absorb those skills. Training staff members across disciplines via formal sessions and by rotating staff members through the various NTSB offices would create a larger number of generalists, giving the NTSB more robust investigation capabilities.

This approach to skill acquisition could supply another important benefit by helping to “grow” new IICs. Staff rotation could also allow IICs to “decompress” from particularly demanding assignments, refresh staff members by varying their assignments, and make the technical and operational communities at the NTSB less insular. In short, the content of training and the means by which it is conveyed to the workforce are equally important factors when addressing staffing and training issues at the NTSB.