Staffing Standards for Aviation Safety Inspectors

DETAILS

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William C. Howell and Susan B. Van Hemel, *Editors*

Board on Behavioral, Cognitive, and Sensory Sciences
Division of Behavioral and Social Sciences and Education

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Preface

This report is the result of one and one-half years of effort by a committee of nine experts. The study was performed in response to a congressional mandate and a contract from the Federal Aviation Administration (FAA). The task, in short, was to study the current and past processes used by the FAA to determine their staffing needs for aviation safety inspectors and to provide guidance on ways to improve the staffing process. The committee gathered regulatory materials, reports, and other documentation from the FAA and other sources, listened to briefings and presentations by FAA headquarters managers and many stakeholders from the aviation industry and related communities, interviewed aviation safety inspectors (ASIs) and managers at their job sites, and reviewed the literature on staffing methodology relevant to the FAA's situation. Using all of this information and its combined expertise, the committee has attempted to provide the FAA with its best advice on methods for determining the need for ASI staffing.

Members of the study committee, volunteers selected from several academic and professional practice specialties, found the project an interesting and stimulating opportunity for interdisciplinary collaboration. They cooperated in work groups, learned each other's technical languages, and exemplified in their work the collegial qualities that are among the National Academies' unique strengths. The Academies are grateful to them for their hard work, expertise, and good humor.

On behalf of the committee I would like to express my appreciation to the many other people who contributed to this project. At FAA headquarters, Robert Caldwell, Kevin Iacobacci, Regenia Ramsey-Outlaw, Rosanne Marion, and Kay Kennedy-Roberts of Flight Standards Service (AFS) 160, Deane Hausler of Aircraft Certification Service (AIR) 530, and James Ballough, AFS director, provided help, including briefings, documentation, coordination in support of our field visits, and referrals to other information sources. At FAA field offices, 39 ASIs and managers took time to talk with committee members about their jobs and about staffing issues. Stakeholders from many organizations in the aviation industry came to our sessions to present information to the committee and patiently answered our many questions (participants are listed in Chapter 1). Linda Goodrich, Region 4 vice president for the Professional Airways Systems Specialists (PASS) union, was especially generous with her help. At the Government Accountability Office (GAO), Gerald Dillingham, Teresa Spisak, James Ratzenberger, and others took time to discuss with the committee staff the studies relevant to ASI staffing under way at GAO.

At the National Research Council (NRC), Susan Van Hemel, study director for the project, Christine Hartel, director of the Center for Studies of Behavior and Development, and Jim Jensen, the Academies' director of congressional and government affairs, provided critical support for the project. Three senior program assistants, Jessica Martinez, Allison Brantley, and Kristin Martin, provided administrative and logistic support over the course of the study. Kristin Martin performed manuscript preparation and bibliographic tasks as well. The executive office reports staff of the Division of Behavioral and Social Sciences and Education, especially Christine McShane and Yvonne Wise, provided valuable help with editing and production of the report. Kirsten Sampson Snyder managed the report review process. The Transportation Research Board (TRB) had a consulting role in the study. Nancy Humphrey served as liaison from the TRB, contributing valuable ideas and providing helpful comments on the draft report.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the Report Review Committee of the NRC. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

We thank the following individuals for their participation in the review of this report: Marvin S. Cohen, Office of the President, Cognitive

Technologies, Inc., Arlington VA; Kurt Kraiger, Department of Psychology, Colorado State University; John K. Lauber, Office of Product Safety, Airbus SAS, Blagnac, France; John F. Lockett III, Human Research and Engineering Directorate, U.S. Army Research Laboratory, Aberdeen Proving Ground, MD; Benjamin Schneider, Office of Senior Research Fellows, Valtera Corporation, La Jolla, CA; Daniel Serfaty, Office of the President, Aptima, Inc., Woburn, MA; Philip J. Smith, Institute for Ergonomics, The Ohio State University.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations nor did they see the final draft of the report before its release. The review of this report was overseen by Paul R. Sackett, of the University of Minnesota, and Alexander H. Flax, consultant. Appointed by the NRC, they were responsible for making sure that an independent examination of this report was carried out in accordance with institutional procedures and that all reviewers' comments were considered carefully. Responsibility for the final content of this report, however, rests entirely with the authoring committee and the institution.

William C. Howell, *Chair*
Committee on Federal Aviation Administration Aviation Safety Inspector Staffing Standards

Contents

Executive Summary

The Federal Aviation Administration (FAA) is responsible for ensuring safety in all U.S. civil aviation. Two offices within the Aviation Safety (AVS) organization enforce and maintain aviation safety regulations and promote safety in aviation. The Flight Standards Service (AFS) is charged with overseeing aviation operations, maintenance, training, and other programs, and the Aircraft Certification Service (AIR) is charged with ensuring the safety of aircraft design and manufacture. In 2005 there were over 3,600 aviation safety inspectors (ASIs): about 3,450 in AFS and 175 in AIR.

The number of these inspectors employed by the FAA has changed little over the past several years, although aviation industries have been expanding and changing rapidly. Also, the FAA has made more use of what it calls designees—nongovernment employees certified to act on behalf of the FAA—to assume some of the responsibilities formerly assigned to aviation safety inspectors. There is concern in several communities that the staffing levels of safety inspectors may not be adequate to fulfill the FAA's responsibilities. The Aviation Subcommittee of the Committee on Transportation and Infrastructure of the U.S. House of Representatives responded to these concerns by mandating the current study in the Vision 100—Century of Aviation Reauthorization Act.

The Committee on FAA Aviation Safety Inspector Staffing Standards was consequently established at the National Research Council to examine the models and methods used to determine inspector staffing needs for these two FAA units. The objective of the study is to determine the strengths and weaknesses of the methods and models that the FAA now uses in developing staffing standards and projections of ASI staffing needs and to advise on potential areas for improvement.

The term "staffing standards" is used in this report to denote the FAA's concept of sheer *numbers* of personnel required to fill specified jobs, without regard for quality or skill levels. While the term is often used to refer to levels of qualifications or skills needed by individuals for particular jobs, it is not used in that way by the FAA. The FAA uses "staffing standards" to refer to the numbers of personnel of various job categories deemed appropriate to staff its facilities.[1]

The distinction between individual and collective standards represents a long-standing functional demarcation used in the professional human resource and staffing community. Determining and providing the number of personnel in various categories that an organization needs to accomplish its goals (the current AVS focus) is a *manpower planning and management* function, whereas describing and classifying jobs and establishing the knowledge, skills, and abilities (KSA) requirements for each are considered *human resource* or *personnel management* functions.

The formal task statement from the FAA's contract with the National Research Council reads:

> 1. Critically examine the current staffing standards for FAA Aviation Safety Inspectors and the assumptions underlying those standards. The committee will confine its study to ASIs only; other inspector jobs will not be considered. The committee will not consider issues of compensation, work rules, or similar labor relations matters.
>
> 2. Gather information about the ASI job series and about the specific factors that may characterize the FAA as an organization and the ASI job series that would influence the choice of methods that might best be used to develop staffing standards; for example, it will compare engineered to performance-based staffing standards.
>
> 3. Review the staffing models, methodologies, and tools currently available, and some of those in use at other organizations with important similarities to the FAA, and determine which might be applicable or adaptable to the FAA's needs.
>
> 4. Propose models, methods, and tools that would enable the FAA to more accurately estimate ASI staffing needs and allocate staffing *resources* at the national, regional, and facility levels, particularly in light of the occasional but urgent need to reallocate resources on short notice.
>
> 5. Estimate the approximate cost and length of time needed to develop the appropriate models.

[1]Throughout the report we have tried to use the term "staffing" to denote only manpower-related functions or issues.

Since this statement of task is directed exclusively toward *manpower planning and management* issues (i.e., the adequacy of staffing "standards" and models), the committee focused its efforts accordingly. However, we recognized from the outset that any attempt to assess or improve the FAA's overall staffing operation would be impossible without first engaging a critical set of *human resources and personnel management* issues (e.g., the adequacy of job descriptions, qualifications, performance measures). Simply put, unless one knows precisely what the various inspectors are expected to do, what qualifications they must have to do it, how the quality of their performance is distinguished, and what the consequences of different performance levels are, it is impossible to determine how *many* inspectors the system needs to function properly—no matter how appropriate and sophisticated the staffing models that are used. Since the level of effort required to address these human resources and personnel management issues extends well beyond this committee's charge and resources, yet is so critical to the ultimate goal, we deemed it our responsibility to articulate clearly the need while focusing our attention on the specific charge.

The committee, therefore, proceeded to develop criteria for key features and functions of a staffing model to meet the FAA's needs. We then evaluated several staffing model approaches, some that are used or proposed by the FAA as well as those of several other public-sector organizations, against those criteria. The results of this evaluation inform our recommendations for the FAA's future staffing model development. In this way we have addressed the formal charge while emphasizing that these modeling recommendations are contingent on seriously engaging the human resource and personnel management issues.

CONCLUSIONS AND RECOMMENDATIONS

Important Factors to Be Considered in Model Development

The Changing Aviation Landscape

The changing U.S. and global aviation landscape has important implications for ASI staffing. Five features are expected to be especially important drivers of future staffing needs for ASIs:

1. introduction of advanced flight deck and air-ground technologies,
2. increasing number of variants and derivatives of aircraft and systems,
3. continuing growth in regional carrier and general aviation operations,

4. outsourcing and offshoring of maintenance, and
5. new manufacturing tools and techniques.

Changing FAA Policy and Business Practices, Attrition, and Retirements

Four areas of change within the FAA are particularly noteworthy with respect to their implications for future ASI staffing needs:

1. the increasing use of designees,
2. the shift to a system safety approach,
3. regulatory changes, and
4. attrition and retirements of safety inspectors.

FAA Human Resource Management Practices

The committee's first goal is to "critically examine staffing standards for FAA Aviation Safety Inspectors and the assumptions underlying those standards." We detected the following qualitative issues related to current human resources (as distinguished from manpower) management practices that were intrinsically linked to the determination of the demand for aviation safety inspectors, and that should be addressed before the development of a staffing model is attempted:

- new knowledge demands of system safety approaches,
- new skill demands to support new ways of working with industry,
- new and continuing technology knowledge demands,
- failure of job specifications to adequately capture current job requirements or to accommodate changes, and
- lack of job performance criteria.

Evaluation of FAA Models

All organizations base staffing decisions on a paradigm of the underlying production process, whether they do so explicitly or not, and whether it approaches reality or not. This conceptualization is often referred to as a staffing model. The committee's charge is cast in those terms—we were asked to examine and evaluate the FAA's models as well as possible alternatives for the staffing of ASIs.

The Holistic Staffing Model was initiated by AFS in response to a safety review conducted following the 1996 crash of a ValuJet aircraft. As the model design evolved, it became clear that AFS could not implement the model cost-effectively, and the effort was discontinued in 2002. More recently, the Automated Staffing Allocation Model (ASAM) was developed by AFS as a forecasting and planning tool for staffing needs.

In AIR, a different staffing approach is used for the inspectors responsible for aircraft design and manufacture. AIR's staffing standards primarily depend on a work recording system that lists activities, products, and services to record inspectors' work. The system has also used time standards (in hours) based on job task analysis and observation and on actual hours recorded in labor reporting systems.

Conclusions

In reviewing the two comprehensive models of staffing demand—ASAM and the aborted Holistic Staffing Model—against the features we consider essential, the committee concludes that both fall short in certain areas. ASAM, as currently structured, appears deficient in at least the following respects:

- It does not predict the consequences of staffing shortfalls at any level, a primary criterion for most staffing models.
- It fails to account for some important factors affecting inspector workload.
- Many of its key parameters derive from expert judgment and have not been empirically validated. Hence it is not an empirically based model.

The holistic model, while potentially closer to the structure we consider appropriate, was lacking in the following respects:

- The documentation suggested statistically weak univariate methods for estimating parameters.
- It appears to be quite detailed in its structure, almost certainly exceeding a level that available data could support.
- There was no discernible plan for formal model validation, nor was it clear precisely what predictions the model would make regarding the consequences of alternative levels of staffing.
- Most importantly, the model was never developed or tested, so its potential utility and validity are unknown.

Recommendations

In view of the above limitations and of good software development practices, neither the ASAM nor the holistic model offers a promising departure point for a future staffing model. We therefore recommend that any effort directed toward improving the FAA's approach to addressing the need structure for ASIs begin afresh. Both ASAM, as it exists, and the holistic model, as it was described, provide a rich store of knowledge that would be useful in developing a new modeling approach. In particular, the existing documentation and the knowledge and experience of the FAA staff involved in the development of these models should be tapped in any new development effort. We emphasize, however, that the total cost (financial and otherwise) involved in attempting to preserve the basic structure of the ASAM model, or to replicate the holistic approach, while overcoming their limitations would far exceed that of creating a model with all the essential features unencumbered by such considerations.

Evaluation of Potential Alternatives Adapted from Other Organizations

In addition to the models that the FAA presented for review, the committee examined manpower and staffing models from other organizations for their potential relevance to our task. Because of the proprietary nature of staffing for any business, we had a very limited opportunity to review and document staffing models from private industry. However, we were able to review a number of public-sector manpower planning models, tools, and processes that resemble the staffing situation for safety inspectors in at least some respects. They include airport security staffing, distributed service networks, Air Force manpower assessments, Army manpower analysis and modeling, Navy manpower modeling, the U.S. Environmental Protection Agency, state courts, and the FAA's Air Traffic Controller staffing model.

Conclusions

Our analysis of approaches used by these organizations that bear a resemblance to the FAA, as well as of the approach used by the FAA's air traffic control organization, reveals that in certain key respects there is little potential for direct transfer—or adaptation—of any of these models to the staffing situation for aviation safety inspectors. In each case, unique features far outweigh the common ones, and the solutions that have evolved reflect that diversity.

Recommendations

The staffing challenge for aviation safety inspectors is sufficiently distinctive to rule out the option of importing, in whole or in part, an already developed model. Therefore, improvement over current practices can be achieved only through development of a new model, drawing on both the FAA's previous experience with modeling efforts and careful consideration of the salient model properties described in this report.

Model Development in Light of Unit Differences

Conclusions

The staffing situations in the two FAA units responsible for aviation safety are markedly different. With over 3,400 inspectors widely distributed across functional and geographical job domains and the obvious deficiencies in its ASAM model, AFS is clearly in a position to benefit from (and justify the cost involved in) developing a new model. By contrast, it would be difficult to justify a costly modeling effort for staffing the fewer than 175 inspector positions in the AIR organization, especially since the approach currently in use appears to be generally satisfactory.

The challenge facing AFS is considerably larger and more complex. To be demonstrably effective, a staffing model must incorporate accurate representations of workforce supply and demand, applying well-designed algorithms to produce accurate projections of staffing needs and the consequences of staffing shortfalls. It should also enable frequent updates and changes to the work processes. Most important of all, it must be integrally linked to appropriate measures of individual and system performance, without which its validity and utility cannot be established.

Recommendations

AIR. The committee recommends continued effort aimed at improving the work recording systems for the AIR inspectors rather than development of a new staffing model at this time. Should significant changes in the workload drivers appear in the future, the current staffing approach might warrant another review.

AFS. We recommend that the FAA initiate a systematic effort to make a fresh analysis of the staffing need structure and develop a suitable model, using recently developed software tools and methods. We elaborate this recommendation below.

1. The approach should draw on the FAA's previous experience with ASAM and the Holistic Staffing Model, but it should not attempt to preserve the architecture of either of these models. The development process should include the following phases:

- requirements definition,
- model specification,
- model development, and
- model verification and validation.

We recognize that the initial development and appropriate testing of a new model will require an up-front investment and take time. However, weighing it against the long-term benefits afforded by a model capable of estimating overall staffing needs, optimal distribution, and understaffing consequences, we recommend making that investment, after careful consideration of the factors discussed below.

2. The modeling effort should be undertaken with the goal of supporting FAA decision making in both *sufficiency* decisions (predicting the resources needed to sustain system performance at an acceptable level) and *allocation* decisions (distributing available resources equitably and effectively irrespective of their collective adequacy). Most importantly, it should be empirically based, although certain relationships may necessarily be established through expert judgment—at least initially. We recommend that the model designers explicitly consider which aspects of the model should be process-based and which based primarily on statistical relationships. For example, routine tasks that have a long history of performance could probably be modeled statistically, while new or modified tasks may require more detailed process modeling. More precise specification than this would require a far more comprehensive analysis than was possible within the scope of the present study.

3. Appropriate measures of system and individual performance are essential for both the development and validation of *any* improved staffing approach, irrespective of model properties and features. We therefore recommend that a concerted effort be invested at the outset in developing meaningful performance indices. We recognize that this is not a simple matter, and that heavy reliance on expert judgment at all levels will be necessary in order to devise measures that are both meaningful and widely accepted.

4. One of the most significant weaknesses in the current modeling practices is the burden of entering data to populate the model prior to making predictions. Hence we recommend that any future model should be designed so that it can be supported by institutionalized administrative databases, not by ad hoc surveys or other extraordinary data sources.

5. In addition to model features per se, the FAA and those assisting

with the development of a staffing model must consider the following additional issues, mostly of a practical nature, that bear on model implementation.

Cost. It was difficult for the committee to estimate the cost of designing, developing, operating, and maintaining a staffing model for aviation safety inspectors with the information available to us, and the estimate presented here necessarily is based on assumptions about the modeling environment. Our best estimate is that it will take about $600-800K to design and build the modeling tool, $300-400K to initially populate the model with data and develop mechanisms to keep the data updated, and perhaps $100K per year to keep the model and data current. There are many uncertainties that could affect the cost, including the availability of the needed data in easily usable form, the number of variables and level of detail that must be represented in the model, and the choice of method and of model developers.

Time. The previous experience of committee members suggests that one to two years will be required to go through the development process that we recommend, if it is performed by an FAA-contractor team. Development of a model using only FAA in-house resources would be very likely to take longer. By the end of this period, a working model should be in place. However, the model itself will continue to evolve over time as data are accumulated on its functioning, and inevitably adjustments will need to be made. We recommend that the development of a new model be undertaken in full recognition of this evolutionary requirement.

Organizational constraints and culture. Perhaps the most critical determinants of a model's long-term value are the organizational constraints and culture in which it is introduced and maintained. If the model is perceived as merely creating work for its own care and feeding (e.g., gathering data to populate it) rather than as a valued aid to decision making, it will fail. Therefore, once a model is developed, its value must be actively promoted to those using it and affected by it.

Any effort of this sort will also be accepted most readily if those who are affected by its use are involved in the process of its development. ASIs and their managers (and perhaps the Professional Airway Systems Specialists organization) should be consulted from the beginning, and they should have significant roles in the model's design, development, and implementation.

The management of the modeling effort will be critical to its success, cost, and timeliness. The managers should be skilled and experienced in managing software development projects and committed to the success of the effort.

Finally, the FAA should address the human resource issues associated with changes to the position of aviation safety inspector and to AFS business processes before developing a new staffing model.

Available data and improvements. Whenever possible, the FAA should seek and take advantage of available data to populate new staffing models. Since a model's predictions are only as good as the data that go into it, careful consideration should be given to the relative costs of modifying existing data-gathering systems versus creating new ones.

Resources. The committee's sense is that one of the failings of past staffing models is that they required a commitment of resources for development, maintenance, and use beyond what FAA or AFS management was able or willing to provide. This is not a problem unique to the FAA. Modeling endeavors often begin with great ambitions and expectations, only to be undone by the weight of the work that is required to realize their ambitious goals.

We strongly recommend that during the model design phase the FAA should focus on the tradeoff between what it is willing to invest (both for development and for maintenance and use of the model) and what it is expecting to gain. Constant and explicit consideration of this trade-off is imperative during the early stages of staffing model design and development. The gains should be viewed from the perspective of the breadth of the staffing questions that the model will be able to answer as well as the validity and utility of the answers it is able to yield. In a word, we recommend that the FAA conduct a serious cost-benefit analysis for any new modeling effort that is proposed, undertaking this effort only if it is institutionally committed to the development and maintenance of such a model.

1

Introduction

Aviation Safety Responsibilities of the Federal Aviation Administration

A primary mission of the Federal Aviation Administration (FAA) is the assurance of safety in civil aviation, both private and commercial. To accomplish this mission, the FAA has promulgated a large number of regulations and has established a major division, the Office of Aviation Safety, to enforce and maintain the regulations and effectively promote safety in aviation. Within the office there are several subordinate organizations (see Figure 1-1). This study is concerned with two of them (highlighted in the figure): the Flight Standards Service (called AFS), charged with overseeing aviation operations and maintenance, as well as other programs, and the Aircraft Certification Service (AIR), charged with ensuring the safety of aircraft through regulation and oversight of their design and manufacture.

The present study was commissioned to examine the models and methods that have been used to determine the staffing needs for aviation safety inspectors for these two units, who are responsible for ensuring the safety of nearly all critical functions of the aviation industry. Currently there are between 3,000 and 4,000 FAA inspectors in these two organizations, as well as a large number of what are called designees, who are

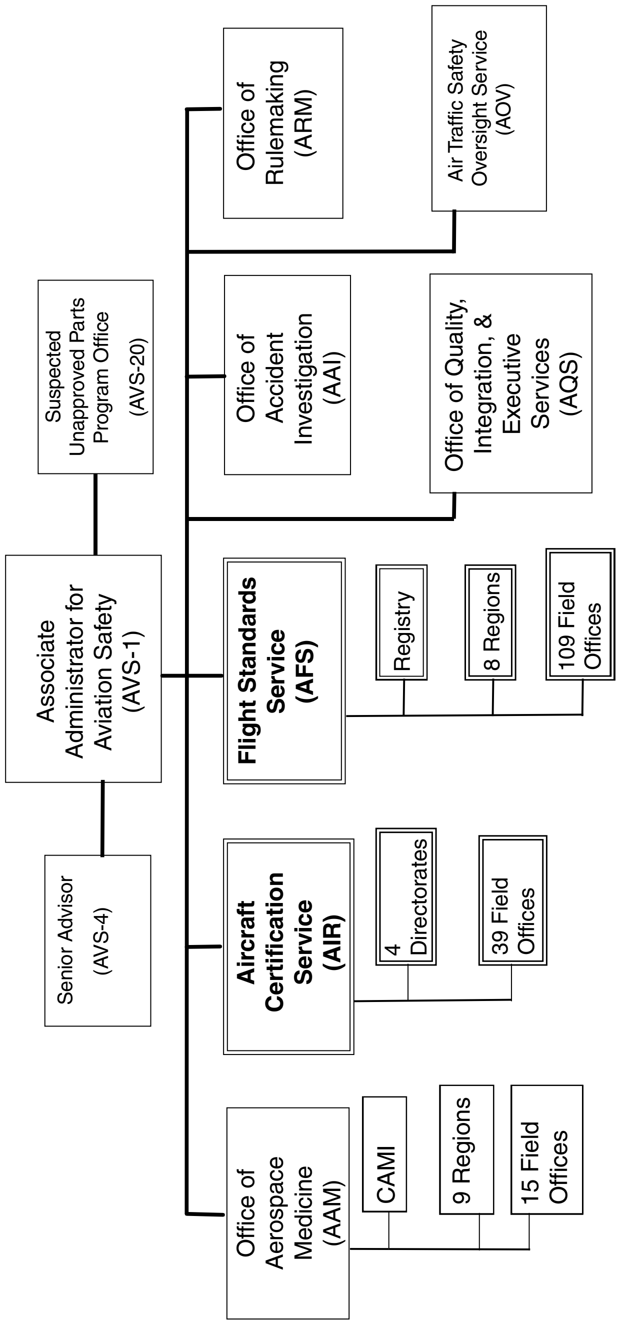

FIGURE 1-1 FAA Safety Office (AVS) Organization Chart.
SOURCE: Federal Aviation Administration (2006).

nongovernment personnel authorized by the FAA to perform some inspection functions.[1]

Aviation Safety Inspectors

The AFS employs more than 3,400 personnel in the aviation safety inspector (ASI) job series 1825. These are the people who work with the aviation community to promote safety and enforce FAA regulations. These inspectors include specialists in operations, maintenance, and avionics, and some of them are also responsible for oversight of cabin safety and dispatch functions.

Their duties are extremely diverse, as are the sectors of the aviation industry they oversee. For example, one operations inspector may be responsible for a number of air taxi services, agricultural applicators (crop dusters), and flying schools, while another may have responsibility for a portion of the operations of a major airline. One maintenance inspector may have primary responsibility for a very large airline overhaul facility, while another may be tasked with overseeing a number of small repair stations. Many of the AFS inspectors are also responsible for oversight of designees, the non-FAA inspectors to whom inspection and approval authority may be delegated. The use of designees is intended to expand the capability of the inspection system without increasing the number of FAA inspectors or increasing their workload, but it imposes a workload of its own on those tasked with monitoring the designees.

The AIR has fewer than 175 series 1825 inspectors, but their responsibility is great. In cooperation with the greater number of aviation safety engineers employed by AIR, they must ensure the safety and compliance of aircraft design and manufacturing, from the smallest safety-related components to entire airplanes. AIR personnel are supplemented by a large number of designees, who may be employed by manufacturers of aircraft or aircraft components or may be self-employed.

Roles and Duties

The traditional role of the ASI is to be the frontline FAA regulatory contact with the aviation industry. The industry includes aircraft operators (e.g., air carriers of all sizes, air taxi services, general aviation opera-

[1] The information on FAA programs, operations, and staffing cited in this report was gathered from sources that include personal communication with AFS and AIR headquarters staff, briefings provided by FAA staff, and FAA documents and web pages. It was verified to be current as of April 2006.

tors, agricultural applicators), pilots, flight attendants, dispatchers, flight and maintenance schools, maintenance facilities and their personnel, aircraft and component manufacturers, and other aviation-related facilities and personnel. ASIs historically have been both enforcers, seeing that the aviation industry complies with all Federal Aviation Regulations (FARs), and advisers, helping the firms for which they are responsible to operate safely and efficiently. Their work thus involves more than policing the industry. ASIs are expected to work with their aviation customers to inform them of new requirements and help them interpret and comply with the regulations, to troubleshoot problems that involve compliance with the regulations, and to educate industry personnel in safe practices and procedures.

Until recently, the typical ASI spent much of his or her time in hands-on inspection duties, observing and assessing the performance of the people and aviation businesses for which he or she was responsible and ensuring that they met the requirements of the FARs. ASIs have been expected to have experience in and technical knowledge of the aviation industry as qualifications for employment, and most AFS inspectors are required to have certification and experience as mechanics or pilots at the time of hiring (U.S. Office of Personnel Management, 1999).

Stresses imposed by the sustained growth in both the sheer volume of air travel and the complexity of the industry's operations have forced significant changes on the inspection system, including these traditional ASI roles. The FAA is working in a number of areas to maintain safety and performance in the face of growing demands. Among the changes confronting the agency are new technologies in airframes, propulsion systems, and avionics; altered manufacturing and maintenance operations and management systems; and revamped airline operations and business models. Specific examples include the emergence of low-cost airlines and the increased outsourcing of aircraft maintenance tasks to subcontractors, many of them outside the United States. In response to such changes, the FAA is moving to a "system safety" approach to oversight, with less emphasis on direct physical contact with individual equipment and operators and greater emphasis on the oversight of programs and processes to ensure safety. Box 1-1 presents a capsule description of system safety from the FAA's *System Safety Handbook* (Federal Aviation Administration, 2000b).

Many of the data on which the system safety approach rests now come from automated data capture systems maintained by the aviation industry. They are collected in database systems designed to help FAA inspectors detect and flag trends that might indicate incipient safety problems. One prominent example is the Air Transportation Oversight System (described in Chapter 4) now being phased into use for monitoring

BOX 1-1
FAA System Safety Definition

The application of engineering and management principles, criteria, and techniques to optimize safety within the constraints of operational effectiveness, time, and cost throughout all phases of the system life cycle. A standardized management and engineering discipline that integrates the consideration of man, machine, and environment in planning, designing, testing, operating, and maintaining FAA operations, procedures, and acquisition projects. System safety is applied throughout a system's entire life cycle to achieve an acceptable level of risk within the constraints of operational effectiveness, time, and cost.

SOURCE: Federal Aviation Administration (2000b, p. A-15).

of major airlines. To use this and other system safety tools effectively, the FAA must have ASIs who are sophisticated database users, with knowledge of system safety principles and processes and an analytic approach to their work. This is a different skill set from the one that supports on-site inspection. Other FAA initiatives, like Flight Operational Quality Assurance (Federal Aviation Administration, 2001) and the Aviation Safety Action Program (Federal Aviation Administration, 2002a) have similar skill requirements. The increasing emphasis on the use of system safety methods also means that many ASIs will interface less with front-line operational personnel in the aviation industry and more with technical professionals and managers, and they will need to understand the jobs of those personnel. They also will have increasing responsibility for interpreting the regulations and working cooperatively with aviation industry personnel.

Origin of the Study

The number of ASIs employed by the FAA has remained nearly unchanged over the past several years, while aviation industries, especially the commercial air carriers, have been expanding and changing rapidly. Increasingly, the FAA has used designees to assume some of the responsibilities formerly assigned to ASIs. There is concern in several communities, including the labor union that represents many of the ASIs, Professional Airways Systems Specialists (PASS), that the ASI staffing levels may not be adequate to the tasks the inspectors face. The Aviation Subcommittee of the U.S. House of Representatives' Committee on Transportation and Infrastructure responded to these concerns by including the current study in the Vision 100—Century of Aviation Reauthorization Act of 2003. The aviation subcommittee and others have some specific concerns:

- The overall ASI staffing level may be too low for the current and expected near-term workload, and it may preclude effective responses to peak or quick-response requirements.
- The FAA may be relying excessively on designees to perform work that should be done by FAA employees.
  - —Designees may be subject to pressures and incentives that could affect the integrity of their work performance.
  - —The workload involved in the oversight of designees may be greater than is recognized in the staffing models now in use.
- The FAA's ability to monitor outsourced work, especially maintenance, may be insufficient for emerging requirements.
- The distribution of ASI staff across FAA regions, districts, and facilities may not be consistent with the distribution of the workload, especially in the face of the aforementioned growth in volume and complexity.
  - —Some offices may experience work overload while others are slack, resulting in wide variation in workload across the inspector workforce.
  - —The FAA may not have geographically redistributed its inspector resources in response to industry changes.

The Congress requested the U.S. Government Accountability Office to address the use and management of designees (see GAO 05-40, October 2004) as well as issues associated with ASI training (see GAO 05-728, September 2005), and asked the National Academies to address only ASI staffing issues.

The Committee's Task

The objective of the study is to determine the strengths and weaknesses of the methods and models that the FAA now uses in developing staffing standards and projections of staffing needs for ASIs and to advise the FAA on potential improvements. The term "staffing standards," as used by the Aviation Safety organizatoin (AVS) for manpower planning, does not imply any measure of skill level or qualitative differences in knowledge, skills, or abilities beyond those implied by published qualifications for hiring or promotion as a particular type of inspector at a particular level.

This distinction is important for present purposes, in that it represents a long-standing functional division that persists in the professional human resources and staffing community. Determining and providing the number of personnel in various categories that an organization needs to accomplish its goals (the current AVS focus) is a *manpower planning and management* function, whereas describing and classifying jobs and establishing the knowledge, skills, abilities (KSA) requirements for each are considered *human resource* or *personnel management* functions. To maintain this distinction, we have used the word "staffing" to refer only to manpower issues and functions throughout this report.

Although the committee's formal charge is focused explicitly on manpower planning and management functions, it was clear from the outset that any improvement in the FAA's approach to staffing would need to begin by addressing human resource and personnel management deficiencies—notably the accuracy and currency of job descriptions and KSA requirements, along with the establishment of sound performance measures. Although expertise in these functional areas was well represented on the committee, actually addressing such deficiencies (i.e., by identifying the extent and nature of specific shortcomings) was clearly well beyond the scope of this limited study. Consequently, attention was directed primarily toward the FAA's staffing systems and models, along with comparative manpower and staffing practices from other organizations, under the assumption that any changes would be preceded by investment in the human resource prerequisites.

The formal task statement from the FAA's contract with the National Research Council (NRC) reads:

> 1. Critically examine the current staffing standards for FAA Aviation Safety Inspectors and the assumptions underlying those standards. The committee will confine its study to ASIs only; other inspector jobs will not be considered. The committee will not consider issues of compensation, work rules, or similar labor relations matters.
>
> 2. Gather information about the ASI job series and about the specific factors that may characterize the FAA as an organization and the ASI job series that would influence the choice of methods that might best be used to develop staffing standards; for example, it will compare engineered to performance-based staffing standards.
>
> 3. Review the staffing models, methodologies, and tools currently available, and some of those in use at other organizations with important similarities to the FAA, and determine which might be applicable or adaptable to the FAA's needs.
>
> 4. Propose models, methods, and tools that would enable the FAA to more accurately estimate ASI staffing needs and allocate staffing *resourc-*

es at the national, regional, and facility levels, particularly in light of the occasional but urgent need to reallocate resources on short notice.

5. Estimate the approximate cost and length of time needed to develop the appropriate models.

From the task statement, it should be clear that the committee's task, rather than directly addressing the stakeholders' concerns outlined earlier, was to help the FAA identify and implement methods and models to support sound staffing decisions responsive to those concerns.

The National Academies' Response

The Division of Behavioral and Social Sciences and Education of the NRC, an operating arm of the National Academies, entered into a contract with the FAA in June 2004 to perform the present study. A committee of nine experts was appointed to perform the study, following the procedures mandated for all NRC committee appointments. These procedures are designed to ensure that committee members are chosen for their expertise, independence, and diversity and that the committee's membership is balanced and without conflicts of interest. The appointments were finalized after the discussion of sources of potential bias and conflict of interest at the committee's first meeting in January 2005. Brief biographies of the committee members appear in Appendix C.

The Committee's Approach

We developed our approach to the task at the first meeting. The committee identified information needs in several domains, including the FAA and its safety inspector staffing history, methodologies, constraints, and requirements; the technical and scholarly literature on manpower and staffing methodology; the experience of other organizations in their approach to manpower and staffing; and the perceptions of individuals and organizations that have a stake in ASI staffing. We developed plans for obtaining and analyzing the needed information and for organizing the report. The committee also discussed the scope of its task and determined what would and would not be attempted.

Defining the Project Scope

The committee's charge was to examine the manpower planning methods and models currently used by the FAA for establishing ASI staffing standards or levels and to suggest approaches aimed at improvement. We were not tasked to develop an ASI staffing model for the FAA nor to implement such a model to determine how many ASIs are needed. We have been careful to explain this to the FAA and to all stakeholders.

This report therefore reviews the information we were able to obtain, evaluates alternatives, and provides the FAA with recommendations for approaching the core questions in an effort to develop and implement improved ASI staffing standards. While any such effort does involve modeling, and the committee devoted considerable attention to this facet of our charge, it is important to recognize that the utility of any manpower modeling approach rests heavily on situational characteristics and ultimate objectives. Thus considerable attention is paid in this report to the fundamental properties and requirements of models as they relate to the specific resources and objectives of the FAA's ASI program. It is important to remember also that models are used as tools in a broader context of manpower planning and resource management and are not the sole determinant in staffing decisions. The current staffing model reflects many, but not all, of the factors that drive the need for ASI staff, and the decision process must take these other factors into consideration.

A point that bears repeating is that although the committee's major task was to study *manpower* questions, we considered that it was unlikely that a change in manpower planning methods would be profitable until other human resource management issues were addressed, and we have devoted Chapter 4 to a discussion of these issues.

Data Gathering

The committee gathered information from the FAA and stakeholders on several issues, including:

- the current staffing situation in the AFS and AIR organizations;
- the history of staffing standards and methods in these organizations;
- the FAA's hopes and expectations for any new staffing methodology or model;
- the environmental factors that drive staffing needs and resources;
- the perceptions of ASIs and managers and of stakeholders in ASI staffing, including various sectors of the aviation industry; and
- the FAA regulations and guidance that control and influence ASI staffing.

We used several methods to gather the information needed. These are described in detail below.

Literature Review. The committee and its staff searched for and reviewed a large number of FAA documents relevant to the work of ASIs and ASI staffing (see the Bibliography). Most of the committee members have expertise in manpower, staffing, and workload assessment, and they were able to draw on their professional experience when reviewing and evaluating these materials. The materials we reviewed include:

- Documents describing the FAA organizations in which the aviation safety inspectors work. These included organizational handbooks, web pages, and other materials.
- Documents describing the jobs and job qualifications of ASIs. These included job postings and descriptions, job classification guidance, and qualification standards.
- Specific regulations enforced by ASIs and documents describing the general regulatory environment in which ASIs work, including major FAA programs that ASIs are charged with implementing. These included parts of the FARs and documents describing and providing implementation guidance for such programs as the Air Transportation Oversight System, the Aircraft Certification Systems Evaluation Program, Flight Operational Quality Assurance, the Commercial Aviation Safety Team, and others.
- Orders, guides, and handbooks providing work instructions and requirements for ASIs. These included FAA Orders in the 8300 series (Federal Aviation Administration, 2004a), the 8400 series (Federal Aviation Administration, 1994, 2004c, 2005b, 2005c, undated), and the 8700 series (Federal Aviation Administration, 2003b, 2004b), which are handbooks for various inspection programs; the National Flight Standards Work Program Guidelines (Federal Aviation Administration, 2005a), the guidance for the management of designees (Federal Aviation Administration, 2003a), as well as others.
- Documents setting forth federal government and FAA personnel and staffing policies and procedures, including past and present staffing standards and descriptions of FAA labor reporting systems. These included descriptions and documentation provided by FAA headquarters staff for the Holistic Staffing Model, the Automated Staffing Allocation Model, and the staffing system for AIR (Order 1380.49 series and related documents) (Federal Aviation Administration, 1989, 1995, 1997, 1999, 2002b), as well as others.

We examined many other FAA documents and web pages with possible relevance to the committee's task. FAA staff provided helpful explanations and answered the committee's questions about the documents and their applicability to ASIs today. For some orders and guidance documents, the committee was unable to obtain definitive information on how they were being applied or whether they were currently in force. These were related mainly to the labor recording systems used to record ASI activities, tasks, and work production, especially in AIR. These systems, documenting tasks, workloads, and the time to complete standard units of work, provide critical input required to implement staffing models.

The committee also reviewed a number of reports of the U.S. Government Accountability Office and the U.S. Department of Transportation Inspector General's Office that have relevance to ASI staffing. Committee staff met with GAO personnel who performed their studies of designee management and ASI training to gain a better understanding of those studies, which were in progress as our work began. In addition to all of these materials, some of the stakeholders and other sources provided documents for our review. Some of these were clearly opinion pieces advocating specific points of view or courses of action and were evaluated as such.

The committee reviewed a selection of scientific and professional literature in several areas of human resources: manpower allocation and modeling, staffing, workload measurement, and the like. We were especially interested in materials describing alternative approaches to manpower and staffing used by organizations similar to the FAA in important ways, as well as articles on principles and methods used to establish staffing models and systems.

A subgroup of the committee with special expertise in manpower and staffing models was tasked to explore alternative modeling approaches for their potential relevance to the FAA staffing situation. This group reviewed approaches used by the U.S. military and other government and civilian organizations, as well as those used or previously considered for use by the FAA. The organizations studied include the U.S. Army, the U.S. Air Force, the Environmental Protection Agency, and others.

Briefings by FAA Headquarters Staff. We invited FAA headquarters personnel from AFS and AIR to brief us at our first committee meeting and later requested additional briefings on specific aspects of ASI staffing. The FAA headquarters personnel who briefed the committee or responded to questions are listed in Table 1-1. Some FAA personnel attended the stakeholder panels described below, providing clarification or additional information there as well as in formal briefings. In addition, the meetings of the committee were open when presentations were made and were closed only when the committee dealt with confidential information or discussed what conclusions might be made from the data at hand. Several members of PASS, including its Region IV vice president, Linda Goodrich, regularly attended the briefing sessions.

TABLE 1-1 FAA Briefers and Subjects

FAA Staff Member	Subject of Briefing
James Ballough, Director, AFS-1	AFS and AIR missions, ASI responsibilities, ASI staffing and history of staffing systems.
Robert Caldwell, AFS -160	Informal information on many aspects of ASI staffing; no formal briefing.
Deane Hausler, AIR	Description of staffing approaches used in AIR.
Kevin Iacobacci, AFS-160	Description and explanation of ASAM staffing model in AFS.
Colleen Kennedy-Roberts, Manager, AFS-100	Informal contributions; no formal briefing.
Rosanne Marion, Manager, AFS-160	Additional background on AFS mission and ASI work.

Stakeholder Panels. The committee determined that, in order to better understand the ASI workload, discussions with various stakeholders—industry and other groups that are affected by the work of ASIs—would be useful. It was also important to ensure that the relevant groups had the opportunity to provide their viewpoints on the current and needed staffing levels of ASIs, as well as on factors that influence staffing levels.

The committee developed a list of questions to pose to stakeholder groups related to perceptions of ASI staffing, factors influencing ASI staffing, and outcomes of adequate and inadequate staffing levels that affected that particular constituency. These questions were distributed to all organizations that were invited to participate in the panels. Appendix B includes the list of questions posed to stakeholders.

After consultation with FAA staff and PASS representatives, as well as a general discussion in the committee, a number of stakeholders were identified. These included air carriers, aircraft manufacturers, general aviation and specialty aviation associations, maintenance providers, pilots and other workers' associations, and consumer safety groups. Representatives from these organizations were invited to attend a meeting of the committee and provide a briefing or to submit a written response to questions posed by the committee. Table 1-2 lists those organizations that were invited to provide a briefing to the committee.

The organizations that accepted the invitation are shown in bold in the table. We made a good faith effort to reach a broad sampling of stake-

TABLE 1-2 Stakeholder Groups Invited to Provide Briefings

Organization	Type
Aeronautical Repair Station Association	Repair stations
Aerospace Industries Association	Large plane manufacturers
Air Carriers Association of America	Air carriers
Air Line Dispatchers Federation	Dispatchers
Air Line Pilots Association	Pilots
Air Transport Association of America	Major air carriers
Aircraft Electronics Association	Avionics systems and maintenance
Aircraft Mechanics Fraternal Association	Maintenance workers
Aircraft Owners and Pilots Association	General aviation owners
Association of Flight Attendants	Flight attendants
Aviation Distributors and Manufacturers Association	Parts manufacturers
Federal Aviation Administration (briefed earlier, attended stakeholder panels)	Consumer advocates
Flight Safety Foundation	
General Aviation Manufacturers Association	General aviation manufacturers
Helicopter Association International	Helicopter interests
International Association of Machinists and Aerospace Workers	Maintenance and manufacturing workers
National Agricultural Aviation Association	Agricultural aviation interests
National Air Carrier Association	Charter and cargo air carriers
National Air Transportation Association	Charter air carriers
National Association of Flight Instructors	Flight instructors
Professional Airways Systems Specialists (briefed earlier, attended stakeholder panels)	ASI workers
Professional Aviation Maintenance Association	Maintenance professionals

NOTE: Boldface type indicates organizations that sent representatives to brief the committee.

holders, but several interest groups whose inputs we solicited did not choose to participate, even after we made follow-up contacts. We understand that we may not have heard all relevant points of view, but we had no choice but to work with the information obtained from those who agreed to participate.

Briefings were presented at the committee's meetings in March and June 2005. Table 1-3 lists the individuals providing briefings and the organizations they represented. A detailed summary of the themes from the briefings appears in Chapter 4.

Visits to ASI Work Sites. The committee requested assistance from the FAA headquarters staff to facilitate visits to several FAA field offices where ASIs are employed. We requested and received contact information and introductions for sites that would give us access to ASIs and managers representing the major categories of ASI jobs (operations, maintenance, avionics, and manufacturing) and serving major sectors of the industry, including air carriers (operating under FAR Sections 121 and 135), general aviation, and manufacturing. The facility managers selected the ASIs in the requested categories to be interviewed. Some of those interviewed were PASS representatives or individuals recommended by PASS.

The selection of sites for visitation did not follow a scientific sampling process, and the sites chosen were not necessarily representative of the universe of ASI positions or worksites. It was a convenience sample selected to educate the committee on the work of ASIs and the environments in which the work is done, and to help us understand a variety of points of view on ASI staffing.

The committee decided to provide all interview participants with an assurance of anonymity and keep their individual responses confidential. This was done to ensure that respondents could talk freely with the interviewers without fear of any negative consequences. Thus job titles and other information that would allow ASIs to be individually identified are not included here.

The committee developed a protocol to structure the conversations with ASIs and their managers to efficiently collect information relevant to the tasks. Committee members with interviewing expertise conducted pilot visits to two FAA sites, and the committee discussed and revised the protocol in light of what was learned on these initial visits. The final protocol is reproduced in Appendix B. Committee members then visited the remaining five sites and conducted individual and group interviews with operations, maintenance, and avionics ASIs and managers. Table 1-4 shows the sites and number of people interviewed at each. (We planned but were not able to complete a visit to interview manufacturing

TABLE 1-3 Organizations and Individuals Providing Input to the Committee

Organization	Representative	Title
Aeronautical Repair Station Association	Sarah McLeod	Executive director
Aerospace Industries Association	Mike Romanowski	Vice president, civil aviation
Aircraft Electronics Association	Paula Derks	President
Aircraft Mechanics Fraternal Association	Maryanne DeMarco	Legislative liaison
Aircraft Owners and Pilots Association	Melissa Rudinger	Vide president, regulatory policy
Air Line Pilots Association	Charlie Bergman	Manager, air safety and operations
Federal Aviation Administration	Kevin Iacobacci Deane Hausler	AFS and AIR headquarters staff
General Aviation Manufacturers Association	Walter Desrosier	Engineering and maintenance
Individual safety consultant	John Goglia	Senior vice president, Professional Aviation Maintenance Association
International Association of Machinists and Aerospace Workers	David Supplee	Director of IAM flight safety
National Agricultural Aviation Association	Andrew Moore	Executive director
National Air Carrier Association	George Paul	Safety and maintenance director

TABLE 1-4 Flight Standards District Offices Visited and Number Interviewed per Site

Location	Number Interviewed
Baltimore, MD	7
Columbia, SC	4
Detroit, MI	5
Fort Worth, TX	7
Grand Rapids, MI	5
Miami, FL	3
Scottsdale, AZ	8

inspectors at a manufacturing inspection district office.) The findings from these visits are discussed in Chapter 4.

Structure of the Report

This report is organized in an Executive Summary and five chapters. This first chapter provides the background of the study and explains the committee's approach to its task. Chapter 2 discusses modeling and its applicability to the development of staffing standards for such organizations as the Flight Standards Service and the Aircraft Certification Service. Chapter 3 traces the recent history of staffing standards in these organizations and considers manpower and staffing models and methods used by other organizations. Chapter 4 examines factors to be considered in the development of ASI staffing standards and the challenges faced by any methodology applied to this task. Chapter 5 presents the committee's findings and recommendations, including a discussion of issues and constraints that must be considered in weighing the implementation of alternative approaches.

Box 1-2 lists aviation-related and other acronyms relevant to the topics of this report.

BOX 1-2
Selected Aviation-Related and Other Acronyms and Abbreviations

AFS	Flight Standards Service
AIR	Aircraft Certification Service
ASAM	Automated Staffing Allocation Model
ASI	Aviation Safety Inspector
ATCS	Air Traffic Control Specialists
ATOS	Air Transportation Oversight System
AVS	Aviation Safety organization
CMIS	Certificate Management Information System
CPMIS	Consolidated Personnel Management Information System
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FTE	Full-Time Equivalent
GAO	U.S. Government Accountability Office (formerly General Accounting Office)
LDR	Labor Distribution Reporting
MIMIS	Manufacturing Inspection Management Information System
NVIS	National Vital Information Subsystem
PASS	Professional Airway Systems Specialists
PTRS	Program Tracking and Reporting Subsystem
SASO	System Approach for Safety Oversight
SPAS	Safety Performance Analysis System

NOTE: Acronyms used in some Federal Aviation Administration offices may reflect their organizational history rather than their literal titles.

2

Modeling as Applied to Staffing

What Is a Staffing Model?

The term “staffing” is often used to refer to a range of processes, such as recruitment, selection, placement, and training, through which an organization applies human resources to the work needed for it to achieve its goals (Schneider, 1976). At the Federal Aviation Administration (FAA), staffing models and staffing standards are terms used to denote tools for the management of manpower only. As explained in Chapter 1, these are tools that enable the organization to determine the right number of people with the right skill sets in the right positions to accomplish the responsibilities of the job in a satisfactory manner. Staffing needs are determined mainly by how the organization has defined its goals and designed the jobs that make up its total workload.

How effectively an organization is able to meet those needs, once they are defined, depends on both its staffing processes and the characteristics of the available human resource pool. While manpower planning and management, and the models used in these activities, are important parts of the overall staffing picture, many other factors enter into human resource management, as noted earlier. In this chapter, we concentrate on models for manpower management, that is, for deciding how many workers, of what general types, are needed to staff the organization without regard for specific job characteristics, worker qualifications, or performance standards. In Chapter 4 we discuss these and other considerations that are also important for effective deployment of human resources.

It is important to recognize that determining the appropriate number of aviation safety inspectors (ASIs), system-wide or locally, at any given time is by no means a simple matter, since it is dependent on how work is structured and what defines acceptable individual and system performance, as well as the characteristics of the current and projected workforce. For example, the FAA's adoption of the system safety philosophy radically changes the nature of many ASI jobs and, as a consequence, the skills required to perform them. The expectation of the system safety philosophy is that high standards for safety in the aviation industry can be maintained with the same or fewer people. However, estimating how many people are needed is difficult at best.

All organizations base staffing decisions on a paradigm of the underlying production process, whether they do so explicitly or not and whether it approaches reality or not. This conceptualization is often referred to as a staffing model. The Flight Standards (AFS) and Aircraft Certification (AIR) offices have made a commitment to using staffing models as a tool to develop staffing standards (the FAA's term for the documents that detail the numbers of staff needed at its facilities). A staffing model is a formal representation of the mechanisms that drive the need for staffing and of the interactions among staffing needs and staffing resources. The operation of a good model should provide useful standards as an output if the proper data are input and the algorithms of the model accurately reflect the mechanisms driving staffing needs.

Staffing standards are *not* identical to authorized or filled positions. They are one source of guidance used by AFS headquarters, regional offices, and facilities in the development of staffing plans and projections and in the authorization of safety inspector and other staff positions.

The current Automated Staffing Allocation Model (ASAM) reflects many, but not all, of the factors that drive the need for ASI staff and the decision process must take these other factors into consideration. A staffing model that accounts for more of these factors could perhaps play a more central role in staffing decisions, leaving less of the decision making subjective and thus open to question. However, there will no doubt always be some subjectivity in the setting of staffing levels, some need to consider regional differences and local, short-term, or emergent demand factors that are not practical to include in a staffing model, as well as the changing strategies or priorities of AFS. For these and other reasons, managers will still always be responsible for the final staffing decisions.

We were asked to examine and evaluate both the FAA's model and possible alternative models for ASI staffing. The more faithfully a model represents reality, of course, the more likely it is that staffing processes based on it will satisfy staffing demands. In view of the complex and dynamic nature of ASI staffing demands, as well as the wide variety of forms that models and modeling efforts can take, it is necessary at this point to consider some of the more salient aspects of modeling per se. Only then will we be in a position to apply modeling principles to the issues involved in ASI staffing.

Distinguishing Features of Models

"Model" is a widely used term with many meanings and implications. In this section, we define more specifically how the term is used in the present context and identify some of the issues we have considered as the term applies to ASI staffing decisions.

First, a model is simply a representation of some actual process or system, typically created for the purpose of understanding it more completely and predicting the future state of affairs. The purpose of a model is to make inherently complex processes simpler, so that their essential elements can be better understood. A model is an abstraction of reality. However, the more faithfully a model captures the essential features of its real-world counterpart, the better able it is to fulfill its intended function.

A familiar example is the modeling used by meteorologists to better understand and predict weather phenomena. Mathematical representations of atmospheric and oceanic processes allow meteorologists to analyze enormous amounts of data very quickly to predict, for example, the probable intensity and path of a hurricane with some accuracy. As the precision of these models has improved, so too has their practical utility. While not always quantitative or highly formalized, the most precise and useful models represent the phenomena of interest through sets of algorithms and equations. As with the meteorological example, the complexity of the ASI staffing need structure requires both formalization and the computational power of the modern computer.

Second, models are generally characterized as either descriptive or predictive. Descriptive models typically document the structure and processes of a system, but they do not add a computational component to enable predictions about system behavior as a function of system design. An information flow diagram for a business process is an example of a simple descriptive model. Predictive models (like the hurricane model) include such a component; hence they do enable prediction. In this project we have focused on predictive models because our charge is to articulate methods for determining the appropriate numbers and types of aviation safety inspectors as a function of the factors that drive the demand for their services. Unless a staffing model can predict with some level of precision how well the inspection system will perform given the need structure, it would be impossible to estimate appropriate staffing levels.

Third, models can be stochastic or deterministic. Stochastic models, a prominent form of which is the Monte Carlo simulation model, attempt to take into account the unpredictable elements of system behavior, whereas deterministic ones do not. For example, the need for aviation safety inspections cannot be predicted with 100 percent accuracy even under optimal circumstances because of unknown factors, such as the increase or decrease in the general aviation population, random or unpredictable factors affecting the time required to complete tasks, and changes in the location of aviation maintenance facilities. Almost every system has some elements of uncertainty in it, so the question is not whether variability exists but rather how important it is to the system behavior that the model is designed to predict. If ignoring the variable nature of the system is likely to lead to inaccurate predictions or, equally important, a failure to recognize potential staffing risks, then stochastic modeling techniques should be used. However, if the variability is not likely to affect model predictions, or the variability is small and unimportant, a deterministic model—one that ignores the stochastic properties of the system—should suffice.[1] For example, if one were developing models to estimate the time that airplanes spend waiting for safety inspections, the variability associated with the arrival rate of airplanes into the inspection process would need to be incorporated. However, if the goal instead were to estimate the total number of aviation safety inspection hours required, this variability would be far less important, and it would be sufficient simply to enter average arrival rates.

The importance of the distinction between questions requiring stochastic model properties and those for which deterministic properties are sufficient cannot be overemphasized as it applies to the committee's charge. While we think that a deterministic model can provide enough predictive power to yield fairly straightforward answers to a number of key staffing questions, we can envision issues for which the complexity of a stochastic model would be required.

Consider the following contrasting examples. If the FAA needed only an estimate of the total demand for inspectors and their optimal geographic distribution, a deterministic model that simply tracked all of the important demand factors and translated the projected demand into hours of inspector time at locations around the world (considering both performance and cost consequences) would suffice. However, if the question concerns not only how many hours of inspector time were needed, but

[1]It is important to recognize that both the stochastic model and the deterministic model can produce accurate expected values for an outcome. The stochastic model's advantage is that it can also provide an estimate of the variation in realized values around the expected value. This allows one to better assess risk in the staffing decisions that are made.

also the likelihood that an ASI inspector will be available when an inspection is required, then it is necessary to invoke a stochastic model that will take into account queuing issues and the stochastic nature of factors driving the demand for inspections.

Fourth, the distinction between the underlying predictive model and the *data* needed to make predictions using the model is critical. A model is created on the basis of the inherent properties of the system that drive its behavior. In the case of the aviation safety inspection system, this includes factors that drive demand for ASI resources and how these ASI resources are deployed in response to that demand. However, even if these relationships are understood and well represented in a quantitative model, the model is worthless without the data that enable meaningful and realistic predictions. For example, if a model hypothesized a relationship between the number of aircraft in the U.S. fleet by zip code where they are based and the need for inspectors in various regions, that model would be useful only if we could collect the data on aircraft by zip code. Therefore, as the FAA considers the choice of an underlying model to represent ASI processes and resources, it must also consider the availability and cost of collecting the data needed to implement the chosen model.

Fifth, predictive models tend to be either decision support tools, designed to allow the user to explore alternative options for achieving desired results, or summative evaluation tools, which tell the user how well the proposed system is going to achieve the specified goals. While not mutually exclusive alternatives, the distinction represents primary emphases that drive model development. We think the present effort should emphasize the decision support role, since the complexity of the need structure and the difficulty of quantifying ultimate criteria render summative evaluation problematic at this time.

Finally, models, such as one for ASI staffing, may be either allocation models or sufficiency models, or both. An allocation model is one aimed at distributing available resources equitably and effectively irrespective of their collective adequacy, whereas a sufficiency model is designed to predict the resources needed to sustain system performance at what is deemed an acceptable level. To date, apart from one aborted effort, the staffing models developed by AFS have been exclusively of the allocation variety—the goal being to achieve the most effective distribution of limited ASI resources across organizational units. A sufficiency model is more difficult to develop. It requires the organization to make decisions about, and set standards for, acceptable performance and to develop performance measures so that outcomes can be evaluated against those standards (i.e., it can be empirically validated). A validated sufficiency model has the advantage that it can be used to justify budget requests and other decisions by generating predictions of organizational performance with and without additional resources, or with different distributions of current resources.

Desirable Model Characteristics

Predictive models developed as decision support tools may be characterized in terms of five important qualities: transparency, scalability, usability, relevance, and validity. Each of these is described briefly below.

Transparency is the extent to which the model can be explained and understood by interested individuals other than the model developers—most importantly the users of the model and those affected by decisions based on model implementation. Models that are relatively transparent, those in which the critical relationships among variables can be seen and understood by stakeholders, are inherently more likely to be accepted.

Scalability refers to the extent to which a model can be useful at different levels of systems analysis. For example, is it useful for predicting ASI staffing needs for regions as well as the entire nation? Can it provide guidance on staffing at the flight standards district office or other facility level?

Usability refers to the ease with which the model can be implemented and enhanced to make the predictions for which it was designed. Does it have an interface that is sufficiently intuitive to enable the model users to enter data efficiently and accurately? Is it appropriate to the skills and preferences of the intended users? Are the results presented in ways that support decision making? Can the model easily be updated to reflect changes in the ASI work requirements and environment or changes in FAA policy?

Relevance concerns the extent to which the model addresses the important portions of the issues for which it is designed and, equally important, the extent to which it excludes extraneous or marginally relevant issues or data. Does the model capture all of the important ASI workload drivers? Does it operate at the right level of detail?

Validity is the final and, in many respects, the most critical feature. The extent to which the predictions of the model correspond to the actual, real-world outcomes constitutes its validity. Indeed, the most powerful means of evaluating a model's worth—the ultimate proof of the pudding—is the direct comparison of predicted with observed outcome (criterion) measures when such measures are obtainable. It is often the case that the ultimate criterion (i.e., aviation safety) is not directly measurable in any practical sense, so the model's predictive validity must be estimated against surrogate criterion measures (e.g., level of risk posed by various inspection scenarios). As becomes clear later in the report, establishing meaningful criteria is one of the main challenges facing the developers of any predictive ASI staffing model.

All of the five qualities described above should be considered in the evaluation or development of an ASI staffing model. They apply equally to models that the FAA has used or is using as well as to any future modeling effort it may undertake.

Alternative Approaches to Model Development

In view of the fact that the questions posed to the committee imply models of the sufficiency variety that are capable of making and validating performance-based staffing predictions, and that none of the staffing models developed or in use by the FAA possesses those characteristics, it may well be that an entirely new approach is called for. If that turns out to be the case, there are two major alternatives representing substantially different modeling concepts that should be considered. Either one, if implemented appropriately, could satisfy the staffing model requirements we have set out.

The first approach, process modeling, incorporates the key processes that drive the need for staff, while explicitly representing staffing resources and their use in those processes. The second approach, statistical modeling, does not focus on the explicit processes that drive the staffing need. Rather, it assumes that the relationship between future staffing requirements and the factors driving those needs—whatever the underlying processes may be—is relatively stable. If one has historical data on which to build statistical relationships between staffing demand factors and staffing requirements, then these statistical relationships can be projected onto new situations without understanding what accounts for them. Simply put, a statistical model seeks merely to describe a stable empirical relationship; a process model attempts to depict the mechanisms underlying that relationship. While either could serve in the present context, the advantage of a process approach is that it is more easily adapted to change, and change is rather prominent in today's aviation landscape. The advantage of the statistical model is that it is empirically based, and is likely to be less costly to develop and implement.

A detailed description of process and statistical modeling methodology appears in Appendix A. Below are brief descriptions of important distinguishing features of each, as well as of alternative approaches to the estimation of model parameters.

Process Modeling

Process modeling can be more or less complex and detailed in its representation of the relationships among system factors, but by definition it requires decomposition and analysis of work processes. To develop a process model, then, modelers must understand in some depth the operations of the system to be modeled. Usually this is accomplished by involving subject matter experts in the model analysis and design phases. One example of a process modeling method is called task network modeling. A graphic representation of a part of a task network model is shown in Figure 2-1.

To build a task network model, the modelers must decompose the work represented in the model, that is, break it down into successively smaller units, usually ending at the level of the task. This process is commonly called a task analysis. Each task is then modeled, along with its relationships to other tasks—hence a task network—and the system representation is synthesized from these components. Key attributes of each task must be specified: how long it takes to perform, who must perform it, the task's priority, what other tasks must be completed before it can begin, what its outputs are and how they are used, whether decisions are made based on the outputs, etc.

The level of detail needed in the model will depend on the complexity of the system modeled and the outputs needed by the users. For the purposes of ASI staffing, a process model would probably not require a very detailed task analysis, although the level of detail required would have to be determined during the model requirements definition process.

Outputs of process models can be as varied as the systems they represent. Typical outputs for staffing process models fall into just two general categories: measures of personnel utilization (e.g., how busy each type of ASI will be at each location) and estimates of delays or failures to complete work associated with the unavailability of staff to perform the work. Such outputs would allow users to estimate the effectiveness with which ASI staffing resources are used and their ability to meet work demand. There are many ways to express and quantify such information, and a model can be designed to provide the most appropriate and usable output to serve the needs of its users.

Over the past decade, many tools have emerged that have made the job of building and maintaining process models easier and more transparent than older tools. A model designed using one of these tools should be able to:

- allow data entry in a manner consistent with user terminology and expectations;
- automatically import data from other digitized sources; and
- present the simulation results in a usable and understandable form.

Some of the modeling tools now on the market include the Extend product line from Imagine That, Inc.; SimScript from CACI Products

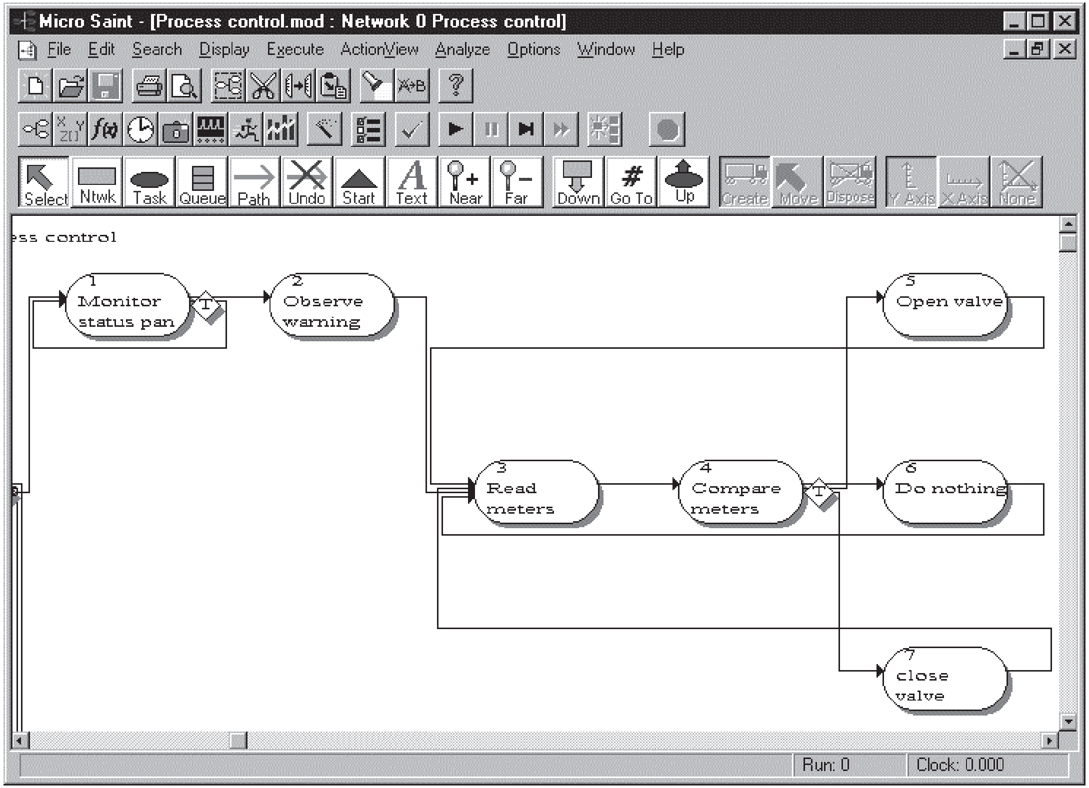

FIGURE 2-1 Sample task network model of a process control operator responding to a warning. SOURCE: Laughery (2005). Reprinted with permission.

Company; Flexsim from Flexsim Software Products, Inc.; Micro Saint Sharp from Micro Analysis and Design; and Arena from Rockwell Software. These tools provide such useful features as interfaces to common database applications, optimization capabilities, and the ability to run "what-if" simulations. When requirements and a modeling approach have been defined for a specific project, appropriate tools can be selected, purchased or licensed, and employed.

Statistical Modeling

A statistical model relies on empirically defining mathematical relationships between system inputs and outputs. The mathematical formulas are estimated from the observed historical data on the system, such as records of work accomplished by known staffing resources over a given time under known environmental demands and other relevant conditions. Thus a statistical staffing model is dependent on accurate work recording systems to provide the data it uses to estimate critical relationships. A statistical model does not require a task analysis, but it does require that the modelers identify and represent in the model all factors that substantially affect the relationship between staff resource inputs and work outputs (system performance). Other factors, such as operating policies and procedures, are not modeled explicitly but are implicit in the input-output relationships. For this reason, if there are changes to work policies or procedures or other factors not modeled but material to the way the work is done, the model will no longer generate accurate predictions. The system will have to operate for some time under new conditions to produce the data needed to update the model.

Finally, it is important to recognize that the dichotomy drawn here between a process simulation model and a statistical model may be overstated. As we discuss next, a process model may use statistical methods to estimate some, or all, of its parameters, and a statistical model may include relationships between resource inputs and overall or intermediate output at fine levels of detail, similar to the tasks and steps of the process model.

Parameter Estimation

For any model, values must be obtained for the parameters of the model. The parameters are the values that are used in a model to quantify key relationships among variables. Thus, if one is modeling the time taken by a train to travel between two points, one parameter would be the distance between the points. The time is a function of the distance, the train's speed (another parameter), and other factors. Similarly, in a staffing model, an important parameter might be the time it takes an ASI to perform inspection Activity x. There are several ways in which parameters for a model may be estimated, some more suitable than others for particular situations.

The most reliable approach, when reliable data are available, involves statistical estimation based on documented relationships among important variables. An example of this would be to estimate the time needed to perform Activity x from work records showing time spent by a large sample of ASIs on many recorded performances of that activity. This empirical method works best for a staffing model when the model designers have access to data from work records that are known to be accurate and representative of the current state of the system to be modeled.

An alternative, but generally less desirable, means of estimating parameters is through expert judgment. An example of this would be to gather a group of ASI subject matter experts and ask them to estimate how long it takes to perform Activity x, given their experience with the activity. Of course, expert judgment is subjective, so a model with parameters estimated in this way may not be considered credible unless it is empirically validated by testing predictions generated by the model against observed outcomes.

Finally, parameters may be estimated by calibration or fitting. In this method, modelers generate preliminary parameter estimates based on judgment and then fine-tune them by running the model against known outcomes and adjusting the parameters until the model produces acceptably accurate predictions—provides a good fit to the known data. This method is a hybrid of the statistical and the expert judgment methods. It uses judgment first and then an ad hoc statistical and empirical procedure to adjust the parameter estimates, but it lacks the rigor of a formal statistical method.

Practical Considerations in Model Development

When considering the generic features of predictive models used as decision support tools, it is important to recognize that practical circumstances often dictate the relative weight that should be accorded various facets of the modeling approach.

As explained above, models are abstractions of the reality they seek to represent and are created for a number of different purposes. The more clearly and precisely the model's purpose can be specified, the more readily one can judge the relative importance of the various features, whether evaluating an existing model or developing a new one.

Although we devoted considerable attention to understanding the goals of an ASI staffing model, gaining some insight into the aspirations involved, the committee is not in a position to articulate for the FAA what its specific priorities should be. Rather, we simply cite the specification of the model's purpose as a critical first step in any modeling initiative that the FAA may undertake. That is, actual model development should be guided by a set of clear, concrete statements about how the model will support, first, FAA decision making and, ultimately, the FAA mission.

Another set of practical issues that should be given serious prior attention are the operational constraints that will be placed on the use of the model once it is developed. Who are the users? What are their expectations of the model? What skills and knowledge do they have? What data can be used to populate the model and how easily can those data be obtained? Will data need to be manually input or can they be captured from existing management information systems? What resources can be made available to implement and maintain the model and its data sources? What is the time frame for model use and, by inference, the amount of time between the assignment of a prediction task and the deadline for an answer to be provided? What level of precision is required of the answer? A successful ASI staffing model will be possible only if the team that is tasked with building it confronts these issues at the outset, head-on.

Another critical consideration in building a staffing model is the need for measures of outcomes—performance measures—that can be applied to ASI system performance. The importance of performance measures to the design and utility of a staffing model cannot be overemphasized. Such measures are required to rigorously specify both the purpose of staffing and the consequences associated with staffing decisions. A discussion of some issues related to the development of performance measures for the ASI situation is found in Chapter 4.

Value of a Model for ASI Staffing

With the foregoing discussion of modeling characteristics, concepts, and principles as context, we return now to the current application—the use of models in ASI staffing. Before proceeding further, however, one fundamental question must be addressed: Is modeling a potentially useful approach for aviation safety inspector staffing? Although once again we must note that neither modeling per se nor any approach relying exclusively on manpower management tools can ensure optimal staffing, we think modeling does have potential in two areas that correspond, respectively, to the distinction between sufficiency and allocation models.

First, by providing an estimate of the resources necessary to meet policy and safety goals, a sufficiency model can be the most rigorous way to determine staffing needs and to support budget requests for ASI positions. To do this, however, the model must be able to estimate aggregate staffing requirements, to justify the appropriateness of that estimate, and most importantly, to predict consequences of staffing below the prescribed level. It should be noted that none of these estimates is possible without a credible means of documenting performance; hence performance measurement is essential for any staffing model to realize its full potential. In the present case, performance measurement poses a number of daunting challenges.

The second area in which modeling could prove useful is the distribution of ASI resources—an allocation model could help guide these decisions. Available ASI resources should be allocated to regions and offices in which they are needed the most, so that they provide the greatest possible benefit to flight safety. To do this, a model must reflect all elements of the ASI need structure, including the external drivers as well as internal policies, processes, and practices as applied to ASI functions and across regions and offices. Finally, despite the distinction between sufficiency and allocation roles, we think that an ASI staffing model should serve both functions. That is, it should be able to estimate aggregate staffing demand, provide predictions regarding the consequences of alternative levels of staffing, and help guide the allocation of resources across functions, regions, and offices. A single model would help ensure consistency across both aggregate and local staffing decisions.

Requirements for a Staffing Model

Having summarized salient model characteristics and the potential of modeling for ASI staffing applications, we conclude with a review of the model features that we think should characterize an ASI staffing model. First and foremost, as noted above, we think that a single model could and should serve both the sufficiency and allocation functions. To do this, a staffing model should have the structure depicted in Figure 2-2. In the following sections, we consider first the demand side of the model and the diagram, then the supply side. Finally, we discuss how the two components come together and the importance of this for model relevance and validation.

The Model Should Be Driven by Demand for Work.

The model must be demand driven. That is, it must represent the full array of factors that in combination determine the total amount of work required of the workforce. These demand factors, which in the FAA case derive primarily from two sources (the environment and FAA policy, procedures, and guidance), must be captured adequately in the model

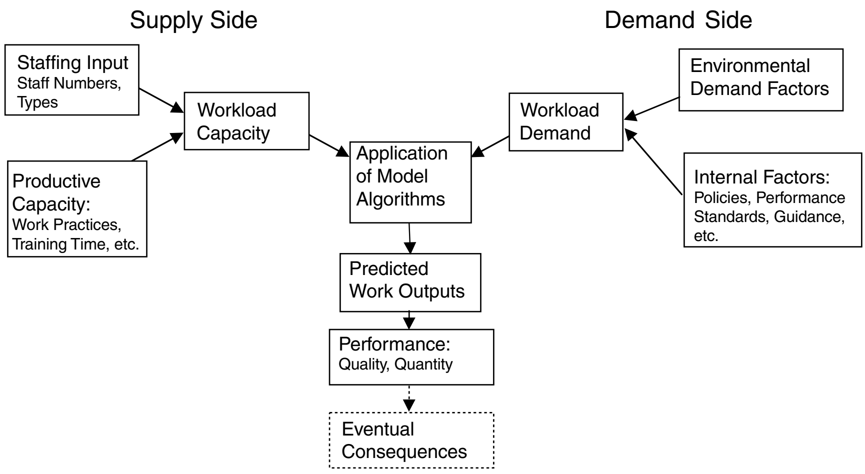

FIGURE 2-2 Generic staffing model: Essential elements.

(i.e., must "drive" it) in order for its output to yield a useful estimate of total workload. Actual staffing demand will thus vary over time with changes in the distribution and mix of workload drivers (e.g., for the FAA, numbers of certificates, public airports, and pilots requiring oversight; job specifications; technological innovations; regulations and other policy mandates), and the model must reflect this variation. In addition to workload driven by predictable factors, there will also be demand for services on an unpredictable as-needed basis, and that too must be accommodated in any attempt to estimate overall staffing requirements. Whatever their source, then, these demand indices should be translated into workload estimates represented in terms of staff person-hours or full-time equivalents (FTEs) needed to accomplish the work.[2] This translation from drivers to required hours or FTEs should be empirically based, if possible. That is, it should be based either on a statistical relationship between person-hours or FTEs and demand factors, using recent data, or on direct observations of time required to perform tasks (job and task analysis). While expert judgment may substitute for the empirical estimates in the short run, a plan should be in place for empirical validation.

[2]Intermediate steps might include estimating the numbers of specified activities required, given the factors driving demand, and the time required to complete each activity.

The Staffing Model Should Provide Staffing Demand Estimates That Are Based on Some Measures of Performance.

The user must be able to say "We need enough employees with the right knowledge, skills, and abilities, in the right places, to perform x," where x is a measure of work output, quality, and/or outcomes for each organizational entity modeled. One must be able to measure work, the amount of work accomplished, and the amount left undone. Preferably, the measure should incorporate a quality dimension. For the purposes of a staffing model, something as simple as a minimum time to complete a task may be appropriate. For example, if experience has shown that four hours are required to do a thorough job of Task x, then a record of having performed Task x in one hour would not be accepted as documentation of satisfactory performance, and the model should incorporate in its demand functions that Task x requires four staff hours each time it is performed.

The Model Should Represent the Supply of Staff to Perform Work.

The supply of staff FTEs must be translated into (or functionally related to) the capacity for carrying out the required work, using the same metrics (e.g., person-hours or FTEs) in which the demand-side workload is expressed. That is, the productive capability of the organization's staff must be incorporated into the estimate of available capacity or, viewed a bit differently, the model should provide an estimate of the workload that can be accomplished with any given level of staffing (capacity). This involves calculating the policy-driven and practical limitations on the use of staff for the work to be modeled. In most staffing systems, these result in adjustments to full-time hours for training, leave, travel time, administrative tasks, and other nonmodeled activities.

The Model Should Make a Performance-Based Supply-Demand Comparison.

The demand side of the model should thus produce an estimate of the staffing necessary to satisfy workload demand at a satisfactory level of performance. The model then should be able to compare staffing necessary to meet demand with staffing available. Based on this comparison, the model, in its resource allocation role, should project the distribution of human resources that will best allow demand to be fulfilled, given organizational priorities and practical constraints.

In addition, a sufficiency model should predict the workload that can be accomplished acceptably with available staffing. It should also provide an estimate of the work requirements (if any) that will have to either remain undone or be performed with less than the required quality and thoroughness. The actual performance will depend on management decisions and staff follow-through, but at least there will be information available to guide those decisions. Some estimate of the consequences of these shortfalls in accomplishing the work should also be generated.

Consequences or outcomes resulting from actual staffing compared to staffing necessary to meet demand can be described and measured on many levels; we consider three. First, the workload that cannot be accomplished because of inadequate staffing is quantified simply as backlog. This can be translated into a shortage of person-hours or FTEs. These are the additional hours or FTEs that would be necessary to meet workload demands consistent with policy. Second, the first level performance implications should be estimated. Examples include reduced frequencies of required activities or increased customer waiting time for processes to be completed. These immediate and measurable consequences commonly serve as performance measures for a system.

A third, less immediate, level of outcome or performance is the effect that the deterioration of performance, as measured in the second level of description, will have on the final output of the system—in the FAA case, the timely provision of services that ensure aviation safety—and on safety itself. While this relationship is extremely important, and the raison d'etre for aviation inspection in the first place, such a relationship is extremely difficult to measure empirically. The first reason is that safety is generally very good, so that adverse events are rare. To establish such a relationship empirically requires natural variation in the data and outcomes that is unlikely to be present. Second, many factors not under the control of AFS may affect safety outcomes in U.S. aviation. Third, there has been little agreement until recently on a suitable measure of aviation safety.[3] As a practical matter, therefore, it will be necessary to rely on outcomes more immediate than system safety per se in the development and validation of a staffing model.

[3]The FAA has this year proposed a Composite Safety Indicator to quantify overall airline safety, for purposes of evaluating the effectiveness of FAA programs (Flight Plan 2006-2010, Federal Aviation Administration, 2006). This could be of some use in an effort to examine outcomes of ASI staffing, although it reflects the combined effects of many factors beyond the performance of ASIs. Also, because the Composite Safety Indicator is a rolling three-year average, it will mask short-term variations.

The Model Outputs Should Be Usable Both for Staffing and for Validation.

For a model to meet commonly accepted scientific norms, the predictions it generates must be capable of empirical test. Elementary though it may seem, this requirement is often ignored in many so-called models through which appropriate staffing levels are estimated. Thus they are unable to predict the consequences of over- or understaffing through which their validity might be tested. Such models should be validated by generating predictions of how much of a specified workload various levels of staffing can accomplish, controlling for overtime and other factors used to stretch staffing in the short run, and comparing those predicted accomplishment levels with levels actually observed. Such validation might be possible using historical data during formative evaluation of the model, and certainly it should be pursued for continuing validation once the model is implemented.

In addition to validation of the model's predictions, standard errors of key model parameter estimates should be computed and reported, along with other measures of the goodness of fit between the model and the data.

The Parameter Estimation Methods Should Be Appropriate to the System Modeled.

Earlier in this chapter we describe methods for estimating the parameters of models in general. The parameters of a staffing model should be estimated using statistically sound, efficient estimation methods. The primary parameters to be estimated in a staffing model are the relationships among demand factors, workload, staffing inputs, and staffing productivity.

Any of the estimation methods described earlier may be used, but for any given staffing model the decisions about parameter estimation should be made by expert modelers with input from people who understand the practical realities of the system to be modeled. It is especially important that the modelers understand the limitations of the data available for generating estimates, as well as the expected stability or change in operations and business practices between the period providing historical data and the period in which the model will be used. In principle, modelers should use the most rigorous, most empirical method that is practical. Any nonempirically based estimates should be empirically validated to the extent possible during pilot implementation of the model.

The Model Should Represent All Important System Dimensions at Appropriate Levels of Detail.

The selection of factors to be included in any staffing model will be critical to the model's success. Recall that the purpose of the model is to abstract from reality the essential elements, not to duplicate that reality's complexity. If too much detailed data input is required to support the model, it is likely to be left on the shelf and not used, because implementation will be expensive, difficult, or impossible. If too little detail is included or if important drivers or moderating factors are omitted from the model, it will not provide valid predictions and will not be worth using. Again, the model design must be performed by experts with knowledge both of modeling techniques and of the system to be modeled.

Summary

The overarching goal for this chapter was to examine generic features, characteristics, and requirements of the two principal approaches to modeling (process and statistical approaches) in the context of the ASI staffing situation. Explicit consideration of these fundamentals is necessary for evaluating current ASI staffing models and any potential alternatives, for judging the merit and difficulty of making substantial improvements in those models, and for developing an entirely new approach, should that prove advisable. It is, in short, essential preparation for both the chapters to follow in which the specific components of our charge are addressed.

In the committee's view, the ASI situation *does* call for a formal modeling approach, one that supports staffing decisions in both the allocation and sufficiency functions through valid predictions of system-performance consequences.

We wish to emphasize again that a staffing model is not, and should not be, the only tool used in the development of manpower or staffing plans (called staffing standards at the FAA). Other factors rightfully enter into the manpower planning process. But if a model is to be used, it should be the best model that the FAA can feasibly develop and implement.

The question of how best to proceed toward achieving this goal can be answered only through the application of the principles presented in this chapter to current and previous ASI staffing models, alternatives derived from other large organizations, and consideration of an entirely new model. The following chapters address in depth these three applications together with characteristics of the aviation environment to which any ASI staffing model must be sensitive.

3

Approaches to Staffing

Having established a conceptual frame of reference for staffing models, we are in a position to begin the examination and ultimate assessment of the actual approaches of the Federal Aviation Administration (FAA) as well as selected examples from organizations with somewhat comparable staffing situations. Representing as it does the essence of our charge, yet encompassing three fairly distinct perspectives, our in-depth analysis is divided into three chapters. This chapter is primarily descriptive—a review and analysis of systematic approaches to staffing, past and present, inside and outside the FAA. Chapter 4 focuses on the specific factors (many of them unique) that contribute to the staffing need structure for aviation safety inspectors (ASIs), along with their modeling implications. Chapter 5 brings the consideration of realities and requirements together in articulating our conclusions and recommendations to the FAA.

History of FAA Modeling Efforts

During the past several years, the Flight Standards (AFS) and Aircraft Certification (AIR) offices of the FAA have engaged in several efforts to improve the approaches they use to determine levels of staffing for aviation safety inspectors. Although referred to internally as "staffing standards," they all fall within the committee's definition of staffing models discussed in Chapter 2 and constitute efforts to represent the human resources "need structure" as conceptualized there. All are tools for use in manpower planning, determining how many staff of various types or categories are needed at AFS or AIR facilities. They are not used in individual hiring, assignment, promotion, or other such personnel decisions.

Concurrent changes in the nation's aviation environment have presented the FAA with a number of significant challenges in this effort. These include:

- variations in workload drivers and work environments across the regions and the individual facilities in which aviation safety inspectors work,
- changes over time in the geographic distribution of workload, along with the costs and morale issues associated with relocating personnel and offices to adapt to such changes,
- changes in the skills required of inspectors driven by changes in the aviation industry and the FAA's approach to maintaining aviation safety, and
- resource constraints as the FAA has absorbed reductions in funding, either absolute or in proportion to expanding aviation operations.

Another challenge is the cost and the personnel time and effort required to implement any new method of developing staffing standards. The worth of any method or model is dependent on the quality of the data populating it, and the timely collection and validation of suitable data can be difficult and costly. Foremost among the data required in a staffing model are those describing the work that the staff—in this case, the ASI workforce—is expected to accomplish.

In particular, analyses of some kind must be performed to document what inspectors do on the job and how long it takes them to do it, and record-keeping systems must be designed and implemented to capture these data. As jobs and tasks change, the data yielded by earlier analyses become obsolete, so analyses must be performed repeatedly to provide accurate information—a very costly process often requiring outside contractors. Even with well-designed systems, the procedures, forms, and data entry effort needed to continuously document task performance and resource use can be onerous. Such work often is perceived as a nonproductive use of inspector and manager time in a resource-constrained environment.

During the past few years, the systems used by the FAA for labor-hour reporting (important sources of workload inputs for any staffing model) have undergone some noteworthy changes. The new systems have been devised primarily to improve resource tracking, and their utility for providing the essential input to staffing models is questionable. A system called Program Tracking and Reporting Subsystem (PTRS) has long been used in AFS to record the work activities performed. A new system called

BOX 3-1

What is LDR?

LDR is a new financial management tool to help give us a more accurate picture of FAA's major costs. Each employee and manager will identify the time he or she spends on various projects and activities. Time will be reported in one-hour blocks.

Why are we doing this?

FAA is required to do this, in large part because historically it has been difficult to quantify our costs. LDR will support Cost and Performance Management (C/PM) and the Cost Accounting System (CAS), which are also just around the corner. C/PM will allow us to better allocate and manage resources. This program will ultimately change how we view and understand our contribution to the FAA vision and mission.

Also, it will help us make better business decisions. The data we input into LDR will feed into the CAS, which will generate reports reflecting the total cost per project or activity.

Together, LDR and CAS data should give us better information for decisions when we project budgets, estimate staffing levels, assess employee skill mix, and recruit. Management will be able to better defend the need for added resources and will be able to cite hard supporting evidence.

SOURCE: Available: http://www.faa.gov/ahr/super/LDR.cfm.

Labor Distribution Reporting (LDR) was introduced FAA-wide as a labor-hour reporting (i.e., timesheet) system beginning in fiscal year (FY) 2002. LDR has recently been enhanced; the number of codes used to identify work performed has been expanded to allow more fine-grained tracking of work times. Employees are required to record their work in both the PTRS and the LDR systems. Box 3-1 presents a brief description of LDR from the FAA's web site.

LDR aggregates work information differently from PTRS, recording hours as the primary entry, rather than activities. The first version provided less detail than PTRS as well, causing difficulties for staffing models that are based on documentation of labor hours by task. Although LDR has not been proposed as a source of model data, we note these features as a caution, in case other recording systems are discontinued or changed in ways that make them unsuitable data sources and LDR becomes the sole documentation of task performance times. Other difficulties that arise in the use of any labor reporting system data as input to represent workload in staffing models result from the fact that only the work actually performed is reported; no record is produced of work that should have been performed but was not done because of resource constraints or other limitations or work that was done but simply not reported. Changes in the way tasks are classified, aggregated, and reported can make it difficult to track changes in workloads for particular tasks or groups of tasks over time. There is no direct translation between the PTRS and LDR reporting systems.

Staffing Models in AFS

Until 1995, AFS used a system of complexity points as a surrogate for workload to develop staffing standards. Complexity points were originally developed by the U.S. Office of Personnel Management for use in job evaluation and setting levels and pay grades of various jobs. The FAA publication *Position Classification Guide for Aviation Safety Inspector Positions (Air Carrier and General Aviation)—FG-1825* (Federal Aviation Administration, 1998) provides an example of the complexity points system and its use in its Appendix 1, Complexity Report.

By combining complexity points for tasks with the requirements for, and records of the frequency of, task performance and other inputs, AFS calculated what they deemed at the time to represent a rough approximation of actual workloads and staffing needs.

In 1995, AFS determined that this methodology was not as effective as desired, especially as jobs and workloads were changing, and the AFS management team began considering alternative staffing models. Since the late 1990s, the FAA has experienced declining staffing resources in proportion to increasing demand, and AFS has been obliged to develop staffing methodologies aimed at allocating available resources equitably and effectively (allocation models), rather than determining staffing requirements needed to sustain system performance at what is deemed a priori an acceptable level (sufficiency models).

In 1998, development of a new staffing system, called the Holistic Staffing Model, was initiated in response to the recommendations of the 90-Day Safety Review (Federal Aviation Administration, 1996), following the 1996 crash of a ValuJet aircraft. The approach underlying this initiative was patterned after a system then in use by some AFS regional offices, and model development was undertaken with contractor assistance. Documentation provided to the committee (IBES, 2000) indicates that inputs to the development of the holistic model were to include automated systems information (e.g., labor reporting system data), task inventories developed at headquarters and in the field, structured interviews, and self-reporting surveys completed by inspectors. As the model design evolved, it became clear that AFS could not implement this model cost-effectively, and the effort was discontinued in 2002.

More recently, AFS has developed a model called the Automated Staffing Allocation Model (ASAM). ASAM, developed by an FAA work-group under the auspices of the AFS Human Capital Council, incorporates some formulas used by the southern and southwestern regions in their local staffing projections. ASAM is implemented in a Microsoft Excel application. ASAM does not appear to have involved a new task analysis effort, as the holistic model would have, and it relies heavily on the complexity-point computations that are believed to be ineffective in an environment of changing jobs and workloads (Federal Aviation Administration, 2003b).

AFS is now implementing ASAM as a forecasting and planning tool for staffing needs, although it is not being used as a standard for authorizing staffing levels. The actual staffing levels are set in regional offices, with guidance from the ASAM model and from other sources. The ASAM model is still undergoing refinement as its early results are evaluated. Both the holistic model and ASAM are described in detail later in this chapter.

Staffing Models in AIR

In AIR, a different staffing approach is used for manufacturing inspectors.[1] A staffing model for AIR was developed in the mid-1990s and first implemented in 1997 through updates to Order 1380.49, *Staffing Standards for Aviation Safety Inspectors* (see Order 1380.49D, 2002, for the current version) (Federal Aviation Administration, 1995, 2002). These standards have not been used officially since some time in 2004, according to information we obtained from AIR and Professional Airways Systems Specialists (PASS).

Under Order 1380.49 (Federal Aviation Administration, 1995, 2002), AIR employed a work recording system called the Manufacturing Inspection Management Information System (MIMIS), consisting of a list of 78 activities, products (reports, certificates, etc.), and services, to record inspectors' work. The system also used time standards (in hours) that had

[1]This information on AIR staffing standards is derived from a briefing to the committee by Deane Hausler of AIR 530 on March 8, 2005, personal communication with James Pratt, an ASI and a PASS representative at the Cleveland, OH, Manufacturing Inspection District Office, and documentation provided to the committee by the FAA or accessed on the FAA web site. The committee understands that the staffing system in AIR is still undergoing review and that changes are likely.

been developed for tasks, products, etc., based on job task analysis and observation and on actual hours recorded in labor reporting systems.

In addition to inputs from work recording systems, AIR uses information gathered from division and field office managers and from customers (manufacturers) to forecast staffing needs. The staffing projections generated at headquarters using all of these inputs serve as guidance to the divisions and offices as they make their staffing decisions given available resources, but they are not used to mandate staffing levels.

Unlike MIMIS, the recently implemented LDF system originally recorded hours worked using only 25 major activities, said to account for about 80 percent of the activities recorded under MIMIS. LDR does not record products and services completed. The Certificate Management Information System (CMIS) records inspections performed, while MIMIS is still used to record work products at this time. AIR management had planned to discontinue the use of MIMIS and staffing standards reporting in FY 2004, but questions concerning the adequacy of the LDR system for AIR purposes prompted delay of that decision. As of 2005, staffing standards reporting was being retained, although recent enhancements to the LDR system may affect this decision.[2]

Of course the FAA's human resource management functions include selection, assignment, training, and development of inspectors with the particular skills needed for their individual jobs. ASI position announcements note the specific assignment for which hiring is anticipated, often with special knowledge, skills, abilities, and experience requirements specified. But these human resource management functions are not addressed by FAA staffing standards.

Analysis of the ASAM

The purpose of the ASAM is to improve the allocation of ASI and other AFS staffing resources across regions and across offices within regions in AFS. It does this by providing an estimate of total staffing requirements for flight standards district offices, certificate management offices in the region, and international field offices (Federal Aviation Administration, 2005c). Staffing demand is estimated by using algorithms relating demand factors, such as number of certificates, registered aircraft, commercial airports, etc., either to staffing directly or to staffing

[2]As an example of the ambiguity about labor reporting in AIR, it is interesting to note that Order 2700.37 establishing LDR was published in 2001. Order 1380.49D, issued in 2002, is now shown on the FAA regulatory library web site as having been cancelled by Order 2700.37. A new MIMIS guide was issued in 2004.

hours required, which are then converted into full-time equivalents. The original relationships between demand factors and staffing are based on expert judgment and experience, rather than data obtained through some empirical process.

It should be noted that although the model captures some of the factors that contribute to inspector workload and overall staffing needs, a number of important drivers are either underrepresented or neglected completely. For example, designee staff are not directly included in the model as workload drivers for inspectors. Recent changes and evolution in workload demands and how they are staffed are not fully incorporated into the model. The model's data and algorithms lag behind in fully incorporating the Air Transportation Oversight System (ATOS), for example, as well as some new relationships in general aviation staffing and maintenance/repair inspection. The emphasis on work sampling, for example, is probably a pre-ATOS carryover, at least in part.

Incomplete though it may be, the model's estimate of total staffing demand is compared with total ASI staffing resources in order to guide distribution decisions. The ratio of staffing resources to estimated staffing demand is applied to the model's estimate of demand at the district and office level to yield an index of the staffing resources that the district or office should have. In practice, however, this index does not represent a requirement or directive for allocations at the district or office level; rather, it is regarded primarily as a basis for management discussions and possible negotiation (Federal Aviation Administration, 2004b).

From everything the committee was able to determine regarding its current use, therefore, ASAM is basically an allocation rather than a sufficiency model. That is, it is not used to determine the appropriate overall level of staffing, but rather to ensure that available resources are allocated reasonably, which means in proportion to estimated workload. Deviations between actual and estimated staffing do not necessarily result in corrections, but they may form a basis for subsequent adjustments at the discretion of management.

Model Parameters and Logic

The ASAM model builds staffing demand from the bottom up, relying heavily on two types of relationships. The first consists of a large number of identities representing "core" staffing principles that were established by definition, by custom, or by simple rules of thumb (e.g., one manager per field office). These equations are location specific, so they generate staffing demands at specific locations.

The second type of relationship is somewhat more analytical and empirical, at least in theory. Staffing demand is estimated as a function of workload measures. Algorithms (some of them from the *Position Classification Guide* complexity report) (Federal Aviation Administration, 1998) relate variables that generate the demand for staffing, such as the number of pilots requiring certification or the number of airports, to hours required. Table 3-1 shows a page of an ASAM worksheet with documentation from a sample file provided to the committee by AFS. In some cases the equations go directly from the workload driver to full-time equivalent positions (FTEs). Demand for staff hours of service of particular types is estimated from the underlying factors generating demand. The algorithms are typically (though not all) linear, with coefficients or parameters relating demand measures to service hour requirements. The sources or rationales for some of the algorithms are documented in the literature the committee was provided; for other algorithms, these are not documented.

FTEs are estimated from hours by dividing total hours demanded by an estimate of service hours that can be supplied annually by a full-time ASI in the respective category. Supervisor requirements are determined by identities that relate number of FTE inspectors of a given category to numbers of people needed to supervise them, based on predetermined supervisor to staff ratios.

Overall staffing demand at a given location is computed by summing all of the sources of demand. Some positions—officer managers and supervisors—are based on identities, while others are derived empirically from underlying factors presumed to generate demand. It is important to note that although the values used in this computation may be empirically determined, the relationships among variables (the parameter or coefficient estimates) typically are not; rather, they are based on expert judgment and past experience (often the most reasonable source). Order 8400.10 is a source for some factors, such as supervisor to staff ratios and hours available per FTE (Federal Aviation Administration, 1994).

Data Sources

Three data sources are used in the ASAM model. The first is a staffing questionnaire, versions of which are administered at the district and field office levels (Federal Aviation Administration, 2004c). This instrument requests data on actual (assigned) staffing, authorized staffing, and information on workload as measured, typically, by the number and size class of carriers supported. It constitutes the primary data source for the ASAM index of actual or current staffing.

A second data source is derived from direct demand measures—"aviation services data" provided by both the region and headquarters. These data have important direct effects on the staffing requirement estimates produced by the model. Workload-related data for the region or

TABLE 3-1 Sample Page from ASAM Worksheet Documentation

Section	Item	Question	Field Name
Table 2: Aviation Services Index	Aircraft Based in FSDO Geographic Area Conversion to Hours		[CodeE_Hours]
Table 2: Aviation Services Index	Accidents / Incidents / Eir / Complaints (Ops)B (Code F)		[CodeF]
Table 2: Aviation Services Index	Accidents / Incidents / Eir / Complaints (Ops)B (Code F)		[CodeF_Hours]
Table 2: Aviation Services Index	Accidents / Incidents / Eir / Complaints (Aw)C+D (Code G)		[CodeG]
Table 2: Aviation Services Index	Accidents / Incidents / Eir / Complaints (Aw)C+D Conversion to Hours		[CodeG_Hours]
Table 2: Aviation Services Index	Accidents / Incidents / Eir / Complaints (Av)C (Code H)		[CodeH]
Table 2: Aviation Services Index	Accidents / Incidents / Eir / Complaints (Av)C Conversion to Hours		[CodeH_Hours]

Actual Number	Authorized or Derived Value	Notes
Derived from [CodeE] Data Source	=IF([CodeE]<100,[CodeE]*0.5, IF([CodeE]<200,[CodeE]*0.4, IF([CodeE]<400,[CodeE]*0.35, IF([CodeE]<500,[CodeE]*0.33, IF([CodeE]<1000,[CodeE]*0.28, IF([CodeE]<2000,[CodeE]*0.16, IF([CodeE]<3000, [CodeE]*0.16, IF([CodeE]<4000, [CodeE]*0.088, IF([CodeE]<5000, [CodeE]*0.077, IF([CodeE]<10000,[CodeE]*0.037, ”Error”))))))))))	This is meant to generate the number of hours inspectors in the region must spend each year inspecting the data element. The hours value is driven by the 8400.10 handbook chart on page 6-5. It is meant to ensure that there is a 95% confidence that the surveyed group is similar to the entire population.
Same as [Code_B] (Certificated Airmen (Pilots))	=[Code_B]	The value being used is the Certificated Airmen (Pilots) value ([Code_B]).
Derived from [CodeF] Data Source	=([Code F]*.02)*11	This is direct from ASAM spreadsheet. The source of formula is unknown.
Same as [Code_B] (Certificated Airmen (Pilots))	=[Code_B]	The value being used is the Certificated Airmen (Pilots) value ([Code_B]).
Derived from [CodeG] Data Source	=([Code G]*.02)*10	This is direct from ASAM spreadsheet. The source of formula is unknown.
From Data Source	=[CodeB]*0.1	The value being used is the Certificated Airmen (Pilots) value ([Code_B]) times 0.1.
Derived from [CodeH] Data Source	[CodeH_Hours]= ([Code H]*.02)*10	This is direct from ASAM spreadsheet. The source of formula is unknown.

facility, such as the number of public use airports in a region, the number of air carriers of each type, and many other indicators are included. Finally, the third data source is "national" data, collected at the nationwide level and provided by FAA headquarters.

Additional key sources of information supporting the model, though not of current data inputs, are the *FAA Inspector Handbooks* (Orders 8300.10, 8400.10, 8700.1, etc., Federal Aviation Administration, 1994, 2003a, 2004a, 2005c, 2005d, undated) and the *Work Program Guidelines* (Federal Aviation Administration, 2005a), which provide specifications for many of the tasks to be performed by inspectors. As background to understanding ASI staffing, it is also important to know that ASI work is divided by the FAA into three categories or levels of priority: (1) required work, (2) planned items, and (3) demand items. Required work is a top-priority workload for each fiscal year that is required by policy. It is largely independent of external environmental conditions. Planned items are specific items generating workload that are determined for the year at the regional or field office level. Demand items are performed on an as-needed basis. They are typically generated by incidents, accidents, and the demands of the public and require rapid response.

Basis for the Relationship Between Workload and Staffing

There is little direct documentation of the basis of the relationship between workload and staffing in ASAM. The relationships appear to be determined by administrative judgment or policy. Some relationships are taken from the Complexity Report (Federal Aviation Administration, 1998) and have not been updated in recent years.[3]

Simple logic suggests that workload should be one (if not the sole) major determinant of quantitative staffing requirements; hence the precision with which this relationship can be specified is a vital consideration in the evaluation of any staffing model. Clearly, when it is available, empirical evidence constitutes the most credible basis for estimating the relationship. For ASAM, it appears that a combination of historical experience, administrative judgments, and policy or regulations rather than current empirical evidence underlie the estimates. References to certain instructions, handbooks, and other sources provide some documentation,

[3]The model clearly uses complexity points in estimating demand. However, the *Position Classification Guide: Aviation Safety Inspector Positions* (Federal Aviation Administration, 1998) states that "the complexity report is used to determine the complexity of an individual inspector's assignment, not to make conclusions regarding the overall staffing needs of an office" (part VII, Position Management).

but clearly the basis for most of them is the judgment of experts. Expert judgment can, of course, yield valuable information, but in the absence of empirical verification, the validity of such estimates is indeterminate. In addition to its questionable precision, the ASAM model provides no estimates of predicted performance; that is, it does not indicate the consequences of being understaffed (or overstaffed) relative to the model's prescriptions in terms of workload cycle times, or backlog, or safety.

Analysis of the Holistic Model[4]

The Holistic Staffing Model was proposed in the mid-1990s as an improved way to estimate staffing demand for the AFS. It was never made operational, but the design of the surveillance submodel was well developed. We are reviewing it here in some detail because we think that important lessons for future modeling efforts can be learned from this modeling effort. The basic concept underlying the holistic model is that staffing demand is best established from the bottom up, starting at the level of activity (i.e., functional elements of work determined through systematic job or task analysis). The more variable and complex the to-be-described job domain is, along with the context in which it operates, the more challenging and costly the effort required to adequately represent it. The holistic model was undertaken in full recognition of this challenge, including the fact that it would be necessary to identify and measure a number of key factors controlling the demand for specific activities in order to provide credible estimates of staffing requirements. Such factors are referred to throughout this report as workload drivers.

The demand for aviation safety inspectors is estimated in the holistic model by estimating the activities of inspectors by 13 office types[5] and the three categories of tasks—required, planned, and demand—discussed earlier. Basic factors affecting the demand for work, such as the number of certificates, public use airports, and aircraft, generate the demand for various activities. Then ASI inspector requirements are estimated by dividing total activities by the average number of the identified activities that can be performed by an inspector.

To this requirement for inspectors, administrative and support staffing is added. A fixed component of administrative and support staffing, one that is approximately constant over time, is distinguished from a

[4]This discussion is based largely on a contractor report, "Flight Standards Service Holistic Staffing Model: Final Report," prepared June 11, 1999, by IBES (2000).

[5]The office types include small, medium, and large variants of commercial and general aviation, mixed, ATOS and others.

variable component, one that may vary with changes in workload. The first component is entered as "current staffing" under the assumption that the current administrative and support staffing levels are correct for the current workload. The variable component is estimated as ratios to current operational staffing. As that staffing changes, support and administration staffing based on average ratios between particular administrative and support staff and inspectors changes also. Hence, the variable component of support and administration staff changes indirectly in response to workload changes, if the number of inspectors changes.

The model estimates and equations are based on a sampling approach in which typical office types are constructed. Based on the parameters estimated for the typical offices, the relationship between demand and staffing is then applied to offices across the regions.

The holistic model, in concept, allows the estimation of AFS staffing demand, serving as a sufficiency model. As demand factors change, the model would be responsive and estimates of staffing requirements would change. In principle, it could help estimate changes in staffing demand as aggregate workload changes and as relative workload shifts among regions and field offices. Since it was never actually implemented, of course, whatever potential it may have was never realized. We therefore present the following description of model characteristics as they would have been had the holistic model become a reality.

Model Parameters and Logic

The logic of the holistic model is relatively straightforward. Demand factors generate workload activities across inspector staff. This activity workload and its relationship to demand factors are documented through administrative and survey data. An average time to perform an activity is calculated. Staffing demands for inspectors are then estimated across field offices and regions based on anticipated activity workload.

A sampling approach is taken with the data. Parameters for model or typical field office types are calculated and then applied to all similar office types. Administrative and support staff are estimated based on staffing to support the historical workload. Ratios of support to inspector staff are used to estimate needed changes in support/administrative staff when inspector staff changes.

Key input data include activities by workload type (required, planned, and demand) by type of office. In addition, time required to accomplish these activities is critical. From these, the key set of model parameters—average times to complete the activities—is generated.

The key model parameters are then used to project inspector staffing demand as a function of demand factors. Administrative and support staffing are added, based on historically determined ratios of support to inspector staff.

Key outputs of the model, then, are estimates of inspector staffing demand as a function of workload-generating demand factors across regions and offices. Actual staffing can be compared with staffing demand to project shortages or surpluses. Furthermore, the model enables "what-if" analyses to determine the effect of changes in the total demand or mix of demand factors on staffing shortages or surpluses. The model does not directly predict the consequences of shortages (or surpluses) in terms of the effect of outputs, although it is capable of estimating the expected number of required, planned, and demand activities that may not be accomplished for a given set of staffing shortages.

Model Data Sources

The holistic model relies on a combination of administrative databases and survey data collected from the regions and field offices. The administrative databases include the PTRS, which tracks and documents much of the workload, including the required and planned items, performed by the regions and field offices. It includes data regarding the activities performed, the type of staff performing the activities, and the time necessary to perform each activity. The Consolidated Personnel Management Information System (CPMIS) (no longer available since the beginning of FY 2006) was used to document on-board staff at all levels, including administrative and support staff. The National Vital Information Subsystem (NVIS), a headquarters-level database, documents the environment, including the number, kind, and distribution of offices.

Field Office Self-Reporting Surveys are administered at sampled field offices. The purpose is to document the workload activities and time required for these activities, based on the responses of the field offices. The surveys both complement the PTRS data, because some activities are not recorded in it, and serve as a second source for the PTRS data. The surveys provide additional information on a key input of the model—frequencies of various activities and time required to perform various activities. Note that the survey is administered to only a sample of AFS offices. The sampling unit is the field office, and data at the activity level are collected from the field office.

A survey was designed to be administered to staff offices and division managers at the headquarters level. The purpose of this survey is to obtain information on the major tasks performed, the job series performing each task, and documentation regarding programs, databases, handbooks, and other information. This information is generally to provide background, to identify surveillance tasks performed, and to provide information to form a sampling frame for the Field Office Self-Reporting Survey, rather than to provide data that are directly used in model calculations.

The proposed data collection for the holistic model has two desirable features. First, much of the critical information is routinely collected through PTRS, an administrative database that is maintained for operational purposes, not simply for the model. In principle, the PTRS data could be improved over time and, if necessary, expanded to support particular aspects of the modeling, at relatively low additional cost. The quality of the data can be tested and improved systematically, improving not only the estimates of the model but also the original application of PTRS. Second, the survey collection of self-reported data is based on sampling, targeted to information most needed for the model. This lowers the overall cost of data collection. Moreover, targeting of particular types of information has the potential for improving data quality.

The holistic model's use of data also has some undesirable qualities. First, the level of detail required poses a difficult challenge to the FAA's data recording and analytic capacities, and it was one of the contributors to the rejection of the model. Second, we were told that the model does not account for variations in complexity among some work drivers;[6] it treats them as equivalent, thus failing to accurately represent real workload.

Basis for the Relationship Between Workload and Staffing

Workload is defined in terms of activities. The time to perform the activities is provided through PTRS and through the field office survey. Based on estimates of average time to perform an activity, staffing demand is estimated by dividing the total demand for activities by the average yearly hours available for work per inspector. As factors generating demand increase (for example, certificates), staffing demand increases through the relationship between activities generated by demand factors and estimates of time to accomplish an activity.

The simple averages used to generate parameters to provide the link between workload and staffing are less accurate than estimates derived from regression and maximum likelihood methods that take into account other factors that moderate the relationship between staffing and activities.

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[6] An example given by an FAA staff member was the average age of the aircraft fleets at different carriers. Older fleets require more intensive oversight than newer ones, but the model does not recognize this difference.

Summary Evaluation of the ASAM and Holistic Models

The ASAM and holistic models each have systemic deficiencies that would not be overcome by patching new software into old. It is likely that development of a new model, if done well, would produce a much better product than such a remodeling effort. We do want to make clear that these models both have features that could be profitably incorporated into a new model. The development efforts for the two models have made AFS staff aware of many useful techniques and data sources and have exposed potential pitfalls in developing a staffing model. This experience and knowledge should be used in the process of developing any new model.

Analysis of Potential Alternatives Adapted from Other Organizations

In addition to the ASI-specific holistic and ASAM models that the FAA presented for review, the committee examined staffing models from other organizations for their potential relevance to our task. Because of the proprietary nature of staffing for any business, we had a very limited opportunity to review and document staffing models from private industry. However, we were able to review a number of public-sector manpower planning models, tools, and processes that resemble the ASI staffing situation in at least some respects. These include:

- airport security staffing (Atkins, Begen, Kluczny, Parkinson, and Puterman, 2003);
- distributed service networks (Palekar, Delli, and Rajagopalan, 2000);
- Air Force manpower assessments (U.S. General Accounting Office, 2002);
- Army manpower analysis (U.S. Army FORSCOM, 2005);
- Army manpower modeling (Hawley, Lockett, and Allender, 2005);
- Navy manpower modeling (Bowen and Wetteland, 2003);
- U.S. Environmental Protection Agency (U.S. General Accounting Office, 2000); and
- state courts (Fautsko, Hall, and Ryan, 2001).

These organizations employ systematic approaches to satisfy their manpower and staffing needs. Their staffing situations are similar to that faced by the FAA, in that fairly substantial pools of diverse human resources are required on a sustained basis, but with continuously changing characteristics and levels. However, each organization has evolved a solution that is unique to its situation, and none seems to have generalized to the others. Simply put, we were unable to find anything approaching a generic manpower/staffing model. What we concluded from our review, then, was that the unique features of any organization's staffing requirements dominate the generic ones so that it is virtually impossible to successfully adapt a systematic approach from one to another. Since staffing models per se apparently do not generalize, our focus shifted from a search for proven alternatives to a consideration of generic model characteristics with reference to the ASI staffing situation.

This refocused review, coupled with the committee's experience, revealed only two important, broadly shared characteristics. First, all models must address the issue of factors driving the demand for manpower. Whether it involves court caseload, component failure rates, or number of calls per minute, staffing models must be able to predict or otherwise explicitly reflect the demand for human services as a function of the factors that drive that demand. Second, most models address the consequences of manpower supply-demand imbalance. In other words, they address not only how many staff members of each type are needed, but also the implications of having less staffing than is recommended by the model's output. Viewed from a characteristics as well as an overall perspective, therefore, it is clear that unique considerations dominate, but it is equally clear that specification of both the factors driving demand (demand drivers) and the consequences of staffing deficiencies is essential to any viable staffing model.

Rather than continuing the search for promising models external to the FAA or advising the FAA to do so, we decided that effort would be better spent considering the factors that are very specific to the ASI situation (e.g., aircraft types, travel time between locations, qualifications of different inspector types, designee oversight, ATOS transition, performance criteria, etc.) and the model characteristics that appear most salient to this unique set of requirements. In other words, the committee deemed adaptation of general modeling principles to the specific characteristics of the ASI staffing situation the most promising approach to both evaluating current practices and seeking improvements.

The committee also reviewed the staffing standards used by the FAA's air traffic organization for air traffic control specialists (ATCSs). A National Research Council committee reviewed the ATCS standards in 1997 and made recommendations for improvement (National Research Council, 1997). Some of those recommendations may have been implemented, but a review of recent FAA documents reveals that air traffic staffing still uses multilevel "engineered" standards, with a strong emphasis on detailed task analysis and on quantifying ATCS workload and activities (Mills, Pfleiderer, and Manning, 2002; Federal Aviation Administration, 2004d). The data from these analyses are used in combination with targets for maximizing staffing efficiency and reducing staffing costs over time to determine staffing standards.

The 2004 document describes a reassessment of the air traffic staffing standards to be performed starting in FY 2005 but, as they stand now, the ATCS staffing methods appear not to meet several of the model criteria described in Chapter 2. Most importantly, both the composition of the ATCS jobs and the context in which they are carried out are considerably more homogeneous than the wide array of ASI jobs and work settings. In sum, the committee believes that the current ATCS staffing standards are not a useful source of improvements to the AFS staffing methodology.

Summary

This chapter presents an in-depth analysis of staffing models developed inside and outside the FAA organization from the perspective of current and projected ASI staffing needs. In particular, it addresses the core question posed in the committee's charge: Are current approaches to ASI staffing sufficient to cope with the growing demand and, if not, could upgrading or adapting other models in current use satisfy the need? To answer this question, the committee first reviewed past and present approaches developed by the FAA to guide staffing decisions, focusing particular attention on the two most comprehensive such efforts: the ASAM model currently in use by the AFS organization and the holistic model, which AFS conceived but never implemented, due primarily to cost considerations. We found both seriously deficient in a number of respects, most importantly, in their inability to predict the consequences of understaffing at either the local or the system level. The holistic approach did incorporate a number of essential features, but since it never materialized and—like ASAM—would have proven difficult to validate had it done so, we conclude that neither model represents a particularly promising point of departure for system improvement. However, analysis of the approach in use by the considerably different, substantially smaller AIR organization led us to conclude that it is sufficient to support the current AIR staffing requirements, subject only to improved recording systems.

Next we explored staffing approaches in use by a sample of large organizations whose situations appear comparable in certain respects to that facing the FAA. But even a cursory analysis revealed that none would be adaptable, in whole or in part, to the ASI staffing situation. The reason, very simply, is that the unique features of each clearly dominate the shared ones to the extent that there is little to be gained in attempting to transport elements from one to another. We therefore conclude that the ASI demand structure is sufficiently unique to rule out either substituting or adapting a model in use outside the FAA. Even the FAA's ATCS staffing model was deemed unsuitable for ASI purposes.

On the basis of these analyses, we therefore conclude that neither modifying current FAA models nor adapting those from the outside represents the most cost-effective strategy for the much-needed upgrading of the ASI staffing process. Although there is much to be gained from the ASAM and holistic efforts, we think that the present and anticipated future ASI staffing situation calls for development of an entirely new model.

In the next chapter, the focus therefore shifts to identification of the specific facets of the ASI situation that, based on our multi-source investigation, we think must be considered in developing an effective staffing model.

4

Issues to Be Addressed in Staffing Models

The committee identified the unique challenges and issues that must be addressed by the staffing models for aviation safety inspectors (ASIs) by reviewing documents and gathering the perspectives of a wide array of stakeholders—including ASIs themselves. From this background material, we identified factors affecting demand for ASIs that result from the unique aspects of the Federal Aviation Administration (FAA) as an organization and from the external aviation environment. In this chapter we first briefly review the information we obtained from stakeholders and ASIs, and then we provide our assessment of major factors that should be considered when developing a model designed to guide the ASI staffing process. Many of the factors discussed in this chapter involve FAA human resource issues rather than those typically regarded as manpower issues, to which this study was primarily directed. As explained in Chapter 1, despite the directed emphasis on manpower planning, we think it essential that the human resource deficiencies be addressed in order that an intelligent manpower modeling effort can be undertaken.

Issues Raised by Stakeholders

The committee heard from representatives of numerous groups that are directly affected by the ASI workforce. (See Chapter 1 for a list of stakeholder representatives who addressed the committee.) The committee's sampling from these stakeholder groups revealed several points of agreement on perceived problems, along with some areas of disagreement on how the FAA should approach the ASI staffing situation. We heard from stakeholder communities that include those who are overseen and inspected by the ASIs, the ASIs themselves (including their union representatives), and the FAA management, so it should not be surprising that perspectives differed substantially on a number of points. Our purpose in this section is to summarize, not to evaluate, the comments, concerns, and suggestions presented to the committee by various stakeholder groups—regardless of the level of agreement across groups. The section is generally organized around the issues identified rather than the groups identifying them. However, because the committee conducted numerous interviews with ASIs representing a wide range of functional roles and geographical locations, we summarize those interviews separately. Many of the issues identified by stakeholders mirror those listed as concerns in the discussion of the origin of the study in Chapter 1.

General Comments

Stakeholders generally agreed on one very important aspect of the ASI workforce: most ASIs are dedicated to their mission and serve their customers well. The issue of the proper staffing levels and distribution of ASIs is a distinctly different question from that of the competence of individual members of the ASI workforce. In addition, industry trade group representatives uniformly welcomed the oversight of knowledgeable ASIs, acknowledging that it can help them maintain safety and reliability in their operations. At the same time, many aviation industry representatives noted that it is in their own best interests to maintain high safety standards, and that they would do so whether or not they were being inspected by the FAA. Finally, the aviation community generally accepts the use of designees, noting that they are for the most part competent, appropriately used, and vital to the efficiency of the system. That is, given a regulatory environment that mandates certain inspections, reviews, and audits, the system could not function at current ASI staffing levels without the use of competent designees.

Perceived Problem Areas

Stakeholders representing various groups in the aviation community identified a number of perceived problems with current ASI staffing and human resource management, often illustrating specific cases in which the number of ASIs or their collective technical capacity was deemed inadequate.

Staffing Levels and Distribution. Many stakeholders were reluctant to comment on the overall level of staffing required for ASIs. There was some indication from stakeholders that this reluctance stems from recognition that the overall number of ASIs is driven by budget constraints. However, they were much less reluctant to comment on the distribution of ASIs across offices (and, in some cases, even within offices), noting that staffing levels may not be appropriate to changing local workloads. Specifically, there were assertions that industry changes sometimes have not been accompanied by corresponding changes in FAA assignments and office locations. Other stakeholders believed that the number of ASIs is adequate for everyday workload but not for peak demand. For example, if a regulatory change requires modifications to manuals and procedures by a large number of carriers or repair facilities at the same time, staffing levels are inadequate to handle the surge in demand occasioned by the requirement that ASIs review and approve the changes. The result is lost productivity on the part of the carrier or repair facility while waiting for review and approval. Some stakeholders also raised concern about the FAA's ability to focus ASI resources in areas of greatest need. That is, even if overall numbers of ASIs are sufficient, the FAA may not have available a sufficient number of appropriately skilled ASIs in the right place to resolve a specific problem.

ASI Knowledge and Training. While noting that most ASIs are highly skilled in one or more specific aspects of the job, stakeholders also noted that their technical knowledge and experience are sometimes insufficient for getting jobs done properly and in a timely manner. Specifically, the match between individuals' technical knowledge and the particular kinds of facilities and operations they oversee is not always optimal. For example, in the case of emerging avionics systems or agricultural aviation operations, ASIs may not be fully familiar with the equipment or operations for which they are responsible. At the same time, some ASIs lack the knowledge and skills to use data-based tools and systems like the Air Transportation Oversight System (ATOS), the Aviation Safety Action Program, or Flight Operational Quality Assurance. Some stakeholders believe that the knowledge mismatch problem and the problem of ASIs keeping current on new technologies are exacerbated by excluding them, on ethical or other grounds, from free technical training that is offered by organizations under FAA oversight. We note that the U.S. Government Accountability Office (GAO) has addressed the issue of ASI training—including the issue of ASIs receiving training from industry—in its September 2005 report, *Aviation Safety: FAA Management Practices for Technical Training Mostly Effective; Further Actions Could Enhance Results* (U.S. Government Accountability Office, 2005). The GAO found that the FAA had improved its technical training management practices, but it also noted that FAA training management and inspectors differ in their assessments of how well the inspectors' technical training needs are being met. One of its recommendations was that the secretary of transportation should direct the FAA to review its policies on acceptance of free training from the aviation industry and implement methods to ensure compliance with those policies.

Other Problems. Almost all stakeholder representatives addressed the questions of ASI staffing levels, and the distribution, knowledge, and training of ASIs. Many representatives pointed out other areas of concern as well.

A number of industry groups raised a concern about the effectiveness of FAA oversight of outsourced maintenance and other outsourced work. Questions were raised about whether the number of inspectors was keeping up with the growth of outsourcing. In particular, concerns were expressed over how the language and cultural barriers that are unique to international outsourcing ("offshoring") are being addressed. However, some stakeholders observed that the quality of aircraft maintenance at many overseas facilities is currently superior to that performed at many U.S. facilities. Therefore, the proposition that outsourcing maintenance to overseas facilities is a risky endeavor should not be accepted without question. Regardless of whether outsourcing poses any questions of quality, the logistics of covering the geographic area and the cultural differences add to the inspector workload.

On another topic, most stakeholders endorsed the use of designees to increase the efficiency of their operations; however, some groups noted that the use of designees, who charge fees, for tasks formerly performed at no charge by an ASI may impose financial burdens on general aviation customers. Finally, several stakeholders noted that some ASI job descriptions are not accurate or current, and the problem is increasing with the changing aviation and safety oversight landscape.

Needs Identified by Stakeholders

In the course of their discussions with the committee, stakeholders identified a number of actions that they believed would help the FAA in managing the ASI workforce. These were not confined to manpower management. In general, stakeholders endorsed the idea that the FAA needs enough ASIs, properly trained and deployed, to address peak and emerging work demands, as well as to carry out routine processes. There was wide agreement that ASIs need continuing technical training on new systems and equipment, and that ASIs need to better understand the various kinds of businesses and operations they oversee. Some stakeholders noted that many ASIs need better training on the oversight process itself, and that ASIs need to have new knowledge, skills, and abilities and a "systems view" to work with new system safety oversight tools. Finally, some stakeholders believe that the FAA needs better job descriptions and knowledge, skills, and abilities inventories for ASI jobs.

ASI Perspectives

The committee was briefed by a number of ASI representatives during several of its meetings. In addition, 39 ASIs and managers in 7 locations, including various types of offices, were interviewed (see Chapter 1 for details) so that committee members could gain a firsthand understanding of these jobs, along with the perspectives of the professionals performing them.

Most of the issues raised by the ASIs can be grouped under three headings: (1) training and socialization issues, (2) workload issues, and (3) designee issues, and they are summarized in that manner below. Individual ASIs also identified a number of idiosyncratic concerns that are summarized under a fourth heading (other issues). What follows is therefore a purely descriptive listing of information gathered from the ASI briefings and field interviews with no attempt to evaluate or judge the validity of the views expressed.

Training and Socialization Issues

- Little overlap is allowed between a retiring or transferring ASI and his or her replacement. Typically the departing ASI must leave before the new one can start the job. Thus there is a gap between the time one leaves and the other begins, as well as a decreased level of effectiveness during the time the new ASI is learning the job.
- The time needed to become proficient in a particular ASI assignment is lengthy, but ASIs must begin performing their jobs as soon as they are assigned, despite skill deficiencies that could be improved with training. The time to master the job varies with the background and experience of the individual as well as the availability of training. Given wide variations in technology and facilities, prior ASI experience may not necessarily give an ASI the necessary knowledge to do his or her new job; some ASIs reported that it takes a minimum of two to three years to become fully proficient on the job.
- Aviation technology is rapidly evolving, and many ASIs find it difficult to identify appropriate standards for the new technology or to keep up with changes.

—Several ASIs mentioned that technology is changing faster than guidance for the use or maintenance of that technology is developed.

- Training may not be available in a timely fashion. Some ASIs mentioned that they were not trained on aircraft or equipment for which they were responsible. Others indicate they received their training secondhand from other ASIs. Others received their training from the companies that manufactured the equipment, despite some FAA uncertainty about the circumstances under which ASIs should attend such training.
- Some of the training that is provided by the FAA is perceived to be time-consuming and of minimal value. The training is often "one size fits all" and disregards the needs of individual ASIs.
- Some ASIs noted that the manufacturers and the airlines that they oversee are often the best source of training on the latest technologies, yet taking advantage of these training opportunities may be prohibited by rules and regulations or ethical considerations due to an apparent conflict of interest. Some hinted at a conflict of interest (e.g., receiving training on the operation of an aircraft from a school under the ASI's supervision); others saw no problem with receiving training from vendors.
- Some ASIs reported that online training often cannot substitute for or replace on-site training, and therefore providing on-line training is not sufficient to adequately train ASIs in some content areas.
- Not all ASIs share a good understanding of the risk management or system safety approach that is implemented in ATOS and other new FAA systems. It appears that some ASIs believe that a risk management approach increases the amount of paperwork exponentially and therefore places additional time demands on them at the expense of inspection activities that they consider more critical. In a similar vein, other ASIs reported that the only way to ensure safety is to perform frequent surveillance, and that the risk management approach leads to possibly dangerous compromises. Regardless of whether this observation is accurate, the fact that many ASIs believe this suggests that they lack knowledge of, and/or confidence in, the tools at their disposal to perform risk management. The reluctance of many ASIs to accept the preventive or risk management approach suggests that, if this approach is the way of the future, the FAA must do a better job of training and socializing ASIs so they are committed to this philosophy.
- Some ASIs noted that since the risk management approach requires a different mentality and set of qualifications from those traditionally sought, future ASI recruitment should be revised accordingly. For example, a background in quality assurance/control might be accorded a high priority in the qualifications list.

Workload Issues

- Many ASIs believe there is more work expected of them than can be done in the 40-hour work week allocated.

—Most agree that while all required items are completed, some planned items are not accomplished, and a large number of demand items (e.g., investigations of accidents or complaints) are difficult to manage because the ASI does not know how many he or she will get or how long each will take to resolve.

—Some believe they have too many designees and cannot supervise them all effectively.

—Despite the limits on time worked, many ASIs do "off-the-clock" work.

- The work program does not provide adequate time for administrative activities, including paperwork. The work program covers fieldwork but not important administrative activities like cataloguing and updating manuals or creating documentation related to ISO 9000 certification now being pursued by Aviation Safety (Federal Aviation Administration, 2006).
- The system does not take into account unconventional demands on the ASIs' time. For example, the filming of an action movie often involves use of airspace and requires special oversight by the FAA. Planning and coordination for these events take a significant amount of time.
- Few options exist to manage the workload. The number of people that can be hired is constrained, as are the number of hours worked. In general, overtime work is not allowed, and ASIs may not carry more than 40 hours of compensatory time. Many ASIs noted they were not able to take the compensatory time they had already accrued.
- Several ASIs in operations reported that the FAA staffing system places too much emphasis on number of aircraft to determine workload, while ignoring other critical factors such as the age of the fleet. For example, cargo airlines often have older fleets that require additional surveillance beyond that required by the newer aircraft that passenger airlines tend to use.
- Staffing is often inadequate at peak times. ASIs in some locations noted that additional surveillance was needed at peak times (e.g., Thanksgiving), but additional personnel or hours were not available.
- The priority of work items is sometimes unclear. Work programs often have activities that must be accomplished in a year but are neglected for unexpected items that arise during the year that seem to have higher priority.

—The amount of paperwork is immense, and there is little clerical assistance in most offices to assist with the management of documents.

—ASIs are required to complete their own paperwork for tracking time and tasks as well as manage paperwork for an array of citizens who need certification, authorizations, and waivers or who must report accidents.

—ASIs use a number of reference materials (e.g., Inspectors' Handbooks 8700, 8400, 8300; Federal Aviation Administration, 1994, 2003, 2004a, 2004b, 2005b) that must be updated. Keeping manuals current is a time-consuming task that ASIs are not always able to do in a timely fashion.

—Guidance for ASIs shows up in a number of places ranging from the inspectors' handbooks and handbook bulletins to manufacturers' specifications. Ensuring the most current information is sometimes difficult.

- The FAA's time and task tracking systems are difficult to use for a variety of reasons and take more time than necessary in the opinion of some. These difficulties sometimes result in inaccurate reporting.

—The Program Tracking and Reporting Subsystem (PTRS) and the Labor Distribution Reporting (LDR) system require separate entries of the same or similar information, so ASIs spend a significant amount of their time in redundant data entry activities. PTRS tracks completed tasks. LDR tracks the way individuals use their time. In addition, there are written documents for time and attendance, sick leave, etc., that require completion and signature. A better integration of these systems so that they could all share the same database might solve this issue.

—The codes for the LDR system are extensive and can be viewed only 10 at a time. Users cannot back up in the system—only move forward.

- Travel by car to inspection sites can be time-consuming, and resources for faster transportation by air are not available.

—Some ASIs complained that they do not have access to FAA aircraft even when a flight was going to their destination. Others indicated they were required to drive and had little time left for their work once they arrived at their destination.

—Geography and the associated travel time is a major factor in the amount of time available for inspections at some flight standards district offices.

- If ASIs were able to perform more of the aviation education activities included in the work program outlined in Order 1800.56F (Federal Aviation Administration, 2005a, p. 6), general aviation safety could be improved, according to many ASIs. Suggestions ranged from public seminars to more surveillance and presence at air shows. Higher priority tasks leave little time for such activities.
- ASIs often have a sense of never being caught up with their work.

- Many ASIs believe the FAA headquarters is overly reactive to outside pressures and creates work by not considering the broader implications of the actions it takes.
- In addition, there is a strong belief that the FAA in general and the Flight Standards Service (AFS) in particular is a top-down organization in which decisions are made at the top without a genuine understanding of the issues and the ramifications.
- Individuals exercising political influence can place enormous pressure on an FAA office or an individual ASI with the result that work priorities are altered.

Designee Issues[1]

The level of oversight of designees may be inadequate in some cases. The ASIs often worry about their supervision of designees and believe they do not have enough time to observe and coach the less capable designees. Consequently, some designees may not be doing as good a job as they should.

- ASIs use proxies that may not be as good as actual observations for evaluating designees. For example, when ASIs don't have the time to observe all their designees, they may monitor the proportion of examinees passed and failed by a designated pilot examiner. An excessively high pass rate may indicate that the designee's standards are inadequate. Similarly, if a designee regularly gives unqualified approval to maintenance of aircraft that appear to require complex maintenance activities, the ASI may assume the designee is not reviewing the work with sufficient care. The extent to which these reviews are adequate is not known.
- Some ASIs observed that the number of designees is an incomplete index of the amount of work required to oversee designees. Certain designees, such as freelance agents authorized to certify pilots, require extra time because they work only during the weekend, have other unusual schedules, or work in multiple locations and, in general, are more difficult to track and monitor.
- Some ASIs perceived a move toward the privatization of their work and believed that this will result in the loss of their jobs and poorer enforcement of standards.

[1]Note that the Government Accountability Office was tasked to study the use and oversight of designees. Its October 2004 report (GAO 05-40) can be found at http://www.gao.gov/new.items/d0540.pdf.

Other Issues

Concerns of a more idiosyncratic nature expressed in the interviews involved the amount of authority ASIs have (or do not have), coordination across offices, privatization, and ATOS. Below are some specific examples.

- ASIs sometimes lack the authority to handle problems immediately. For example, ASIs have no legal authority to arrest someone or even demand that an individual return his or her certifications. They must use the Enforcement Investigative Report process and the court systems. In one example provided, an ASI noted that he had filed a safety recommendation against a manufacturer. The manufacturer and its designee did not want to adopt the recommendation, and the FAA did not require that they do so. Insurance companies are often perceived as the most powerful force in aviation safety.
- Coordination among government offices is sometimes lacking. For example, some ASIs noted problems certifying foreign pilots through the Transportation Security Agency and the lack of guidance or a clearly specified process for doing this work. Others noted that the National Transportation Safety Board has delegated nonfatal accident investigation to the ASIs in the FAA.
- ASIs voiced concern that the move away from hands-on inspection in favor of a remote, data-based systems approach (i.e., ATOS) is flawed and will ultimately have safety consequences. Some have documented cases of violations in ATOS-certified aircraft and operations that were not uncovered in the systems review.

Despite all the issues and problems that ASIs raised, they also noted that the ASI job is among the highest paid positions in the federal government (GS 13 or 14) and that competition for positions in some locations is fierce.

Major Drivers Behind ASI Staffing Needs

In the previous sections, we summarized what we heard from stakeholders and ASIs. There was general agreement in the areas of training needs, issues of geographic distribution, and impacts of peak demands caused by regulation changes. The committee balanced what we heard from the stakeholders with what we read or learned from the FAA and other sources in forming a general understanding of the unique requirements or challenges involved in the development of any ASI staffing model. ASI human resource demands, both the required number of inspectors and their qualifications, are driven by a combination of factors, some of which are related to the changing U.S. and global aviation landscape and others to policies and changes inside the FAA.

Factors External to the FAA: The Changing Aviation Landscape

The changing U.S. and global aviation landscape has important implications for ASI staffing. The following five features of that changing landscape are expected to be important drivers of future ASI staffing needs:

- introduction of advanced flight deck and air-ground technologies,
- increasing number of variants and derivatives of aircraft and systems,
- continuing growth in regional carrier and general aviation operations,
- outsourcing and offshoring of maintenance; and
- new manufacturing tools and techniques.

Introduction of Advanced Flight Deck and Air-Ground Technologies. With the introduction of more complex airborne and ground-based technologies, not only at major carriers but even at the level of general aviation, the need for ASI training and specialization increases, especially in the areas of avionics and operations. ASIs need a thorough understanding of the design, capabilities, and operation of these systems. These new training requirements will take time away from actual inspections and may lead to a demand for more inspectors in the future. Also, it will be important for inspectors to be aware of potential problems with human-automation interaction and human factors design principles.

Increasing Number of Variants and Derivatives of Aircraft and Systems. Since aircraft manufacturers need to be responsive to customer needs and preferences, an increasing number of derivatives or variants of certain aircraft types continue to enter the market. As an example, six currently available variants of the Boeing 777 are listed on a Boeing web site (Boeing, 1995). Inspectors need to spend time learning about those new aircraft configurations because the presence or absence of components and their interactions can affect risk levels and create overall safety concerns. One frequent comment was that some form of "differences training" should be provided. Yet we heard from ASIs that technology training opportunities for ASIs have been limited in the past, and if a more appropriate level of training were provided, the additional training time would reduce the availability of ASIs to fulfill oversight responsibilities and maintain the current level and timeliness of service to customers.

Continuing Growth in Regional Carrier and General Aviation Operations. One of the many changes under way in the aviation industry is the especially fast growth in regional airline activity. According to the Regional Airline Association, regional airlines carried approximately 134.7 million passengers in 2003, an increase of more than 100 percent over 1994 (http://www.raa.org/news/Industry_Fact_Sheet.cfm, accessed May 11, 2006). The FAA projects 155.9 million enplanements for regional carriers in 2006 and forecasts that this growth will continue at an annual average rate of 4.3 percent in revenue passenger load from 2006 to 2017, reaching 250.4 million enplanements in 2017 (Federal Aviation Administration, 2006). General aviation, still recovering from losses in activity after September 11, 2001 (9/11), is projected to continue growing as well. The FAA forecasts that the U.S. general aviation fleet will grow from 214,591 aircraft in 2005 to 252,775 in 2017, and that hours flown by general aviation aircraft will increase from 28 million in 2005 to 41 million in 2017, a 3.2 percent annual growth rate (Federal Aviation Administration, 2006). These segments of the aviation industry can require more labor-intensive oversight than major carriers, because they are comprised of many small organizations and individual owners/operators. Another challenge associated with further growth in general aviation is the large number of different aircraft models and the fact that owners can tailor the equipment on board to their preferences. Thus inspectors need to know many different aircraft, and for each aircraft model they are likely to encounter a variety of avionics/systems configurations and need to understand whether and how well those components work together.

Outsourcing and Offshoring of Maintenance. The weakened economics of the airline industry, in combination with fast-rising fuel prices and increased safety measures since the events of 9/11, create a challenging business environment for air carriers. In order to stay viable, they need to look for ways to cut costs. At least one cost-cutting measure—the outsourcing of maintenance—has implications for ASI staffing demands. According to the U.S. Department of Transportation inspector general's report (2005), the percentage of outsourced maintenance for most major air carriers has increased in recent years. In September 2004, nine ATOS carriers reviewed by the inspector general contracted out 53 percent of their aircraft maintenance expense (pp. 7-8). Much of this outsourced work is performed in areas outside the United States, such as El Salvador, Hong Kong, and Singapore. These offshoring practices can generate a range of issues.

In order to directly oversee offshore maintenance facilities, ASIs would need to travel extensively, reducing the amount of time available for other responsibilities. Also, in order to effectively oversee these facilities directly, ASIs need a full understanding of the work culture and language of the countries in which maintenance is being performed. In response to these and other challenges, AFS has established international field offices in some locations. The FAA also has implemented agreements with other national and regional aviation regulatory authorities that ensure that they set and enforce quality standards equivalent to those of the FAA, so direct ASI oversight can be reduced (see, for example, Order 8100.14a, Federal Aviation Administration, 2005f). Still, many stakeholders are concerned about oversight of some of these facilities. A December 2005 report by the inspector general on the outsourcing of maintenance to noncertified maintenance facilities, both domestic and foreign, questions the adequacy of the FAA's current oversight of such facilities (for example, AV-2006-031, U.S. Department of Transportation Office of Inspector General, 2005).

Another issue in offshore maintenance is that the maintenance manuals for U.S.-manufactured aircraft and components often are published in English only, presenting a challenge for technicians whose first language is not English. This may require even stricter oversight of such maintenance than would be needed if technicians were using manuals written in their native languages.

New Manufacturing Tools and Techniques. The introduction of new manufacturing tools and techniques affects the required number and, even more importantly, the required skills for manufacturing inspectors who are responsible for administering and enforcing safety regulations and standards for the production or modification of air carrier and general aviation aircraft. For example, inspectors need to have a thorough understanding of software tools like CATIA, which are increasingly used by aircraft manufacturers. CATIA is an example of a commercial software suite that supports all stages of product development, from conceptualization through computer-aided design (CAD), computer-aided engineering (CAE), and computer-aided manufacturing (CAM).

Factors Internal to the FAA: Changing Policy and Business Practices and the Aging Workforce

Four areas of change within the FAA appear particularly noteworthy with respect to their implications for future ASI staffing needs:

1. increasing use of designees,
2. shift to system safety approach,
3. regulatory changes, and
4. ASI attrition and retirements.

Increasing Use of Designees. Designees, the individuals or companies that are authorized by law to conduct tests, examinations, and inspections on behalf of the FAA, can reduce an inspector's workload by assuming some of his or her basic responsibilities. At the same time, however, they create new oversight tasks and challenges for inspectors who are responsible for ensuring the quality of the designees' work. In view of the already rather large and increasing number of designees and their geographical distribution, the net effect of growth of the designee program on the ASI job is likely to be qualitative—that is, an ASI role that becomes more supervisory in nature—rather than quantitative—that is, a reduced number of ASIs.

Shift to System Safety Approach. As noted throughout this report, the FAA's move to a system safety approach has profound implications for both quantitative and qualitative ASI human resource needs. The System Approach for Safety Oversight (SASO) Program is intended to provide an umbrella for all FAA safety oversight responsibilities. It was introduced in hopes of reducing the number of air carrier and general aviation accidents and improving the job training and quality for aviation safety personnel while leading to significant savings for the FAA and the aviation industry (SASO Mission Need Statement, Federal Aviation Administration, 2001). One element of SASO encourages increased information- and tool-sharing between the aviation industry and the FAA to support the early detection and identification of risk factors. Another goal of SASO is to identify early on and support changing training requirements for FAA personnel.

One important safety oversight program that falls under the SASO umbrella is the Air Transportation Oversight System. ATOS is a relatively new data-driven and risk-based air carrier oversight process that was first implemented at 10 major carriers in 1998. ATOS requires inspectors to analyze operational data to identify areas that pose the greatest safety risks for a particular carrier and focus their inspections on those areas (Order 8400.10, Appendix 6, Federal Aviation Administration, 2005d).

The main differences between the traditional surveillance and safety inspection system and ATOS are that the traditional approach focuses on completing a prescribed number of inspections, relies on individual inspector expertise, and is based on checking carrier compliance with regulations. In contrast, under ATOS, inspectors develop and revise specific surveillance plans for each carrier, analysts review air carrier data to identify areas of risk that the inspectors should target, and the focus is on safety vulnerabilities rather than compliance with regulations. Thus, the new approach is anticipatory and preventive in nature and requires a much greater degree of flexibility and tailoring of oversight activities. It also calls for inspectors to develop new skills to be able to develop, execute, and monitor the effectiveness of carrier-specific surveillance plans in collaboration with data analysts.

Regulatory Changes. Regulatory changes have an impact on ASI workload and staffing requirements as well. For example, new FAA regulations that became effective in 2005 (FAR Part 121, Amendment No. 121-130, Federal Aviation Administration, 2005a; FAR Part 129, Amendment No. 129-41, Federal Aviation Administration, 2005b; FAR Part 135 Amendment No. 135-81, Federal Aviation Administration, 2005c) now require that all aircraft of defined types undergo an inspection and review after the 14th year in service and at specified intervals thereafter. These inspections help ensure the adequate and timely maintenance of an aircraft's age-sensitive components. As the number of aircraft falling into this category grows, more field inspectors may be needed to accomplish or to oversee these inspections.

Many regulatory changes require revisions in procedures and supporting manuals for manufacturers, maintainers, or operators of specific aircraft. All such documentation revisions must be reviewed and approved by ASIs. These tasks can impose major burdens on their time.

ASI Attrition and Retirement Rate. Between 2003 and 2005, the FAA ASI workforce was downsized by 231 safety inspectors. While the staffing level in the Office of Aviation Safety is expected to increase by about 80 in 2006, this growth would still leave it below the FY 2004 staffing level. The median age of all AFS ASIs in FY 2003 was 54, with only 32.6 percent under age 50 (staffing tables provided by Robert Caldwell, AFS 160).[2] As these aging inspectors retire, requirements to hire and train new ASIs will increase. These staffing changes contribute to the workload challenge already faced by ASIs and will need to be considered in any model that determines future staffing needs. Viewed differently, the need to recruit many new inspectors can be seen as an opportunity to develop and apply new ASI job descriptions and qualifications to match evolving FAA practices.

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[2] A statement presented by Michael Fanfalone representing Professional Airway Systems Specialists to the House Aviation Subcommittee on April 11, 2002, states that "43% of the inspector workforce is eligible to retire by 2006." He attributes that figure to an FAA report: *FAA's Workforce Planning and Restructuring*, June 4, 2001 (Fanfalone, 2002). The committee has been unable to locate that document to verify the statement.

Factors Internal to the FAA: Human Resource Management Practices

The committee's first goal was to "critically examine staffing standards for FAA Aviation Safety Inspectors and the assumptions underlying those standards." In the process of fulfilling the second element of our task, which directed us to "gather information about the ASI job series," we detected a number of qualitative issues related to current human resource management practices that were intrinsically linked to the determination of ASI demand. The human resource management practices we are concerned with include ASI job design, recruitment, selection, training, and development. Undoubtedly, some modifications of current practices may have implications for work rules, compensation, and labor relations matters, which our tasking explicitly directed us to exclude. We do not discuss any of those potential implications, but we do describe how human resource management practices outside of manpower management may relate to staffing models and standards. We believe that the synthesis of staffing-related issues presented here is consistent with the spirit of our tasking.

We should note that, in accordance with our task, we did not undertake a direct examination of the FAA's recruitment, selection, or training practices, but instead report on issues related to each of these staffing-related functions as they were shared with us in the process of gathering information about the ASI job series. Our findings are therefore based on a relatively small sampling of available data sources—convenience samples that cannot be regarded as representative—so our depiction of the focal issues should be interpreted with this qualification in mind.

New Knowledge Demands of System Safety Approaches. Order 1800.56F (Federal Aviation Administration, 2005g) enumerates the flight standards work functions to be completed by AFS personnel. These work functions fall under the categories of surveillance, investigation, certification, and aviation education. Order 1800.56F advocates a "system safety concept of oversight" (section 6-f, page 4), which goes beyond a mere "checklist" inspection and annotation of observed deficiencies and instead calls for an integrated assessment of system status. Indeed, Order 1800.56F points out that "surveillance is a tool to provide information for performance assessment and risk management" (p. 5). The order calls for inspectors "to target their safety surveillance based upon risk and/or safety assessment," and it advocates a data-driven approach aided by information systems, such as the Safety Performance Analysis System (SPAS). The investigations function also calls for higher order analytic skills as it aims to determine "causal factors of potential or actual problem areas" (p. 5).

Our interviews with ASIs revealed a lack of comfort with or confidence in this system approach to risk assessment among some incumbents. It appears that some ASIs still see themselves as traditional inspectors, perceiving that any approach to their job other than direct-contact, field surveillance represents a compromise that endangers aviation safety. This unwillingness to embrace the system safety and risk assessment approach may suggest a number of problems. For example, tools like SPAS may simply be difficult to use and require retooling to make them more user-friendly. Some ASIs may simply not know how to extract valuable information on trends and probabilities from the data-analytic tools available to them (e.g., SPAS), while others may not know how to make inferences from the data produced. Others may have difficulty transitioning from an environment of wide surveillance activities to one of prioritized surveillance. Other ASIs may doubt the accuracy of the data input into systems like SPAS and thus lack confidence in any decisions based on the analysis of those data.

We learned from our interviews with job incumbents and other stakeholders that individuals enter the ASI job series from a variety of backgrounds. It appears that those individuals whose prior experience has been limited to routine repairs or installations under close monitoring or supervision from others may have an insufficient understanding of how entire systems work, and they may be unprepared to engage in preventive risk assessment following the system safety approach. Thus, some ASIs may benefit from training and development programs intended to sharpen their ability to understand causal relations among system components, identify trends in the data gathered through surveillance activities, and, overall, think in probabilistic terms when assessing risks.

In contrast, individuals with prior experience in managing quality assurance of large and highly distributed aviation operations appeared to be most receptive to, and capable of performing under, the premises of the systems approach to risk assessment. Such prior experience and background may thus be weighted favorably in future ASI recruitment and selection programs. The value of incorporating this or any other prior experience in a selection procedure, however, should not be taken for granted until the appropriate validation study is carried out.

Implications for ASI staffing: If individuals are not comfortable with changing job requirements, the FAA may not be able to staff optimally until all individuals are fully trained, understand, and accept the new work expectations.

New Skill Demands. Order 1800.56F (p. 6) also states that aviation education is one of the primary functions of AFS. Many of our interviewees pointed out that performing the job successfully required a collaborative approach to aviation safety, as opposed to an adversarial approach focused on policing the industry. In this collaborative role, ASIs serve as facilitators who educate the aviation community and the public at large on aviation safety. The set of interpersonal and communication skills required to perform their educational functions in a collaborative manner may be improved on the job or through training and development programs. However, interpersonal and communication skills can be difficult to develop, and therefore the recruitment and selection of individuals with at least a minimum level of such competencies may facilitate their further development.

Implications for ASI staffing: The FAA may not be able to staff optimally until individuals with the requisite interpersonal and communication skill levels (achieved via either training or selection) are in place.

New and Continuing Technology Knowledge Demands. Some ASIs and some stakeholders highlighted the difficulties inherent in finding and accessing relevant training programs that will help them update their knowledge of aviation technology. Some ASIs also pointed out that internal training manuals and training programs are often too basic or do not keep up with the latest innovations in the field. Budgetary restrictions and the FAA's discomfort with having ASIs attend training provided by the manufacturers, the airlines, or any of the other entities that they serve (due to potential conflicts of interest) were deemed to be additional roadblocks in their ability to keep abreast with knowledge in their field. Some stakeholders noted that technical obsolescence impairs or at least slows down the ability of ASIs to serve those who employ the latest aviation technologies. This finding has potential implications not only for ASI training and career development, but also for whether an effective system is in place to detect and respond to their training needs.

Implications for ASI staffing: The FAA may not be able to staff optimally until individuals with the requisite knowledge levels (achieved via either training or selection) are in place and may need to include more time for continuing technical training when determining staffing levels for some ASI positions.

Lack of Performance Criteria for ASIs. The FAA informed the committee of its explicit intention to transition to performance-based management, asking us to look at performance-based versus engineered staffing standards. But any superiority of performance-based over engineered standards (i.e., standards derived from detailed task analysis) is critically dependent on how performance is defined and measured. Moreover, a measure of staffing outcomes, presumably based on the performance of the ASI workforce, is needed to determine the validity and utility of any

ASI staffing model and its outputs. However, the FAA has not developed acceptably explicit performance measures for ASIs. The committee was told by FAA staff that there had been an attempt to use ASI productivity statistics as a measure of performance, but that it had been unsuccessful.

Most ASIs report that they make sure that they accomplish all of their high-priority (required and planned) work and most other surveillance work; others admit that the planned items can be significantly delayed or even omitted on occasion. However, they complain that there are not enough person-hours to do those tasks as well as they would like, and they have very little time for discretionary tasks, such as safety education. This finding suggests that a measure of work quality or thoroughness, rather than merely a count of tasks accomplished, may be needed to reveal shortfalls in ASI staffing.

Implications for ASI staffing: Clearly, neither definition nor measurement of performance is a simple matter for the ASI job domain, but both will be critical to the development of a useful staffing model.

Summary

The material presented in this chapter represents both a compilation of the information gathered in the course of the committee's investigation and a synthesis of that information designed to assist developers of any future modeling effort. Thus it constitutes the basis for the evaluation of existing models and the conclusions reached in Chapter 3, and it also underlies the findings and recommendations summarized in Chapter 5.

In order to understand the ASI staffing situation in its totality, the committee thought it necessary to gather information from multiple sources: official documents and records, stakeholders external to the FAA, various levels of FAA management, ASIs at their workplaces, and union representatives. While recognizing that these perspectives would not be completely congruent, we expected that there would be enough convergence to establish the major facets of the staffing problem and to judge the extent to which current and alternative approaches would be capable of satisfying the growing inspection demand. Both expectations were realized. There was disagreement on a number of mostly lesser issues but substantial agreement on the limitations of current models, current staffing practices, major workload drivers (internal and external to the FAA), and institutional constraints (notably budget limitations). Moreover, there was broad agreement that the long-standing trend of growing demand and static supply cannot continue much longer without serious consequences; hence a major correction is long overdue.

Operating on this premise, the committee directed its attention to identifying deficiencies in current practices (problem areas), the major drivers of present and future demand, and other challenges that would need to be met in order to effect systemic improvement. As noted in the last chapter, this analysis convinced us that the most cost-effective approach would be development of an entirely new ASI staffing model. Whereas Chapter 2 provided guidance on the formal properties that should be considered in developing such a model, this chapter completes the picture by identifying the substantive aspects of the ASI staffing situation that must be accommodated in it. One recurrent theme, introduced in Chapter 1 and sustained through the report, is that no modeling effort, however well conceived, can succeed without the development of defensible human resource management elements—in particular, meaningful performance measures, accurately maintained job descriptions with matching requirements, and the institutional commitment not only to implement the model properly but also to maintain it. It is essential that FAA management recognize the interdependence of human resource and manpower planning functions and appreciate the fact that investment in either alone cannot achieve much in the way of improved staffing, system efficiency, or performance. The commitment must involve both concurrently. Moreover, in view of the changing aviation environment, it must be a sustained commitment.

5

Conclusions and Recommendations

In this report we have examined model features of most relevance to the staffing situation of aviation safety inspectors (ASIs), critically reviewed the modeling approaches that the Federal Aviation Administration (FAA) and other organizations have developed to guide staffing decisions, and identified unique human resource issues that should be addressed prior to initiating any manpower modeling efforts. We return now to the specific questions posed to us. In the following sections, we summarize our conclusions regarding the adequacy of current ASI staffing models, the potential afforded by models drawn from outside the FAA, and the merits of a completely new approach. Our specific recommendations follow each set of conclusions, and the final section provides an elaboration of our recommended approach.

Before proceeding, it is necessary to address one overarching issue that, while not directly related to our modeling charge, has an important bearing on all facets of the ASI staffing question. As explained earlier, staffing needs are heavily dependent on the capabilities of the individual ASIs, their fit with the prescribed work roles, and a host of organizational factors, such as management practices, culture, and other human resource considerations. In the course of our investigation, it became apparent that little can be gained through improved manpower modeling in the present case unless serious prior attention is accorded to these other critical human resource matters. Unless work is described with reasonable accuracy and the required skill sets are ensured through adequate recruitment, selection, training, and placement of personnel, estimates of the number and distribution of ASIs required to sustain system performance will remain equivocal. Since our investigation was not explicitly directed toward these human resource issues, we cannot make explicit recommendations on the direction a preliminary effort of this sort should take. The evidence of weaknesses was sufficient, however, to justify our recommendation that such a prior effort is essential.

Evaluation of the ASI Staffing Models

Conclusions

In reviewing the two comprehensive models of ASI staffing demand—the Automated Staffing Allocation Model (ASAM) and the aborted Holistic Staffing Model—against the features that we consider essential, we conclude that both fall short in certain areas. ASAM, as currently structured, appears deficient in at least the following respects:

- It does not predict the consequences of staffing shortfalls at any level and because of that it cannot be validated.
- It fails to account for some important factors affecting inspector workload.
- Many of its key parameters derive from expert judgment and have not been empirically validated. Hence it is not an empirically based model.

The holistic approach, while potentially closer to the structure we consider appropriate, is lacking in the following respects:

- The documentation suggested statistically weak univariate methods for estimating parameters.
- The detail in its structure almost certainly exceeds a level that available data can support.
- There was no discernible plan for formal model validation,[1] nor was it clear precisely what predictions the model would make regarding the consequences of alternative levels of staffing.
- Most importantly, the model was never developed or tested, so its potential utility and validity are unknown.

[1]The contractor's report describing the model (IBES, 2000) has sections devoted to model validation, but most of them address validation of the data, rather than the overall model predictions.

Recommendations

In view of the above limitations, neither the ASAM nor the holistic model itself represents a promising framework in which to flesh out a more suitable ASI staffing model. Each has systemic deficiencies not easily remedied by piecemeal revisions to the current software. If the Flight Standards Service (AFS) were to continue to use the ASAM model without correcting the deficiencies, it would remain vulnerable to criticisms of the model's validity and suitability for supporting staffing decisions. Staffing standards would continue to be developed without formal consideration of some important work drivers, and the model would remain unvalidated.

In addition, we note that modification of an existing base of software code (particularly by someone other than the original developer) often proves more costly and less efficient than developing completely new code. We therefore recommend that any new modeling effort directed toward improving the FAA's approach to addressing the ASI need structure for AFS not be constrained by over-reliance on the current modeling foundation.

This is not to suggest, however, that nothing can be salvaged from these modeling efforts. Both ASAM, as it exists, and the holistic model, as it was described, provide a rich store of knowledge that would be useful for developing a new modeling approach. In particular, the existing documentation and the knowledge and experience of the FAA staff who were involved in the development of these models should be tapped in any new development effort. Furthermore, data-gathering activities, such as comprehensive job analyses, that were programmed into the holistic approach but never executed might profitably be revisited.

Evaluation of Potential Alternatives Adapted from Other Organizations

Conclusion

Our analysis of approaches used by eight public-sector organizations that bear a resemblance to the FAA in certain key respects, as well as of the FAA's staffing methodology for air traffic controllers, reveals that there is little potential for direct transfer—or adaptation—of any of these models to the FAA's ASI staffing situation. In each case, unique features far outweigh the common ones, and the solutions that have evolved reflect that diversity.

Recommendation

The ASI staffing challenge is sufficiently distinctive to rule out the option of importing, in whole or in part, an already developed model. Therefore, improvement over current practices can only be achieved through development of a new model, drawing on both the FAA's previous experience with modeling efforts and careful consideration of the salient model properties described in this report.

Model Development in Light of AFS/AIR Differences

Conclusions

The staffing situations for the AFS and the Aircraft Certification Service (AIR) are markedly different. With over 3,000 inspectors widely distributed across functional and geographical job domains and obvious deficiencies in the ASAM model, AFS is clearly in a position to benefit from (and justify the cost involved in) developing a new model. By contrast, it is difficult to justify a costly modeling effort for staffing the fewer than 200 AIR inspector positions, especially since the approach currently in use appears generally satisfactory. The main problem in this inspection domain seems to involve work recording systems rather than the staffing model. In particular, there is continuing uncertainty about future plans for the Manufacturing Inspection Management Information Subsystem and the Labor Distribution Reporting system. AIR management has told the committee that it is carefully weighing the effects of changes in FAA labor and services reporting, and it is taking action to ensure that the data needed to support its current approach to staffing are adequate.

The challenge facing the AFS organization is considerably larger and more complex. To be demonstrably effective, a staffing model must incorporate accurate representations of workforce supply and demand, applying well-designed algorithms to produce accurate projections of staffing needs and the consequences of staffing shortfalls. It should also enable frequent updates and changes to ASI work processes.

Most important of all, it must be integrally linked to appropriate measures of individual and system performance, without which its validity and utility cannot be established. Lacking these, any attempt to estimate the expected superiority of one staffing model over another, or the consequences and risks associated with understaffing or suboptimal distribution, is fruitless.

In all the above respects, the current ASAM model is deficient. The holistic approach, while somewhat more promising, never materialized, and in view of its weaknesses does not appear to merit revisiting. What performance measures currently exist are at best of dubious quality and utility.

Recommendations

AIR. The committee recommends continued effort aimed at improving the work recording systems for AIR inspectors rather than development of a new staffing model at this time. Should significant changes in the workload drivers appear in the future, the current AIR staffing approach might warrant another review. We recommend that AIR headquarters should be responsive to the concerns of ASIs and include them in any such improvement efforts.

AFS. In the case of AFS, the situation clearly justifies a fresh analysis of the staffing need structure and development of a suitable model. Thus we recommend that the FAA initiate a systematic effort toward that end.

Software tools and techniques for developing manpower and staffing models are readily available (e.g., Extend, SimScript, Flexsim, Arena, Micro Saint Sharp, and others; see Chapter 2). The use of such tools and software would reduce the cost of model development substantially while providing a powerful and usable modeling environment for predicting ASI staffing needs and the consequences of ASI staffing decisions. Since we recognize that this recommendation would involve a major effort encompassing a number of the considerations presented in this report, we elaborate our recommendations below.

1. The approach should draw on the experience gained in developing ASAM and conceptualizing the holistic staffing approach, but it should not be constrained in an attempt to preserve the structure or core substance of either. While subtle, this distinction is important in the sense that an emphasis on preservation generally results in a more costly and less satisfactory end product than does starting afresh, especially when there are fundamental weaknesses in the initial structure—as clearly there are here. Therefore, the development process should include the following phases:

- *Requirements definition,* in which the questions that the ASI staffing model should address, data sources, and measures of effectiveness are specified;
- *Model specification,* in which a high-level software architecture is defined, including basic data flows, algorithms, and data structures;
- *Model development,* in which modern software engineering techniques and tools and an iterative development approach are utilized; and

- *Model verification and validation,* through which it is demonstrated that the ASI staffing model software behaves as expected, and that the model produces sufficiently accurate predictions of the ASI staffing demand, supply, and supply-demand imbalance consequences.

We recognize that the initial development and appropriate testing of a new model will require an up-front investment and take time. However, weighing that investment against the long-term benefits afforded by a model capable of estimating overall ASI staffing needs, optimal distribution, and understaffing consequences, we recommend making that investment.

2. The modeling effort should be undertaken with the goal of supporting FAA decision making in both sufficiency and allocation decisions. To this end, it should embody as many of the desirable features identified in Chapter 2 as feasible. Most importantly, it should be empirically based, although certain relationships may necessarily be established through expert judgment—at least initially. Weighing the pros and cons of statistical versus process simulation models, we believe a hybrid approach may prove the most feasible and practical. We therefore recommend that the model designers explicitly consider which aspects of the model should be process-based and which based primarily on statistical relationships. As an example, routine tasks that have a long history of performance could most likely be modeled statistically, while new or modified tasks (like those associated with the Air Transportation Oversight System), for which there are few historical data on work processes and task performance times, may require more detailed process modeling. More precise specification than this would require a far more comprehensive analysis than was possible within the scope of the present study.

3. Appropriate measures of system and individual performance are essential for both the development and validation of any improved staffing approach, irrespective of model properties and features. We therefore recommend that a concerted effort be invested at the outset in developing meaningful performance measures. We recognize that this is not a simple matter, and that heavy reliance on expert judgment at all levels will be necessary in order to devise measures that are both meaningful and widely accepted. Particular care should be taken not to sacrifice utility in the interest of convenience in this effort: the temptation to seize measures that are handy (and numeric) without proper regard for what they actually reflect is always present and must be guarded against.

4. One of the most significant weaknesses in the current ASI modeling practices is the burden of entering data to populate the model prior to making predictions. Hence we recommend that any future model should be designed so that it can be supported by institutionalized administrative databases, not by ad hoc surveys or other extraordinary data sources. There are existing databases, such as the Program Tracking and Reporting Subsystem and the National Vital Information Subsystem, that provide an excellent foundation on which to build. Such databases, maintained institutionally for purposes beyond staffing decisions, could be adapted to populate significant portions of the model without the need for manual data entry. This would help to ensure that the data are available, accurate, and timely, while reducing the burden of ad hoc data entry; it is a common practice in other staffing model applications, such as ISMAT, used by the U.S. Navy.[2]

5. In addition to model features per se, the FAA and those assisting with the staffing model development must consider a number of ancillary issues, mostly of a practical nature, that bear on model implementation. We therefore conclude with a set of recommendations addressing the most prominent of these considerations.

Cost. It was difficult for the committee to estimate the cost of designing, developing, operating, and maintaining an ASI staffing model with the information available to us, and the estimate presented here is based on assumptions about the modeling environment that may not be accurate. Thus it should be taken as a rough estimate, with a high level of uncertainty. The greatest uncertainty is associated with the availability of the needed data in easily usable form. Other cost drivers for a modeling effort like this include the complexity of the organization, the number of variables to be modeled, the level of detail at which the model will operate, and the choice of method and model developers. Some of the FAA's previous staffing models have apparently been of some use at the aggregate (AFS-wide) and regional levels, but they have not been useful at the facility level. It would certainly require more effort, and cost more, to design, test, and implement a model that is of proven value at all levels, including that of the individual facilities.

Similarly, some stakeholders noted that the ASAM model fails to take

[2]ISMAT (Integrated Simulation Manpower Analysis Tool) is a manpower analysis product developed for the United States Navy that can automatically import data from several established naval manpower databases that provide information on manpower supply and demand factors central to the manpower analysis issues addressed by the tool (Plott and Wenger, 2005).

account of some of the more subtle variables related to drivers of work demand (examples include number of designees overseen, age and condition of carrier fleets to be monitored), and they would like to see these factors considered in a new model. Again, the addition of variables and detail required in the design and test phases would result in increased cost, as would the greater precision of data required in the implementation phase.

The FAA's choice of a model design and development strategy will also affect the costs and the time (discussed below) needed to develop a model. We have noted that the development effort should be performed by a team that includes both subject matter experts (SMEs, people with an in-depth understanding of AFS operations and staffing issues) and professionals experienced in developing and implementing staffing models and systems. The FAA could assemble such a team relying exclusively on FAA employees, or it could engage a contractor, providing FAA employees as SMEs on a part-time basis with the contractor serving in the primary model development role.

If the requisite staffing and modeling expertise is available in the current FAA workforce, the project could be performed in-house; otherwise, it would require a significant contractor investment. However, in deciding which strategy to pursue, careful consideration should be given to all associated costs, both direct and hidden. For example, on one hand, diverting FAA experts from their current responsibilities incurs hidden costs, as would any delay or compromise in end-product quality that a completely in-house effort might entail. On the other hand, direct investment in what is essentially a contracted "turnkey" effort would be substantial, but it would minimize the hidden costs associated with in-house development. What is essential is that whatever approach is selected should be chosen in full recognition of the level and term of investment required, and with a firm commitment to full completion. A repeat of the holistic experience must be avoided. The committee does not have the information on available talent and relative cost-value considerations to make a recommendation on which course should be pursued. We can, however, provide some rough estimates of the costs and time involved in a largely contracted effort.

The committee's best estimate, based on experience with organizations similar to AFS, is that it will take about $600-800K to design and build the modeling tool, $300-400K to initially populate the model with data and develop mechanisms to keep the data updated, and perhaps as much as $100K per year to keep the model and data current.

Time. The previous experience of committee members who have performed or supported similar model development efforts suggests that one to two years will be required to go through the development process that we recommend, if it is performed by an FAA-contractor team. Development of a model using only FAA in-house resources would be very likely to take longer (see above). By the end of this period, a working model should be in place. However, the model itself will continue to evolve over time as data are accumulated on its functioning, and inevitably adjustments will need to be made. We recommend that the development of a new model be undertaken in full recognition of this evolutionary requirement.

Organizational constraints and culture. Perhaps the most critical determinants of a model's long-term value are the organizational constraints and culture in which it is introduced and maintained. The committee would like to emphasize three points here.

First, if the model is perceived as merely creating work for its care and feeding (e.g., gathering data to populate it) rather than as a valued aid to decision making, it will fail. Certainly, model acceptance depends in part on its ability to make predictions that are valid and consistent with ASI staff and management experience. However, even the most functional model will fail if misapplied or deemed by FAA decision makers and those affected as lacking in validity, utility, or significance. Not only must effort be directed toward developing and documenting a sound staffing model; once developed, its value must be actively promoted to those using it and affected by it. This may require an investment in a communications and training program to familiarize AFS employees with a new model and inform them of its advantages.

Second, any effort of this sort will also be accepted most readily if those who are affected by its use are involved in the process of its development. ASIs and their managers should be consulted from the beginning, and they should have significant roles in the model design, development, and implementation. Because the Professional Airways Systems Specialists organization is an important stakeholder, its inclusion in the design and development process may facilitate the implementation of a new system. This will increase the likelihood that the resulting model will be easy to implement and that ASIs will become committed to the new system and be motivated to support it.

Finally, as noted above, the FAA should address the human resource issues associated with changes to the ASI job and to AFS business processes before developing a new ASI staffing model. A new model of an old job, one that no longer is performed as it is modeled, will be of little value.

Available data and improvements. As stated above, wherever possible, the FAA should seek and take advantage of available data to populate new staffing models. Since a model's predictions are only as good as the data that go into it, careful consideration should be given to the relative costs of modifying existing data-gathering systems versus creating new ones.

Resources. The committee's sense is that past ASI staffing models required a commitment of resources for development, maintenance, and use beyond what AVS or AFS management was able or willing to provide. This is not a problem unique to the FAA—modeling endeavors often begin with great ambitions and expectations, only to be undone by the weight of the work that is required to realize the ambitious goals (witness the holistic attempt). In a word, we recommend that the FAA undertake the development of an ASI staffing model with the features and supporting structure we have outlined above. However, it should undertake this effort only if it is institutionally committed to the development and maintenance of such a model.

In addition, it will be critical to the success of any modeling effort that appropriate management resources be devoted to the effort. The managers should be skilled and experienced in managing software development projects and committed to the success of the effort. The skill with which the model development effort is managed will affect both the time to complete it and its eventual success.

We strongly recommend that during the model design phase, the FAA should focus on what it is willing to invest versus what it is expecting to gain. Constant and explicit consideration of this trade-off is imperative during the early stages of ASI staffing model design and development. As noted above, investment includes not only initial model development cost, but also the costs of ongoing maintenance required to keep the database and model up to date and operating and the cost of continued use of the model. The gains should be viewed from the perspective of the breadth of ASI staffing questions that the model will be able to answer as well as the validity and utility of the answers it is able to yield. In a word, we recommend that the FAA conduct a serious cost-benefit analysis for any new modeling effort that is proposed. We hope that the processes and considerations presented in this report will prove useful in that endeavor.

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Appendix A

Modeling Methods

In Chapter 2, we define models and describe the distinguishing features that could be considered for staffing models for the Federal Aviation Administration's (FAA) aviation safety inspectors (ASIs). We note that predictive, stochastic models, designed as decision support tools, that assist with both allocation and sufficiency decisions, are most appropriate for the FAA's staffing models. We briefly note the distinction between process models and statistical models and conclude that a process-modeling approach may be superior in the FAA's context because it is more easily adapted during environmental changes of the type that characterize today's aviation landscape. The purpose of this appendix is to more precisely describe those two approaches, to emphasize the crucial role that parameter estimation plays in either modeling approach, and to note that statistical procedures are often used to estimate the parameters in process models.

Process Modeling

Process models take many forms, from simple flowcharting to more complex discrete-event simulation. In this discussion, we focus on discrete-event simulation as a more robust form of process modeling that permits prediction of complex system behavior as a result of system design. In this case, the system to which we refer is the FAA regulatory and oversight system that employs ASIs to ensure aviation safety. System design includes all of the factors that drive staffing demand as well as the supply and work capacity of ASI inspectors. In this discussion, we assume that one wants to determine through the use of process models how the two are interrelated, so that reasonable inferences can be drawn regarding the relationship between staffing system design and staffing system performance.

The specific approach we use to illustrate process modeling is known as *task network modeling.* In a task network model, system functions (e.g., performing all the required inspections in a region) are decomposed into a series of subfunctions, which are then decomposed into tasks. This is, in engineering terms, a task analysis. The sequence of tasks is defined by constructing a *task network*.

This concept is illustrated in Figure A-1, which shows a sample task network for a simple procedure—responding to a warning indication. The appropriate level of system decomposition and the portion of the system that is simulated depend on the particular problem. Staffing models have been developed that examine human behavior at the molecular level (e.g., detailed individual user interaction with the human-computer interface) and at a much more aggregated level (e.g., at which the task-level behaviors take hours or days).

In the ASI staffing context, the model might be at a gross level of granularity, since it need only represent inspectors or groups of inspectors as “busy” or “available.” The details of what they are doing are important only to the extent that they relate to factors that drive work demand and capacity.

The task network must also represent in some way the dynamics and dependencies of each task. Such factors include time to perform each task (possibly means and standard deviations), conditions that must be met for the task to start (e.g., available inspector resources, completion of a prerequisite task), and how performance of a given task interacts with other parts of the system.

Every time more than one path out of a task is defined in the network, a decision must be made by a human or other system element on what potential course of action should be followed, and the decision rules must be included in the model. The branching probabilities or decision logic can be represented by numbers, equations, algorithms, and logic of any complexity. In an ASI staffing model, the decision rules would reflect such factors as ASI task prioritization (e.g., required, planned, or demand work).

The paragraphs above describe the essential information that must be defined to adequately represent the relationships underlying a complex process such as the ASI staffing system. However, before a model can be useful in making predictions, it must be capable of accepting and processing changes in its inputs. In particular, the model must be able to accept and process a changing set of demands on the system (e.g., changing the

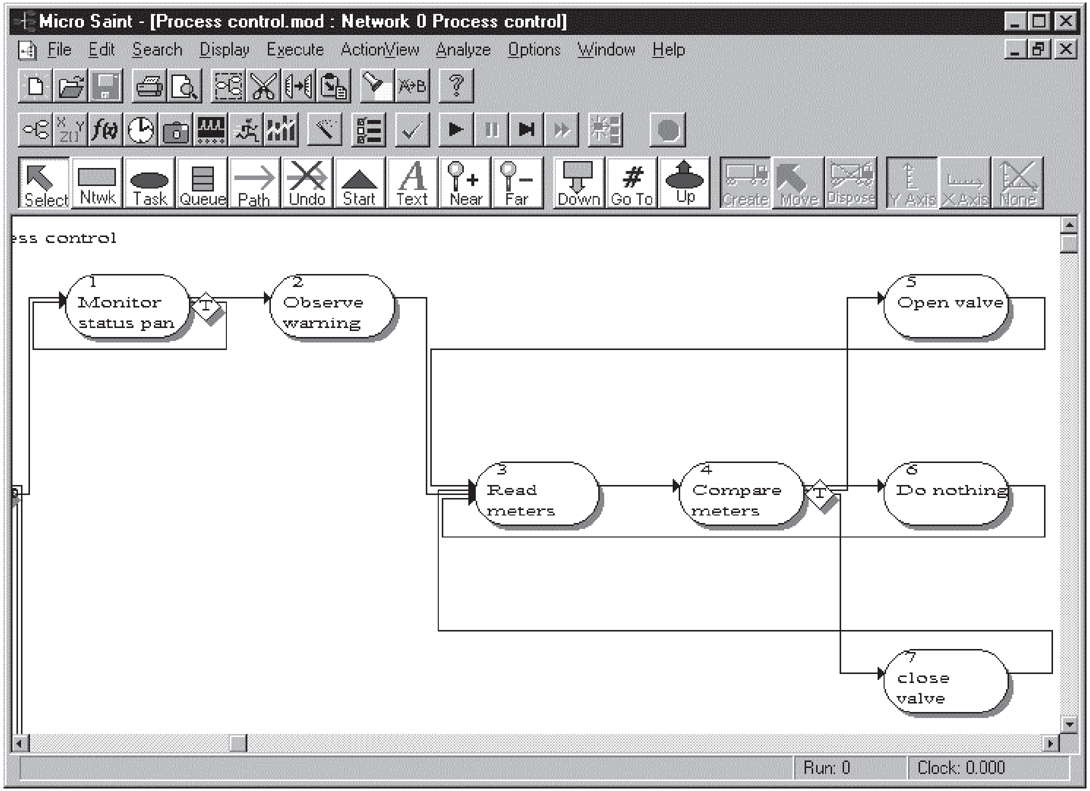

FIGURE A-1 Sample task network for a procedure.
SOURCE: Laughery (2005). Reprinted with permission.

number, location, and mix of carriers, aircraft, and other elements that generate demand for ASI services) as well as a changing supply of ASIs (e.g., changing the number, type, and location of ASI inspectors in the part of the ASI system being modeled). When the staffing model is capable of accepting and processing changes to inputs, decision makers can use the model to estimate resulting changes in outputs. Those outputs can be as varied as the systems they represent. Typical outputs for staffing process models fall into two general categories: measures of personnel utilization (e.g., how busy will each type of ASI be at each location?) and estimates of delays in work completion associated with the unavailability of staff to perform the work. Such outputs allow users to estimate the effectiveness with which ASI staffing resources are used and their ability to meet work demand. There are many ways to express and quantify such information, and a model can be designed to provide the most appropriate and usable output to serve the needs of its users.

Statistical Modeling

A statistical model is based on observed empirical relationships—in this instance, the relationship between workload and the staffing necessary to accomplish the workload. The relationships are specified initially in mathematical form; the parameters or coefficients of the model are then estimated statistically from the data. Repeated observations that pair the workload accomplished with the staff hours expended to accomplish the workload are the minimum data necessary. Other variables should be added if they affect the relationship between workload and staffing; these might include location-specific factors. For example, some locations may require far more staff hours to accomplish a set of inspections when those inspections require extensive travel time by the ASI; in this case, a location factor that accounted for the relatively lower productivity of ASIs in certain locations would need to be included in the model.

An advantage of this statistical (or empirical) approach is that it does not require a detailed understanding of the process by which the work is accomplished. It does require, however, an understanding of the factors that may differentially affect productivity across work centers, so that the effects of these factors can be captured in the relationship. The process model approach breaks down the work tasks to the fundamental elements and models those elements. The statistical approach, in general, models the aggregate relationship. Under the statistical approach, one does not require an understanding of the detailed steps to estimate the aggregate relationship and apply those estimates in a staffing model.[1]

[1]However, the approach can be used to model detailed steps, much like the process model.

Methods used in estimating relationships in the model include ordinary least squares regression, nonlinear least squares regression, and maximum likelihood methods. The relationship in its most general form is given by:

$$y = f(X_1, X_2, \ldots X_n)$$

where y is staffing, measured in hours, days, or full-time equivalents (FTE), and the Xs are workload and factors affecting the staffing-workload relationship. A multivariate model, in which all important observable factors affecting productivity are captured, will provide the best estimates of prediction.

If the functional form or mathematical relationship specified were linear, then the model would be of the form:

$$y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots +$$

where the parameters (α, β) are estimated from the data using, for example, ordinary least squares regression.

Because the statistical model uses the empirically observed relationship between staffing and workload, actual productivity is embedded in the model. The estimated relationship is usually based on the average observed productivity. It is also possible to estimate a "frontier" production function that provides the maximum (rather than the average) workload that can be accomplished (see, for example, Greene, 2002).

A major limitation of the statistical approach is that when processes or productivity changes, the previously observed statistical relationship is no longer valid. New data, generated under the new conditions, must be used to re-estimate the relationship. Thus, if it is known that the existing relationships between staffing and workload are *not* the relationships that will govern future staffing, then a process model approach would be more appropriate. With a process model approach, when a process changes, the model must also be modified to reflect the change. The difference is that, for a process model, the new process may be simulated, perhaps based on analysis and expert judgment, without waiting for new data to be generated.

Finally, it is important to recognize that the dichotomy drawn here between a process simulation model and a statistical model may be overstated. A process model may use statistical methods to estimate some or all of its parameters, while a statistical model may include relationships between workload or intermediate output at fine levels of detail, similar to the tasks and steps of the process model.

Parameter Estimation

Regardless of the type of model—process simulation, statistical model, or another type of model—values must be obtained for the key parameters of the model. These parameters provide the relationship between input variables or factors and intermediate or final output.

In the statistical model, by its nature, the key parameters are estimated statistically using actual data from observations or records of the key relationships. Hence, the parameter estimates are objective and empirically based. Moreover, the standard error of the parameter estimates can be calculated, using standard statistical methods. This provides an estimate of the accuracy of the parameter estimates.[2]

In the process model, there will also be parameters that must be estimated. In general, because a process model attempts to capture all or most of the key steps or processes in the staffing-workload relationship, there are likely to be more parameters to be estimated than in the statistical model.

Methods of estimating the parameters may include the same statistical methods as the statistical models themselves. That is, if the process model requires an estimate of the time required to make a certain type of inspection, one way to estimate this is through statistical estimation using data on actual inspection times, perhaps including other factors affecting the inspection time.

A second way to estimate parameters is through calibration. If one has data on the outcomes and basic inputs, one can calibrate the model by running it with a set of parameters specified using judgment. The model's outcomes are compared with actual outcomes, and the parameters adjusted in directions anticipated to improve the fit or agreement between the simulated outcome and the actual outcome. The process is repeated until a satisfactory set of parameters—one that yields a satisfactory fit—is obtained. The calibration process is similar to statistical estimation, but less formal. Because of its informal nature, the properties of the parameter estimates are not formally established. However, it does have the advantage of being empirically based.

Finally, expert judgment can serve as the basis for determining key

[2]In addition, estimation using certain statistical methods, such as ordinary least squares or maximum likelihood methods, often permit a claim that the estimate will have certain desirable properties. It may be the optimal or best estimate of the parameter under a given set of conditions regarding the distribution of the process. For example, ordinary least squares regression provides the minimum variance unbiased linear estimate of a parameter. Other methods of estimating parameters typically cannot claim such properties.

relationships between staffing and workload or intermediate steps in the process. While expert judgment can be useful, it must ultimately be validated by the accuracy of the predictions that are made with the model using the judgment-based parameters. Because expert judgment is subjective, it risks rapid loss of credibility without such validation.

Appendix B

Committee Data-Gathering Activities

Stakeholders Panel Meeting, March 8-9, 2005

Tuesday, March 8, 2005

8:30 am Continental breakfast

9:00 **Panel 1: Air Carriers**
National Air Carrier Association (NACA)
George Paul, Safety and Maintenance Director

10:30 Break

10:45 **Panel 2: Maintenance Providers and Workers**
Aircraft Electronics Association (AEA)
Paula Derks, President
Aeronautical Repair Station Association (ARSA)
Sarah McLeod, Executive Director
International Association of Machinists and Aerospace Workers
David Supplee, Director of IAM Flight Safety
Aircraft Mechanics Fraternal Association
Maryanne DeMarco, Legislative Liaison

12:30 pm Lunch

1:30 **FAA Staff Briefings and Q&A**
Kevin Iacobacci, AFS 160 and Deane Hausler, AIR 530

3:00 Break

3:15 End open session

Wednesday, March 9

8:30 am Continental breakfast

9:00 **Panel 3: Pilots and Employee Group, General Aviation**
Air Line Pilots Association (ALPA)
Charlie Bergman, Manager, Air Safety and Operations
National Agricultural Aviation Association (NAAA)
Andrew Moore, Executive Director
Aircraft Owners and Pilots Association
Melissa Rudinger, Vice President, Regulatory Policy

10:15 Break

10:30 **Panel 4: Aircraft and Parts Manufacturers**
Aerospace Industries Association (AIA)
Mike Romanowski, Vice President, Civil Aviation
General Aviation Manufacturers Association (GAMA)
Walter Desrosier, Engineering & Maintenance

12:00 pm **Adjourn**

QUESTIONS FOR STAKEHOLDERS

Please respond to the applicable questions below from the viewpoint of the constituency you represent. Some questions may not be relevant to your organization. We would like you to prepare an oral response that can be delivered in about 10 minutes (with a Powerpoint presentation if you wish), and we welcome a written response as well, if you care to prepare one. All materials you provide will become part of the public record of the committee's work. When we use the term "ASI" we refer to *both* the AFS (operations, maintenance, avionics, etc.) *and* the AIR (manufacturing) inspector workforce.

1. How do you (your organization's members or constituency) interact with ASIs?
2. How would you describe the current level of ASI staffing from your perspective?
3. How does the level of staffing of ASIs affect what you do, directly or indirectly?
4. From your perspective, what factors should be considered in determining levels of ASI staffing? Please tell us the order of importance (from most important to least important) of the factors you just described.
5. How, if at all, do ASI staffing levels relate to safety concerns for the people and organizations you represent?
6. Have you or any of the groups you represent conducted studies related to ASI staffing levels and safety that you feel would be helpful to the committee? If so, can you provide a copy to the committee?
7. Aside from levels of safety, what other outcomes of importance to you would be affected by the levels of staffing of ASIs?
8. What future trends/changes in technology/etc. do you foresee as having an impact on the levels of ASI staffing that may be needed?

ORGANIZATIONS INVITED TO THE STAKEHOLDER PANEL MEETING

Organizations shown in **boldface** accepted our invitation.

Aeronautical Repair Station Association
Aerospace Industries Association
Air Carriers Association of America
Air Line Dispatchers Federation
Air Line Pilots Association International
Air Transport Association of America
Aircraft Electronics Association
Aircraft Mechanics Fraternal Association
Aircraft Owners and Pilots Association
Association of Flight Attendants
Aviation Distributors and Manufacturers Association
Flight Safety Foundation
General Aviation Manufacturers Association
Helicopter Association International
International Association of Machinists and Aerospace Workers
National Agricultural Aviation Association
National Air Carrier Association, Inc.
National Air Transportation Association, Inc
National Association of Flight Instructors
Professional Aviation Maintenance Association

QUESTIONS PREPARED FOR ASI INTERVIEWS

Introduction: *Thank you for taking the time to meet with me. My name is (interviewer's name goes here), and I am a member of the National Research Council's Committee on FAA Aviation Safety Inspector Staffing Standards. Our Committee has been charged by the U.S. House of Representatives and the Senate with the task of studying current staffing standards for Aviation Safety Inspectors. This interview is conducted as part of our study, and it should last about 90 minutes. We have a lot to cover so I'll try to keep us moving through the interview questions.*

My purpose today is to get a general understanding of what ASIs do and what variables affect the demand for them.

Please keep in mind that your answers will be kept confidential. No one will see your individual responses; however, they will be summarized with other people's responses and included in aggregate in our final report.

Do you have questions of me before we begin?

What does your office do?

1. What are the major responsibilities of this office?
   Is it a CMO for any major or smaller air carriers?
   Is it involved in the ATOS system?

What is your role and background as an ASI? (Job title, grade, and years on the job)?
What do ASIs do?

1. Describe your job in terms of what you do. Thinking of a typical day on the job may help you.

2. What are the basic responsibilities of your job?
   a. What tasks do you perform?
   b. How do you allocate your time across these tasks?
   c. Please describe the kinds of events that disrupt your daily routine and throw off your schedule. How do you handle these?
   d. Do you sometimes have to take shortcuts or bend rules to get your job done on time? What makes it difficult to do things "by the book"?

3. Where do you perform your work?

4. With whom do you interact? In what capacity?

5. Do you have designee oversight responsibility? If yes:
   a. What makes it difficult to oversee designees?
   b. What would make overseeing designees easier?

c. Do you feel that you are given sufficient authority to sanction designees who don't do their job right? Why?
d. Are designees sufficiently supervised?
e. Do designees generally receive adequate training to do their work?

6. What tools, equipment, systems, references, or job aids do you use?

7. What kinds of paperwork are required to accomplish your job?
   a. Do you have to enter data into a computerized data base? If yes, please describe what kinds of data you record, where you record them, and when you do that.

8. Do you work in ATOS? If yes,
   a. How did the move to ATOS change your job?
   b. Were you adequately trained in ATOS?
   c. What ATOS-related tasks were particularly difficult to learn? Did you learn these tasks during training or on the job?
   d. Are you still learning ATOS by trial-and-error?

9. Is it possible to do everything you should do and do it well?
   a. What kinds of corners can you cut and still get the important parts of your job done?
   b. When forced to choose, how do you determine what to do now and what to postpone?
   c. What do you do when there is more to do than can be accomplished?
   d. If you were to do your job "by the book"…
      i. Will things get done on time? Will it cause delays? Why?
      ii. Will the people with whom you work or to whom you provide services be upset? Why?

What kind of preparation is needed for your job?

1. What knowledge, skills, and abilities (KSAs) does it take to do your job?
   a. Which of these knowledge, skills, and abilities are required on the first day of the job?
   b. Where do most people acquire these KSAs? Where did you acquire this?
   c. What training does the FAA provide? Is it adequate?

   d. What do you learn on the job?
   e. How long does it take to become proficient performing your job?
   f. Do you have re-certification or continuing education requirements?

What drives the demand for ASIs?

1. What are the objective factors or events that drive the demand for ASIs?
   a. What makes for a busy day?

2. Please list the individuals and/or groups that place demands on ASIs.
   a. Do these individuals place conflicting demands on ASIs?
      i. Do these individuals have conflicting interests?
   b. How do you handle the conflicts in demand?
   c. How do you decide what gets done first or gets done at all?

3. What would happen if you didn't do your job promptly?
   a. What impact would delays in performing your job have on safety?
   b. What impact would delays in performing your job have on the financial affairs of others?

What are your ideas about how your work should be organized?

1. What work should be designated to others? What should be kept by the Aviation Safety Inspector?

2. What future changes are likely to occur that will affect your job?
   a. What kinds of technological changes are likely to affect your job?
      i. Will the job requirements change as a result? How?
   b. What kinds of organizational changes might affect your job? How?

Appendix C

Biographical Sketches of Committee Members and Staff

William C. Howell (*Chair*) is retired but holds adjunct professorships at Arizona State and University and Rice University. His research focuses on topics in human performance and engineering psychology. He joined the Aviation Psychology Laboratory at Ohio State University in 1958, eventually serving as its director and holding a professorship in the university's psychology department. In 1968 he moved to Rice University, where he was instrumental in establishing the doctoral-level psychology department that he chaired for 17 years. From 1989 to 1992, he served as chief scientist for human resources for the U.S. Air Force and, following that, was appointed executive officer for science of the American Psychological Association (APA)—a position he held until his retirement in 1997. He has served on the editorial boards of seven journals, including *Human Factors, American Psychologist* and *The Journal of Applied Psychology.* He has held a variety of elective offices, including president of the Human Factors and Ergonomics Society and president of the applied experimental and engineering psychology division of APA. At the National Research Council (NRC), he was a member of the 1996 Committee to Study the Federal Aviation Administration's Methodologies for Estimating Air Traffic Controller Staffing Standards, as well as chair of the Committee on Human Factors and the Committee for the Safety Belt Technology. His NRC service was recognized by the National Academy of Sciences through selection into its first class of National Associates. He has a Ph.D. from the University of Virginia (1958).

Paul F. Hogan is senior vice president and economist at The Lewin Group in Falls Church, Virginia. He has more than 20 years of experience in applying microeconomics, statistics, and operations research methods to problems in labor economics, including labor supply and demand, efficient staffing methods, and performance and cost measurement. He served as the senior analyst on the President's Military Manpower Task Force and as director of Manpower Planning and Analysis in the Office of the Secretary of Defense, the office charged with staffing methods and criteria used by military departments to determine demands for personnel. He was awarded the Secretary of Defense Distinguished Civilian Service medal in 1982 and 1985 and the Navy Superior Civilian Service medal in 1980. At the NRC, he was study director for the Defense Advisory Committee on Military Compensation, and he served on the Committee on the Youth Population and Military Recruitment. His doctoral studies include economics, econometrics, and finance at the University of Rochester and his undergraduate degree is in economics from the University of Virginia.

K. Ronald Laughery, Jr., is president of Micro Analysis and Design, which was recently acquired by Alion Science and Technology. He has 26 years' experience in the management of contract research, development, and engineering. He was a senior systems engineer with Calspan Advanced Technology Center for nine years. At Calspan, he was responsible for a number of large programs in the areas of simulation; human factors engineering; training systems analysis, design, and evaluation; and systems analysis. Since establishing Micro Analysis and Design in 1981, he has managed contracts for the development of computer modeling and simulation languages, the design and evaluation of training simulators, the analysis of training requirements, and the development of tools for many military human-systems integration programs. He also participated in the application of the simulation tools that he and Micro Analysis and Design developed for the Army, the Air Force, and private industry. Many of these applications involved manpower analysis. He has a Ph.D. in industrial engineering from the State University of New York at Buffalo.

James L. Outtz is an industrial/organizational psychologist in Washington, DC, who has been in private practice for over 25 years. His area of specialization is employment selection, and he has worked on a variety of related topics, including the effect of testing medium on validity and subgroup performance, implementing fair selection strategies, the use of test score banding as a referral method, and the role of cognitive ability tests in employment selection. He is a fellow in the Society for Industrial and Organizational Psychology (SIOP) and of the American Psychological Association. He served on the Committee to Revise the SIOP *Principles for the Validation and Use of Personnel Selection Procedures.* He is a consulting editor to the *Journal of Applied Psychology*. He served on the Committee on Psychological Tests and Assessment of the American Psychological Association. At the NRC, he was a member of the Board on Testing and Assessment and the Committee on Workforce Needs in Information Technology. He has a Ph.D. in industrial/organizational psychology from the University of Maryland (1976).

Ann Marie Ryan is a professor of organizational psychology at Michigan State University. She was employed for several years at Bowling Green State University, where she directed the Institute for Psychological Research and Application. She has published widely on the topics of fairness in organizational decision-making processes, contextual and nonability factors in employee selection, applicant perceptions of fairness, recruitment and job search, diversity in organizations, and employee assessment tools. She is a fellow of the Society for Industrial and Organizational Psychology (and recently completed a term as president), the American Psychological Association, and the American Psychological Society. Currently she serves as editor for *Personnel Psychology*. She has also long maintained consulting relationships with both public- and private-sector organizations. She has a Ph.D. from the University of Illinois at Chicago (1987).

Juan I. Sanchez is professor of management and international business and Knight-Ridder research scholar at Florida International University. His research has received awards from the International Personnel Management Association and the National Society for Performance and Instruction. He has published widely, is currently a consulting editor of the *Journal of Applied Psychology*, and serves on the editorial boards of *Personnel Psychology, Group and Organization Management,* and the *International Journal of Selection and Assessment*. He occasionally serves as an expert witness in cases involving human resource management disputes. He has consulted with government agencies, including the Federal Aviation Administration, the U.S. Army, the U.S. Department of Labor, and the Veterans Administration. He has M.A. and Ph.D. degrees from the University of South Florida, Tampa.

Nadine Sarter is an associate professor in the Department of Industrial and Operations Engineering and the Center for Ergonomics at the University of Michigan. Her primary research interests include the design and evaluation of multimodal interfaces in support of effective human-machine communication and coordination, the development of robust and transparent decision support systems, and the use of design and training to support error management in a variety of complex event-driven domains. From 1994 to 1996, she served as technical adviser to the FAA Human Factors Team to provide recommendations for the design, operation, and training for advanced "glass cockpit" aircraft. For her research in the aviation domain, she received the Aviation Week and Space Technology's Aerospace Laurels Award for Outstanding Achievement in the Field of Commercial Air Transport in 1996 and the Turning Goals Into Reality Award as member of the Aircraft Icing Project Team from the NASA-Glenn Research Center in 2001. She has an M.S. in experimental/applied psychology from the University of Hamburg (1983) and a Ph.D. in industrial and systems engineering from the Ohio State University (1994).

William J. Strickland is vice president of the Human Resources Research Organization (HumRRO) in Alexandria, Virginia, and directs its Workforce Analysis and Training Systems Division. Program areas in the division include the Advanced Distributed Training Program; the Modeling and Simulation Program; the Center for Survey Research; the Center for Learning, Evaluation, and Assessment Research; and the Center for Personnel Policy Analysis. In addition to his research and management responsibilities in these areas, he is HumRRO's program manager for support contracts with the Defense Manpower Data Center. A retired Air Force colonel, he was director of human resources research at the U.S. Air Force Armstrong Laboratory. In that position, he was responsible for all Air Force research in the areas of manpower and personnel, education and training, simulation and training devices, and logistics. A fellow of the American Psychological Association, he is a past president of its Division of Military Psychology. He has a Ph.D. in industrial and organizational psychology from the Ohio State University.

Nancy T. Tippins is president of the Selection Practice Group of Valtera Corporation in Greenville, South Carolina. She has extensive experience in the development and validation of selection tests for all levels of management and hourly employees as well as in designing leadership development programs, including the development of assessment programs for executive development and the identification of high potential employees. Prior to joining Valtera, she was the director of leadership development and selection methods at GTE in Irving, Texas. For the Society for Industrial and Organizational Psychology (SIOP), she has served as chair of the Committee on Committees, secretary, member at large, and president. She is currently SIOP's representative to the American Psychological Association's Council of Representatives. She has been a member of several private industry research groups, including the National Staffing Forum, the International Selection and Assessment Conference, and the Equal Employment Advisory Council's Ad Hoc Committee on Employee Selection. She is associate editor of the scientist-practitioner forum of *Personnel Psychology* and serves on the editorial board of the *Journal of Applied Psychology.* She is a fellow of the Society for Industrial and Organizational Psychology and the American Psychological Association. She has a B.A. in history from Agnes Scott College, an M.Ed. in counseling and psychological services from Georgia State University, and M.S. and Ph.D. degrees in industrial and organizational psychology from the Georgia Institute of Technology.

Susan B. Van Hemel *(Study Director)* is a senior program officer in the Center for the Study of Behavior and Development of the Division of Behavioral and Social Sciences and Education at the National Research Council. She currently manages a study of staffing standards for aviation safety inspectors at the Federal Aviation Administration, and a study of organizational modeling research for the U.S. Air Force. Previous projects at the NRC include studies of Social Security disability determination for individuals with visual and hearing impairments and workshops on technology for adaptive aging, and on decision making in older adults. She has also done work for a previous employer on vision requirements for commercial drivers and on commercial driver fatigue. For over 25 years she has managed and performed studies on a variety of topics related to human performance and training. She is a member of the Human Factors and Ergonomics Society and its technical groups on perception and performance and aging. She has a Ph.D. in experimental psychology from the Johns Hopkins University.