SPECIAL REPORT 272

AIRPORT RESEARCH NEEDS

Cooperative Solutions

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Committee for a Study of an
Airport Cooperative Research Program

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This report has been reviewed by a group other than the authors according to the procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Preface

Roughly 5,000 airports open to public use are scattered across the United States, including some 3,300 that are part of the national airport system and eligible for federal grants. Most airports are used exclusively by general aviation (GA) for a range of activities, from crop dusting and flight instruction to private transportation and recreational flying. Others accommodate a mix of GA and air carrier operations. The country's 100 busiest airports, located in large metropolitan areas, handle both GA operations and most of the nation's airline and air cargo traffic. Whether they are small or large, situated in urban or rural areas, or used mostly by airlines or GA operators, the nation's airports face many of the same problems and have many of the same research needs.

While specific research needs and priorities vary from one airport to the next, the general topics of interest are often similar across the airport system. For instance, most airports need better runway pavements; smaller airports need pavements that are economical to build and maintain, and larger airports need pavements that are more durable and capable of handling heavier loads. While such environmental impacts as aircraft noise, air pollution, and deicing chemical runoff are major and almost universal concerns for larger airports, all airports are subject to federal, state, and local environmental regulations, and all face significant challenges in meeting them. In addition, now more than ever, operators of airports of all sizes and types are seeking cost-effective ways to strengthen the security of their airfields, terminals, and other airside and landside facilities.

Research is crucial to meeting these many needs. In some cases a more systematic survey and evaluation of procedures and products that are already working at some airports, and dissemination of good information on effective practices to all airport operators, may be sufficient. In other cases, research may be required to develop new materials, equipment, designs, and techniques to address particular problems. The federal government, through multiple agencies, provides the nation's airports with billions of dollars in aid each year; operates and regulates the nation's air traffic control system; provides and establishes standards for security; and sets environmental, safety, and design standards affecting airport configurations, equipment, and operations. Therefore, it has a key role and much at stake in ensuring that critical airport research needs are met.

The federal government sponsors airport-related research in numerous ways through the Federal Aviation Administration (FAA), the National Aeronautics

and Space Administration (NASA), the Department of Defense (DOD), the Transportation Security Administration (now housed in the Department of Homeland Security), and other agencies. At its Airport Technology Research and Development branch (located at the William J. Hughes Technical Center in Atlantic City, New Jersey) and with grants to universities, FAA sponsors research to investigate alternative runway and taxiway materials and configurations, approach lighting and other visual guidance technologies, runway snow- and ice-control materials and methods, fire and rescue operations, and mitigations for bird and other wildlife hazards. This research supports FAA's overarching mission to promote the safe and efficient operation of the national airspace system. As might be expected, airport-related areas that are major recipients of federal aid and investments, such as runways and taxiways, receive a commensurate amount of attention in FAA research.

FAA also conducts research related to airports through its headquarters and division offices. These offices undertake special studies—for instance, to better model aircraft air pollutant emissions and measure airport noise. For the most part, this research can be characterized as short-term, driven by the specific needs of rulemaking initiatives and policy proposals. At the other end of the spectrum, NASA undertakes aeronautics research with decades-long time horizons in mind. For example, it sponsors research to reduce aircraft noise through innovative propulsion systems, as opposed to incremental improvements in conventional engine noise abatement. DOD, meanwhile, sponsors research on topics relevant to military needs, a few of which have applications in civil aviation. Of course, research that is not normally viewed as directly pertinent to airports, such as the research undertaken by FAA, NASA, and DOD on air traffic control systems, can have significant implications for airport operations, configurations, capacity, and environmental compliance.

Largely missing from this varied R&D portfolio is a research program that views the nation's airport landside, airside, and air traffic management systems as functioning in concert to form the national airspace system. Situated at the nexus of these systems, airport operators are in a position to identify factors that affect the overall safety, capacity, and efficiency of their facilities—for instance, how air traffic control rules can affect airport operations and capacity, how airport facility constraints can affect congestion and delay, and how community noise and other environmental factors can

affect the ability of airports to meet demands for aviation services. At the moment, however, airport operators do not have a direct role in advising the federal agencies on R&D, and they do not have a ready way to pool their ideas and resources to develop or disseminate common solutions to shared problems. The airport-sponsored research that is undertaken is usually done at the behest of individual operators, and dissemination of results to other operators is often haphazard at best, even when the results of the research may have widespread application.

In contrast, operators of two other transportation modes, state highway departments and public transit agencies, have long had the ability to work together to identify needs and find solutions to common problems. The National Cooperative Highway Research Program (NCHRP), established in 1962, pools federal-aid research funds volunteered by individual states to develop near-term, practical solutions to problems facing many highway agencies. For more than a decade, the Transit Cooperative Research Program (TCRP) has likewise sponsored research and other technical activities that respond to the needs of the public transit industry. In both cases, the operators have a central role in identifying problems and in programming specific research projects to address them. These applied research programs do not replicate the work of the federal government or industry. They focus on needs and problems of operators that are often urgent, would otherwise be overlooked, or would only find their way into the research agenda of federal agencies or industry organizations over time.

STUDY REQUEST, STATEMENT OF TASK, AND PROCESS

The creation of an airport cooperative research program, modeled partly on existing cooperative research programs for highways and public transit, has been urged by numerous individuals and organizations over the past decade and has formed the basis of proposals by the National Association of State Aviation Officials (NASAO) and the Airports Council International–North America (ACI-NA). In 2000 legislation reauthorizing FAA (Public Law 106-181),[1] Congress requested a formal study of the concept by the U.S.

[1] Wendell H. Ford Aviation Investment and Reform Act for the 21st Century (AIR 21), enacted April 2000.

Department of Transportation. The study request (in Section 906 of the act) reads as follows:

> The Secretary, in consultation with the National Academy of Sciences and representatives of airports, shall evaluate the applicability of the techniques used to fund and administer research under the National Cooperative Highway Research Program and the National Transit Research Program to the research needs of airports. The Secretary shall transmit to Congress a report on the results of the evaluation conducted under this section.

In response, FAA contracted with the Transportation Research Board (TRB), under the auspices of the National Research Council (NRC) of the National Academies, to conduct the study. Following usual NRC procedures, TRB assembled a committee with a range of expertise and a balance of perspectives on issues related to the study topic. James C. DeLong, Manager, Louisville International Airport, chaired the committee, which included nine other members with expertise in airport management, design, engineering, environmental analysis, and research and planning. Committee members served in the public interest without compensation.

To fulfill its charge, the committee was given the following statement of task by NRC:

> This study will evaluate the applicability of the techniques used to fund and administer research under the National Cooperative Highway Research Program and the Transit Cooperative Research Program to the research needs of airports. Included in the assessment will be:
>
> - Program governance;
> - Contracting processes;
> - Role of merit review in the selection of contractors;
> - Role of peer review in the conduct of the research and completed reports;
> - Research areas to be funded by the program;
> - Funding; and
> - Program administration.

The committee met three times during an 8-month period. During the first meeting, the committee was briefed by representatives from FAA's Airport Technology R&D branch, NASAO, ACI-NA, and the Association of American Airport Executives (AAAE). During the second meeting the committee met with staff from FAA's Office of Airport Planning and Programming and the Air Transport Association (ATA), who offered ideas on airport research needs and additional perspective on the desirability of an airport cooperative research program. In addition, the committee heard from members of the highway and public transit industries who have been actively involved in the formation and administration of NCHRP and TCRP.

ACKNOWLEDGMENTS

The committee is grateful for the help of the following individuals, who provided information to the committee during the course of its study: Richard Marchi, ACI-NA; Henry Ogrodzinski, NASAO; Caren Centorelli, AAAE; Paul McGraw, ATA; and Satish Agrawal, Benito DeLeon, and Paul Jones, FAA. Special thanks are due to Charles Chambers, Senior Vice President of Global Aviation Associates, Ltd.; David Hensing, retired Deputy Executive Director of the American Association of State Highway and Transportation Officials; and William Millar, President of the American Public Transportation Association. Mr. Chambers provided information on aviation finances. Mr. Hensing and Mr. Millar described the experience of the highway and transit communities in organizing and programming NCHRP and TCRP. Robert Reilly, Director of TRB's Cooperative Research Division, which manages these two programs, briefed the committee on program administration, procedures, and finance.

Thomas R. Menzies, Jr., managed the study and drafted the final report under the guidance of the committee and the supervision of Stephen R. Godwin, Director of Studies and Information Services.

The report was reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its 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.

Thanks go to the following individuals for their review of this report: William Flannery, Des Moines International Airport, Iowa; Gina Marie Lindsey, Seattle-Tacoma International Airport, Washington; Peter Mandle, Leigh Fisher Associates, San Mateo, California; Frederick Piccolo, Sarasota-Bradenton International Airport, Florida; Travis Villin, Colorado Division of Aeronautics, Watkins; and C. Michael Walton, University of Texas, Austin. Although these reviewers provided many constructive comments and suggestions, they were not asked to endorse the committee's findings and conclusions, nor did they see the final report before its release. The review of this report was overseen by L. G. (Gary) Byrd, Consulting Engineer, Mill Spring, North Carolina, and Lester A. Hoel, University of Virginia, Charlottesville. Appointed by NRC, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

Suzanne Schneider, Associate Executive Director of TRB, managed the report review process. The report was edited and prepared for publication by Norman Solomon under the supervision of Nancy Ackerman, Director of Publications. Special thanks go to Frances Holland for assistance with meeting arrangements and correspondence with the committee.

Contents

Executive Summary

Airports are vital national resources. More than 500 commercial-service airports and about 2,800 smaller general aviation airports scattered across the country make up the national airport system. Airports have key roles in the transportation of people and goods and in regional, national, and international commerce. They are where the nation's aviation system connects with the other modes of transportation and where the federal responsibility for managing and regulating air traffic operations intersects with the role of the state and local governments that own and operate most airports. Airports are where national goals for aviation system efficiency and safety must maintain a balance with regional and local concerns about noise, environmental quality, and community development. Indeed, they are where the federal government's commitment to protecting the environment must be integrated with its long-standing interest in promoting aviation use and accessibility. And now, more than ever, airports are at the forefront in the effort to ensure aviation security—a national and thus federal government imperative, but one that will require the efforts of thousands of public and private airport operators, regulators, suppliers, and users at all levels of government and industry.

It is in this large and complex environment, with many—and often competing—requirements and expectations, that most airports operate. Responsibilities such as deicing aircraft require airport operators to find methods and materials that are economical for repeated large-scale application; perform quickly and effectively; meet Federal Aviation Administration (FAA) standards for aircraft compatibility; and comply with the runoff containment, capture, and disposal requirements of U.S. Environmental Protection Agency (EPA) water quality standards. To meet such demands, operators need access to good information, technical guidance, and research expertise that cuts across many disciplines. They must understand how one set of demands affects another, and they must be able to work with airport users, regulators, and suppliers to implement solutions. Success in finding solutions will not only benefit airports, but also help all parties achieve their goals and do their jobs better. In the end, users of the nation's aviation system—as well as those who are employed at or live near airports—will be the beneficiaries.

The aviation sector is undergoing rapid change as many institutions, practices, and economic relationships are being rethought and reshaped. Many new problems and issues are emerging, even as many old ones persist. While

airport operators face unprecedented challenges in this changing environment, they are presented with opportunities and incentives to work with one another and with federal agencies, airport users, and others in the aviation community to meet these challenges. Congress requested this study of the idea of creating a cooperative research program for airports—one that might be modeled after existing programs in the highway and transit modes and that will view research needs and priorities from the perspective of the nation's airport operators.

The committee concludes that such cooperative research is more than a good idea; it has become essential for ensuring airport security, efficiency, safety, and environmental compatibility. The committee urges Congress to establish a national airport cooperative research program (ACRP). On the basis of insights gained from studying cooperative research programs in other transportation modes, the committee recommends specific means of financing, governing, and managing the program.

PRESSING NEED FOR COOPERATION IN AIRPORT RESEARCH

Airports present a unique set of challenges and perspectives. By and large, airport operators are implementers charged with meeting these demands and finding solutions to the problems and conflicts that ensue. For instance, operators recognize many of the complexities involved in adopting alternative technologies and methods for screening airline passengers and baggage more thoroughly; they recognize implications for passenger traffic flows and supporting airport infrastructure, and the effects on airport efficiency and economic viability. They experience firsthand how changes in aircraft design and dimensions can have far-reaching effects on airport operations and utility by influencing everything from runway durability and capacity to the service life of passenger loading bridges and the design of terminal waiting areas. They understand how environmental protections and analysis procedures affect airport development and capacity and how changes in federal air traffic control and flight standards may affect airport capacity, utility, and environmental impacts on surrounding communities.

Airport operators have incentives to find solutions to these varied needs. They must satisfy their fiduciary responsibility to their public-sector owners, and they must address local community concerns over economic development, strengthen air service, and comply with environmental regulations. At the same time, the nation as a whole has an interest in resolving the prob-

lems that airport operators encounter, even if they are outside the traditional federal domain. Airports are most valuable collectively, as interconnected parts of the larger aviation network. For instance, when the capacity of a single airport is diminished—whether because of an unserviceable runway or an inefficient terminal layout—adverse effects can propagate throughout the regional or national aviation system. Problems shared by airports compound at the national level. However, operators of individual airports may not appreciate the broader implications of the problems they face; even when they do, they may not have the resources to search for effective solutions.

The federal government, through FAA, the National Aeronautics and Space Administration (NASA), EPA, the Department of Defense, and now the Transportation Security Administration, sponsors and performs research relevant to airports. For the most part, the research supports each federal agency's specific mission, from protecting the environment to ensuring aviation safety and security. But the results of the research must be applied in the field, often by the airport operators themselves. The operators are in a good position to help achieve these federal agency goals, which are often aligned with their own aims. Airport operators, working with one another and with the various federal agencies involved, must be actively involved in the search for solutions to many problems. Furthermore, they must be involved at every stage—from identification and prioritization of problems to the framing of the intended research products and the planning of effective dissemination.

INSIGHTS FROM COOPERATIVE RESEARCH IN OTHER TRANSPORTATION MODES

In requesting this study, Congress asked specifically for an evaluation of the applicability to airport research needs of the approaches to cooperative research in the highway and public transit modes. The experiences of the two main cooperative research programs in these other transportation modes—the National Cooperative Highway Research Program and the Transit Cooperative Research Program—offer lessons on the value of cooperative research and how to structure a cooperative research program for airports.

Both programs fill gaps in and are important complements to the research efforts of the federal agencies, state and local transportation agencies, and private industry. They each provide a continuing means for highway and

public transportation operators to identify shared problems in a diversity of areas and to seek solutions through applied research. The research problems are well defined and framed largely from the perspective of the operators, who ultimately must give practical effect to the results. The research is conducted by contractors selected on a competitive basis, which enables the programs to respond quickly and efficiently to the problems that operators face. The research is geared to providing practical products within 6 months to 3 years. Both programs emphasize disseminating results to end users and involving practitioners at every stage of the research process, including problem identification, design of the research plan and intended products, and review of research progress and results. These important characteristics are embedded in the means by which the programs are governed, financed, and managed.

Careful consideration must be given to ensuring that similar characteristics are built into an ACRP. The following governance, financing, and management characteristics are especially important to fostering these outcomes:

- The program must be governed and the research agenda guided primarily by airport operators, but with the active participation and close collaboration of federal agencies, airport users, and others expected to use and help implement the research results.
- The program must be financed with revenues derived from aviation users. The research agenda must focus on useful products applicable to the diverse range of airport problems. Such an arrangement would prompt a strong sense of ownership of the program by the airport and aviation communities and a commitment to meeting their needs.
- The program must be managed to ensure that the research products meet scientific and professional standards of quality and are accessible to users. All stages of research projects must be guided by a combination of technical experts and practitioners to ensure objectivity, credibility, applicability, and dissemination.

PROPOSAL FOR AN ACRP

A specific proposal for an ACRP is outlined in Box ES-1. The proposal is a starting point embodying the key financing, governance, and management characteristics listed above. The committee recommends that Congress

Box ES-1

Proposal for Financing, Governing, and Managing an ACRP

Finance

- Congress allocates 0.20 percent of annual revenues to the Airport and Airway Trust Fund to ACRP funding, which would generate approximately $20 million per year.
- Congress allocates an amount equivalent to 1.5 cents from the $2.50 passenger security tax to ACRP funding, which would amount to about $10 million per year.

Governance

- The Airports Council International (ACI), the American Association of Airport Executives (AAAE), and the National Association of State Aviation Officials (NASAO) establish a nonprofit organization to create and formally appoint members to the ACRP Governing Board.
- The Governing Board consists of 23 members:
  - ACI names ten members: six officials from large hub airports, two from medium-size hubs, and two from small hubs.
  - NASAO names four members: two officials from nonhub or general aviation airports and two from state aviation departments.
  - AAAE names two members: one official from a nonhub and one from a general aviation airport.
  - The Air Transport Association names one member.
  - The administrators of FAA, NASA, and EPA each name one member.
  - The Undersecretary of Transportation Security names one member.
  - The organization hosting the Governing Board or managing the program nominates two members who are interested in and knowledgeable about airport infrastructure, operations, safety, security, and environmental impacts. These nominations should be rotated periodically among air travelers, general aviation operators, air cargo carriers and shippers, airport consultants and suppliers, and researchers.
- The Governing Board will serve as the focal point for the identification of research needs shared by airport operators, users, and regulators. It will set the annual research agenda by identifying the highest-priority research themes, soliciting problem statements, screening candidate

(continued on next page)

Box ES-1 (*continued*) **Proposal for Financing, Governing, and Managing an ACRP**

projects, defining project funding levels, and articulating expected products of research. It will guide and monitor the overall quality and strategic direction of the program, determine the technical objectives of all research projects, and coordinate with complementary public- and private-sector research programs. It will develop dissemination plans and ensure the dissemination of results. It will be responsible for conducting periodic assessments of the performance of the program in meeting the critical research needs of airports in a timely, credible, and efficient manner.

- The Governing Board will report annually on the program's progress. After 3 years, the board will report on the state and accomplishments of the program and advise on future program funding beyond this trial period.

Program Management

The program will be managed in a manner consistent with the management of the National Cooperative Highway and Transit Cooperative Research Programs, which are administered by the National Academies' Transportation Research Board.

authorize and finance the program by allocating a percentage of Airport and Airway Trust Fund revenues and funds for aviation security generated by airport users. The airport community, acting through the relevant industry associations, should take the lead in forming the governing body to guide the program and in engaging the relevant federal agencies and airport users in the process.

The committee believes that a program structured in this manner will, by its very nature, focus on the most urgent research needs of airports. A trial program authorized for a fixed period may be the most pragmatic means of obtaining broad political support. Moreover, it will compel airport operators and users to demonstrate their commitment to the program from the start. The highway and transit cooperative research programs demonstrate that such involvement is an essential ingredient for lasting success.

1

Study Overview and Background

The concept of a cooperative research program for airports is not new. The complexity of the issues that confront airports and the decentralized nature of the airport industry and its research activities have led to repeated calls for greater cooperation in the funding, programming, and conduct of airport-related research. In 1982, the Federal Aviation Administration (FAA) and the Airports Council International, whose membership includes the nation's largest airports, jointly sponsored a task force to develop a long-range plan for airport system research (ACI and FAA 1985). The task force concluded that "airport management has been given little or no opportunity to contribute to the development or defense of airport research programs." It therefore urged FAA to support "a strong, comprehensive, and continuing airport research program" and to develop "a mechanism which will ensure the continuing effective input of the industry in the development of an airport research program."

A decade later, the National Association of State Aviation Officials (NASAO), which represents state aviation departments, assessed the state of airport research for FAA (NASAO 1992). It observed that "aviation has no standardized process or mechanism to conduct significant research" and that "the failure of the industry as a whole to sponsor and participate in research has let many airport management and operational needs go unattended." It pointed to two research programs in the highway and transit industries as possible models for an airport cooperative research program. Both programs, the National Cooperative Highway Research Program (NCHRP) and the Transit Cooperative Research Program (TCRP), are directed by governing boards that are exclusively or predominantly composed of highway or transit operators. NASAO urged the creation of a research program guided similarly by airport managers and operators. On the basis of a survey of state aviation departments and airport organizations, NASAO identified dozens of problem areas (as discussed in more detail in the next chapter) that would benefit from cooperative research—from better airport pavement specifications to more responsive and efficient means of addressing the Clean Air Act.

In light of these long-standing calls for an airport cooperative research program, Congress charged FAA, in consultation with airport operators and the National Academies, with studying the applicability of the techniques used to fund and administer research under NCHRP and TCRP to meeting the research needs of airports.[1] FAA, in turn, tasked the National Academies with convening a special committee, made up in part of airport operators, to conduct the study and make recommendations.

STUDY APPROACH AND REPORT ORGANIZATION

Airports are commonly viewed as serving the social good in much the same manner as highways, mass transit, and other public transportation infrastructure and services. Airports, which serve both as foundations for economic development and as key elements of the national aviation system, confer many public benefits. Most airports open to the public for civilian use are in fact owned by the public, usually by municipalities or county governments. For the most part, however, airport operations are expected to be self-financed, with revenues derived from concessionaires, passengers, aircraft operators, and other airport users and tenants. Exactly how airport operators go about raising revenues and structuring their operations is heavily influenced by their role in providing a social good and is thus subject to many federal, state, and local controls.

This mix of roles and responsibilities places airport operators in an unusual and often delicate position. On the one hand, they are expected to act nimbly and efficiently, like a private business serving its customers. On the other, they are required to pursue the broader social good, which is evidenced by the many—and sometimes divergent—local, regional, and national demands placed on them. Airport operators are therefore in a challenging environment. The obligations and constraints they face are in many ways unique, derived from their position at both the intersection of the public and private sectors and the nexus of federal, state, and local governments' jurisdictions.

The committee's report is organized into five chapters that mirror the study approach. In the remainder of this chapter the complex operating, financial, and regulatory landscape in which airports exist is described. An understanding of these complexities can be helpful in understanding why a

[1] See Preface for the text of the congressional request.

cooperative research program has much appeal but faces many challenges. Consideration is given to the various types of airports and their uses, financing, regulation, and administration. The chapter concludes with a review of the respective roles of federal agencies, state and local governments, universities, and the private sector in sponsoring and undertaking airport-related research.

In Chapter 2 several important research needs that airport operators have in common are identified. These needs have tended to be neglected or addressed only tangentially or with insufficient urgency by existing research activities. The committee approached the study with an open mind about the need for an airport cooperative research program. Therefore, its initial emphasis was on gaining a better understanding of airport issues and problem areas and how existing research programs are structured to address them. The origins and structure of the existing cooperative research programs in the highway and transit modes are reviewed in Chapter 3. In Chapter 4, the insights gained from these and other program reviews are referred to in examining options for organizing an airport cooperative research program and in proposing a specific means of program funding, governance, and management. The key findings and conclusions of the study are summarized in Chapter 5, and the next steps toward the creation of an airport cooperative research program are recommended.

AIRPORT TYPES AND USES

The United States has some 5,000 airports open to the public, of which about 3,300 are designated by FAA as part of the national airport system and thus eligible for federal aid for planning and infrastructure development (Table 1-1). Most of these public-use airports are owned by local governments.[2]

About 15 percent (525) of the 3,300 airports in the national system [the National Plan of Integrated Airports (NPIAS)] handle airline passenger and cargo traffic (sometimes seasonally) and are thus classified as "commercial-service" airports. The remainder serve general aviation (GA) operations only. About 250 airports are classified as "metropolitan relievers"; they are the busiest and best-equipped GA airports and are often located in the country's largest urban areas. Relievers are often operated in conjunction with a larger

[2] In addition, the country has about 15,000 other private-use airports and landing areas, including many turf landing strips used in agricultural areas. Most of these other airports are lightly used.

Table 1-1 Based Aircraft and Annual Enplanements at Public-Use Airports in National Integrated System, 2000

	Airports		Based Aircraft		Airline Enplanements	
	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total
Commercial-Service Airports						
Airports with at least 100,000 annual airline enplanements	213	6.4	26,991	14.4	667,863,478	98.8
Airports with less than 100,000 annual enplanements	313	9.4	21,095	11.2	7,443,192	1.1
Subtotal	526	15.8	48,086	25.6	675,306,670	99.9
General Aviation Airports						
Metropolitan reliever airports	258	7.8	59,143	31.5	120,578	0.0
Other GA airports	2,543	76.4	80,664	42.9	504,057	0.1
Subtotal	2,801	84.2	139,807	74.4	624,635	0.1
Total	3,327	100.0	187,893	100.0	675,931,305	100.0

SOURCE: TRB 2002. Original data provided to TRB by Airport Planning and Programming Office, FAA, August 2001.

commercial-service airport in an area, typically under the auspices of a regional airport authority. Commercial-service airports are first in federal funding priority. They are followed by relievers and then other GA airports in the national system.

Commercial-Service Airports

The 525 commercial-service airports handle nearly all of the airline passenger traffic in the United States, including passengers on both the major and regional (commuter) airlines. In fact, about two-thirds of the approximately 600 million airline passenger enplanements (boardings) per year are handled by the 30 busiest airports. The top 150 commercial-service airports—ranging from Hartsfield in Atlanta to Asheville Regional Airport in North Carolina—account for 97 percent of airline passenger traffic, and the top 60 of these airports account for nearly all of the traffic carried in large jets (having 60 seats or more).

FAA defines as "large hubs" all airports that account for 1 percent or more of total airline passenger enplanements (see Table 1-2). About 30 airports meet this threshold each year. Roughly 35 airports are categorized by FAA as "medium hubs" because they each account for between 0.25 and 0.99 percent of total airline enplanements. The next-busiest airports, described as "small hubs," account for 0.05 to 0.249 percent of enplanements; they total about 150. The remaining 300 or so commercial-service airports are referred to as "nonhubs," including about 100 (often only partly certificated) that are used by airlines on an irregular or seasonal basis.

Nearly all commercial-service airports accommodate a large amount of GA traffic in addition to airlines. The GA industry encompasses everything from operators of jets and turboprops used for private and on-demand for-hire passenger and cargo transportation to single-engine propeller aircraft used

Table 1-2 Types of Airports According to FAA Definitions

Airport Classification	Hub Type	Percentage of Annual Air Carrier Passenger Enplanements	Common Name
Commercial service[a]			
Primary[b]	Large	1% or more	Large hub
	Medium	At least 0.25% but less than 1%	Medium hub
	Small	At least 0.05% but less than 0.25%	Small hub
	Nonhub[c]	More than 10,000 but less than 0.05%	Nonhub primary
Nonprimary	Nonhub[c]	At least 2,500 and no more than 10,000	Nonprimary commercial service
Other than passenger classes	Not applicable	Not applicable	Cargo service,[d] reliever,[e] general aviation[f]

[a] Commercial service: airports that have at least 2,500 air carrier passenger enplanements each calendar year.

[b] Primary: commercial-service airports with more than 10,000 passenger enplanements each year.

[c] Nonhub: commercial-service airports having fewer than 0.05 percent of U.S. passenger enplanements.

[d] Cargo service: airports that are served by aircraft providing air transportation of cargo with a total annual landed weight of at least 100 million pounds. "Landed weight" means the weight of aircraft transporting only cargo in intrastate, interstate, and foreign air transportation. An airport may be both a commercial-service and a cargo-service airport.

[e] Reliever: airports designated by FAA to relieve congestion at commercial-service airports and to provide improved general aviation access to the overall community. These may be publicly or privately owned.

[f] The remaining airports, while not specifically defined in legislation, are referred to as general aviation airports and make up the largest single group of airports in the U.S. airport system.

for recreation and aerial services such as right-of-way surveillance, highway traffic reporting, law enforcement, and flight instruction. In fact, most commercial-service airports handle far more GA operations (landings and takeoffs) than airline operations. Even at the largest airports, GA can account for 15 to 50 percent of total aircraft operations.

As a practical matter, an airport cannot attain "commercial-service" status unless it meets FAA criteria for facility equipage, design, and operational capabilities that are required for the medium- to large-capacity turbine aircraft commonly used in air carrier service. FAA prescribes minimums for such features as runway marking, lighting, and navigation systems, as well as capabilities such as runway and aircraft deicing, fire fighting, and emergency rescue. The agency has a series of advisory circulars that describe the procedures, designs, and equipment that meet these minimums.

The demands placed on the busiest commercial-service airports in major metropolitan areas of the country differ significantly from those placed on much smaller commercial-service airports serving smaller cities and rural regions. Nevertheless, the smaller commercial airports are under pressure to meet FAA's requirements for scheduled air carrier service, since many provide the regions' only links to the national and international airline systems.

Metropolitan Relievers

All major metropolitan areas are served by one or more GA reliever airports. FAA designates certain GA airports as relievers because these airports can divert GA traffic away from the heavily used commercial-service airports. Relievers tend to be the most intensely used, and hence the best equipped, of the country's GA airports. To be designated as a reliever and thus have priority among GA airports for federal aid, the airport must have at least 25,000 itinerant (point-to-point) operations per year, house 100 or more based aircraft, and be located in a metropolitan area with 250,000 people or more.

Reliever airports are often conveniently located and sufficiently equipped to handle the kind of aircraft used by regional and commuter airlines. Many reliever airports have instrument landing systems, control towers, passenger waiting areas, rescue and fire-fighting services, and other infrastructure that enhance their reliability and support intense use. Some large relievers, such as Teterboro near New York City and Centennial near Denver, average more than 1,000 operations per day. Dekalb–Peachtree Airport near Atlanta is second only to Atlanta–Hartsfield in daily operations

in the entire state of Georgia. Its level of activity surpasses that of the state's eight other commercial-service airports.

Other GA Airports

GA airports must meet certain minimum criteria to be included in the 3,300-airport NPIAS and thus to be eligible for federal aid. For instance, an airport must have at least 10 based aircraft and be available for public use. For the most part, the roughly 2,500 GA nonreliever airports in the national system have paved runways and runway lighting systems, and they are the best equipped and maintained of the nonreliever small airports. Thousands of other publicly and privately owned small airports are not in the national system. Conditions at these airports vary greatly; many do not even have lighted or paved runways (Table 1-3). It is noteworthy that about 2,000 airports not in the national system are nevertheless open to public use, including about 1,000 privately owned airports.

Table 1-3 Runway Characteristics of U.S. Civilian Airports

	Airport Type[a]		
	Public Use	**Private Use**	**Total**
Total number of airports	5,025	9,433	14,458
Airports with paved runway			
Number	3,870	849	4,719
Percent	77	9	33
Airports with lighted runway			
Number	3,970	755	4,725
Percent	79	8	33
Airports without paved or lighted runway			
Number	754	8,585	9,339
Percent	15	91	65
Airports with longest runway length			
Less than 3,000 feet	1,181	6,855	8,036
3,000 to 3,999 feet	1,390	1,163	2,553
4,000 to 4,999 feet	914	364	1,278
5,000 to 5,999 feet	776	152	928
6,000 feet or more	764	57	821

[a] Some (1,012) public-use airports are privately owned but open to the public.

SOURCE: TRB 2002. Original data provided to Transportation Research Board by Airport Planning and Programming Office, Federal Aviation Administration, August 2001.

AIRPORT FINANCE

Most of the public-use airports in the United States are owned by county and municipal governments or by special regional authorities created by one or more government jurisdictions. Many regional authorities operate more than one airport. In some cases, they operate multiple commercial-service airports (for example, the Port Authority of New York and New Jersey); more commonly, they operate a single large airport and one or more GA reliever airports. Some states, such as Alaska and Maryland, own both GA and commercial-service airports, but these are the exceptions. Even rarer is the federal government's ownership of civilian airports. Maritime law set the early precedent for a limited federal role in airport construction and operations. Whereas the marking and maintenance of shipping channels and provision of lighthouses and other navigation aids were deemed to be federal responsibilities, the provision of docks and terminal facilities was treated as a state, local, and private-sector function (Horonjeff and McKelvey 1983, 17). Early air commerce acts went so far as to prohibit the use of federal funds for the construction of airports (a prohibition that was disregarded during the public works programs of the Great Depression).

During World War II, the federal government constructed hundreds of military landing areas and hangars across the country. Soon after the war's end, many of these aviation facilities were designated "surplus" and turned over to state and local governments for civilian use. Coincidentally, Congress passed the Federal Airport Act of 1946, which authorized federal aid for use by state and local governments in airport construction and improvements.

In the two decades after World War II, the aviation sector was transformed. Airlines introduced jet aircraft on many routes beginning in the late 1950s, which made it practical for many more Americans to fly on business and for leisure travel. Meanwhile, private pilots, thousands of them trained in the military, were crowding GA airports throughout the country. These developments created many new demands on airports—including the need for more spacious terminals and new runways to handle the larger jet airliners and the establishment of more modern, high-capacity GA reliever airports in large urban areas. However, federal aid for airports and air traffic management was appropriated by Congress each year as part of FAA's budget, often resulting in a mismatch between the demands placed on the airport system and the resources available to meet them.

Recognizing the need to better match the supply of aviation infrastructure with user demands, Congress created the Airport and Airway Trust Fund in

1970, along with a financing program for airport development now known as the Airport Improvement Program (AIP).[3] The trust fund was to be financed through a series of user-based fees, including—at the time—an 8 percent tax on domestic airline passenger tickets, a $3 levy per passenger on international departures, a 7-cent charge per gallon of fuel used in GA, and a 5 percent tax on all air-cargo waybills.

Grants in Aid from the Federal Trust Fund

The Airport and Airway Trust Fund, often referred to as the Aviation Trust Fund, has now been in existence for more than 30 years. During this time, more than $130 billion in revenue has been collected, and $30 billion has been distributed to state and local governments for airport planning and development. The bulk of the remaining $100 billion has been used to help pay for FAA air traffic management operations, facilities, and equipment.

In FY 2002, the trust fund took in about $10 billion, nearly three-quarters of which was derived from taxes on airline passengers (ticket tax, international arrival/departure fee, and passenger flight segment tax). Grants in aid to airports totaled some $3.2 billion in FY 2002. About 1,000 airports received AIP grants, including more than 500 GA airports. In addition, other GA airports receive federal aid through block grant programs administered by individual states.

These direct and state block grants are apportioned through funding formulas and awarded through competitive applications (in the case of discretionary grants). They are used for a variety of purposes, including the installation of runway lighting, the acquisition of land for longer approaches, the rehabilitation of taxiways, the purchase of noise abatement technologies, and the conduct of environmental impact assessments.

As noted, to be eligible for federal aid, the airport must be in the NPIAS. Commercial-service airports automatically receive AIP funds on the basis of the total number of passengers and the amount of cargo flowing through them. Along with GA airports, they must compete for funds awarded through discretionary grants.

Federal Passenger Facility Charges

In 1990, Congress enacted legislation allowing commercial-service airport operators to levy a $1, $2, or $3 facility charge to be paid by each enplaned passenger (as part of the ticket taxes charged with the air fare). Congress

[3] When it was created in 1970, the federal-aid program was called the Airport Development Aid Program and funded at about $250 million per year (Horonjeff and McKelvey 1983, 40).

stipulated in the law that the proceeds be used to finance FAA-approved projects that reduce noise or enhance safety, security, and capacity. Congress raised the maximum passenger facility charge (PFC) to $4.50 in 2001 (capped at $18.00 per round-trip) and stipulated further that the proceeds be used to furnish opportunities for increased competition among air carriers (e.g., by construction of more gates available to new entrants). Airport operators must apply for permission to levy a PFC, but in doing so they must relinquish a portion of their entitlement AIP funds.

A major advantage of the PFC to airport operators is that the revenues collected can be used for a greater variety of expenditures than can those received through the AIP. For instance, PFCs can be used to construct an access road or buy land for a parking garage. Although such "landside" projects often do not qualify for AIP funding, they can be essential components of plans to expand the overall capacity of an airport. Today, PFCs are in effect at about 300 airports, and operators of most large airports receive more revenues from the PFC than they do from AIP grants.

Other Airport Revenue Sources

Despite the large amount of federal aid to airports each year, most airports derive only a minority of their total operating and capital revenues from federal sources. For most airports, most revenues are locally derived. The commercial-service airports alone generate more than $10 billion in operating revenues each year. Aviation-related revenues—that is, revenues from aviation users of airports—account for about half this figure, with landing and terminal fees being the main sources among the top 150 commercial-service airports (the primary airline markets). By comparison, smaller commercial-service airports rely more on GA services for their revenues, such as rents from fixed-base operators and profits from aviation fuel sales.

Nonaviation sources account for about half of airport operating revenues. At large airports, car parking and rental car concessions are major, and often the largest, sources of revenue. The commercial-service airports took in another $8 billion in nonoperating revenues in 1999. These funds are typically used for capital improvements. For large airports, revenue-bond proceeds are the primary source of these funds. The principal and interest on the bonds are paid through rents and fees obtained from concessionaires, airline tenants, and other airport users.

AIRPORT REGULATION

Although most of the nation's public-use airports are owned and operated by local governments, they have critical roles in interstate transportation and commerce and in the safe and efficient performance of the national aviation system. As a result, airports large and small are subject to numerous rules and requirements of the federal government. Several federal agencies have regulatory and permitting responsibilities affecting airports, including FAA, the U.S. Army Corps of Engineers (USACE), the U.S. Environmental Protection Agency (EPA), and the U.S. Fish and Wildlife Service. In addition, airports are subject to many state and local laws and rules. As a practical matter, nearly all major decisions by airports are influenced or must be approved by many governmental agencies at several jurisdictional levels.

FAA's Role and Requirements

As key elements of the national aviation system, airports are subject to various federal requirements governing operations, safety, and environmental compatibility. For the most part, FAA administers these requirements, because it has primary responsibility for the safety, security, and efficient operations of the civil aviation system. Since the September 11th terrorist attacks, many aviation security responsibilities have been shifted to the newly created Department of Homeland Security and Transportation Security Administration (TSA). TSA requirements, which have major implications for airports, are described later. For other purposes, FAA's authority prevails, since it implements and enforces

1. Rules governing aircraft operations and traffic control in the airways, in terminal airspace, and on the ground at airports;
2. Certification standards for airport operations and safety-related capabilities and services; and
3. Contractual requirements for airports receiving federal grants for development.

FAA Air Traffic Control Requirements

Congress has given FAA exclusive and broad authority to control civil aviation and the use of navigable airspace in the United States. The rationale for this centralized authority is that the aviation sector must have uniformity in

operations and traffic management to function in a safe and orderly manner. Congress views the country's airspace as a public good of national importance whose use must not be hindered by fragmented state and local controls. FAA's authority, therefore, preempts state and local authority over the use of airspace and thus establishes numerous requirements that state, local, and private airports must comply with.

A direct effect of FAA's control of air traffic is numerous federal requirements concerning the design, maintenance, and operation of airside facilities, such as the configuration and use of runways and taxiways and the format and placement of airfield signs, markings, and other visual aids. These requirements stem from the need to ensure safe aircraft operations through consistency and from the recognition that operations at one airport can affect operational performance and safety elsewhere in the national system.

While these are the most obvious effects of FAA's regulation of air traffic on airports, they are by no means the only ones. Perhaps the most controversial effects are those derived from FAA's exclusive control over aircraft operations. In particular, the regulation of aircraft noise—often a major concern of communities—is largely a federal responsibility. FAA has maintained, and Congress and courts have affirmed, that state and local governments cannot create laws and ordinances that restrict operations of aircraft into or out of airports. The concern is that such local powers would impinge on FAA's ability to set consistent operational standards and manage air traffic as a national system.

Only in their capacity as owners of airports do state and local governments have a limited ability to regulate noise through restrictions on aircraft operations. Airport owners can, for instance, prohibit the operation of all aircraft emitting noise above a certain threshold during nighttime hours; however, they cannot ban particular kinds of aircraft, such as jets, or particular kinds of operators, such as airlines. Concerned that such local restrictions would impair its ability to manage air traffic, FAA has been vigilant in protecting its air traffic management prerogatives.

FAA Certification of Airports for Safety

In its capacity as chief regulator of aviation safety, FAA has authority to issue operating certificates to airports handling aircraft used by commercial operators. Airports that seek airline service must first meet a series of FAA safety requirements, such as weather reporting and notification capabilities,

approved instrument approach procedures, runway maintenance programs, and preparedness plans for aircraft accidents and other emergencies. The prescribed standards and procedures, which are more stringent for airports seeking authority to serve passenger airlines using large aircraft, are typically contained in FAA advisory circulars. Approximately 525 airports hold full or limited certificates to handle air carrier operations.

Of course, an airport that is certified to serve air carriers may not have all the qualifications to accommodate all of the many kinds of aircraft used by air carriers. Individual aircraft types are certified by FAA as airworthy and subject to specific operational and maintenance requirements; these requirements can vary depending on how the aircraft is used (e.g., in private or for air transport). A Boeing 737 airliner, for instance, cannot operate from a runway that is shorter than the aircraft's FAA-certified minimum distances for safe landing and takeoff. As a margin of safety, FAA prescribes even longer runway distances for aircraft used in air carrier service. Although they are not required to accommodate all of the many kinds of aircraft used by airlines, commercial-service airports compete for airline services with other airports. They are seldom in a position to ignore these requirements lest they lose their airline tenants. Consequently, FAA's aircraft certification requirements can compel airport operators to make significant investments to change runway and taxiway dimensions, maintenance and fueling facilities, and other services and infrastructure to accommodate as many different kinds of aircraft as possible.

FAA Grant Requirements

FAA, which administers both the AIP and PFC programs, has a stewardship role in ensuring that the funds are used wisely and fairly. Accordingly, airports must obtain FAA approval for intended uses of AIP and PFC funds. To gain this approval, airports must typically follow FAA specifications for designs, materials, methods, and procedures.

FAA maintains a series of advisory circulars that contain many of these standards. They cover all kinds of projects eligible for federal aid. For example, a comprehensive (300-page) circular covers all major aspects of airport design, and specific guidelines cover the design, construction, and testing of aircraft rescue and fire-fighting vehicles procured with federal aid. Airports that do not comply risk losing federal aid; hence, FAA retains a high degree of control over airport projects and procurements through these grant requirements.

Moreover, in accepting federal aid, airports must adhere to a series of contractual "assurances" laid out by the federal government. These assurances compel grant recipients to comply, for instance, with the provisions of relevant federal statutes and executive orders and to use specific project recording, accounting, and procurement procedures. The assurances can obligate the airport to follow procedures that go well beyond the specific project. As an example, an airport that accepts federal aid must make the airport available for public use on reasonable terms and must avoid unjust discrimination among all types, kinds, and classes of aeronautical activities.

Many other grant assurances apply. Together they circumscribe the operator's ability to set user fees, enter into leases and contracts, spend revenues, and restrict the kinds of aviation activities at the airport. As grant administrator, FAA is responsible for ensuring compliance with most of these federal assurances.

Federal Environmental Regulations

Airports have long been a focus of environmental concern. Because of their size, functional requirements, and use in transporting passengers and high-value cargo, airports tend to be located on large, flat sites near populated areas. Suitable sites are often found on the shores of rivers, lakes, and oceans, or in wetlands or other types of landscape thought to have little economic value when originally selected for airport development. However, these sites often support important ecological systems whose disturbance can affect plant and animal communities, as well as humans.

With passage of the National Environmental Policy Act (NEPA) in 1969, airport planning and development projects became subject to much greater scrutiny by the federal government, including EPA. NEPA mandates an environmental impact assessment when a federal action is proposed. Most airports receive federal aid or require some federal decision in connection with airport development programs (e.g., FAA approval of a new instrument approach procedure or runway layout). Therefore, airport operators are often required to initiate such assessments. FAA is responsible for reviewing them, or, if more detailed analyses of impacts are required, for conducting the assessments and preparing environmental impact statements. About 40 federal laws, executive orders, and regulations protect particular elements of the environment, such as the Clean Air Act (CAA), Clean Water Act, Endangered Species Act, and Order on Protection of Wetlands (see Box 1-1 for a listing)

Box 1-1

Federal Laws and Executive Orders Affecting Airports

Federal Laws

Airport and Airway Improvement Act
American Indian Religious Freedom Act
Anadromous Fish Conservation Act
Archeological and Historic Preservation Act
Clean Air Act
Clean Water Act
Coastal Barrier Resources Act
Coastal Zone Management Act
Comprehensive Environmental Response, Compensation, and Liability Act
Department of Transportation Act, Section 4(f)
Endangered Species Act, Section 7
Farmland Protection Policy Act
Fish and Wildlife Conservation Act
Land and Water Conservation Fund, Section 6(f)
Marine Mammal Protection Act
National Environmental Protection Act
National Historic Preservation Act
Native American Graves Protection and Repatriation Act
Pollution Prevention Act
Resources Conservation and Recovery Act
Rivers and Harbors Act
Safe Drinking Water Act
Sikes Act Amendments
Toxic Substances Control Act
Uniform Relocation Assistance and Real Property Acquisition Policies Act
Wild and Scenic Rivers Act

Executive Orders

11593 Protection and Enhancement of the Cultural Environment
11990 Protection of Wetlands
11998 Floodplain Management
12088 Federal Compliance with Pollution Control Standards
12372 Intergovernmental Review of Federal Programs
12892 Federal Actions to Address Environmental Justice in Minority and Low-Income Populations
13007 Indian Sacred Sites
13084 Consultation and Coordination with Indian Tribal Governments
13112 Invasive Species
13186 Responsibilities of Federal Agencies to Protect Migratory Birds

(DOT 2001). Each must be considered by airport operators and FAA during the conduct of environmental impact assessments. EPA and all other federal agencies responsible for administering these laws, orders, and regulations must be given the opportunity to review the impact statements and consulted on means of addressing potential adverse effects of proposed development actions. The NEPA analysis and documentation process cannot be completed and the planned project or action cannot go forward until all the environmental effects identified are resolved to the satisfaction of each responsible agency.

As an example, CAA requires EPA to identify National Ambient Air Quality Standards to protect public health and welfare. EPA has set ambient air quality standards for various pollutants, which are called "criteria" pollutants. Where the standards are not attained, individual states must develop plans prescribing attainment strategies. Many large airports are located in metropolitan areas that are not in attainment for one or more criteria pollutants. Consequently, an airport project that requires federal action or funding will first require FAA to determine whether pollutant thresholds may be exceeded and, if so, to devise mitigations that comport with the state attainment plan. It may be necessary, for instance, to offset projected increases in emissions through reductions in other airport emissions sources or the purchase of emissions "credits" from nonairports (e.g., local stationary sources).

Because aircraft noise has long been a special environmental concern of aviation, it has been the subject of much legislative and regulatory action. Congress passed the Aviation Safety and Noise Abatement Act in 1979 to address mounting concern over airport noise. The act requires FAA to adopt regulations establishing a single system of measuring aircraft noise and determining the exposure of people to airport noise. While airport operators are not required by the act to conduct noise studies or develop abatement plans, federal funds are available for doing so. FAA offers guidance to operators on how to measure noise and develop abatement plans, and operators seeking federal noise abatement funds must follow this guidance.

Airport operators that propose restrictions on aircraft operations must first examine all other reasonable mitigations, including changes in local land use planning and zoning. FAA is authorized to fund noise abatement projects with AIP funds. Such projects also may be funded with PFC revenues on FAA's approval. FAA has sole authority to impose operational restrictions on aircraft and thus to affect noise boundaries.

Federal Security Requirements

FAA has long set rules directing airports serving airlines to ensure security—for instance, by taking steps to control access to runways, parked aircraft, and other airside facilities and to secure baggage-handling areas. FAA rules also required airports, in concert with airlines, to establish "sterile" areas where passengers board aircraft. Airports were given leeway to customize their security plans, which FAA reviewed and approved. In November 2001, President Bush signed the Aviation and Transportation Security Act, which transferred a number of these regulatory responsibilities and some of the security functions themselves to TSA. The act also created new requirements, such as the installation of explosive detection systems at all commercial-service airports. Now TSA must not only approve individual airport security programs, it must also assist in their development and implementation through a federal airport security manager stationed at all major commercial-service airports. Congress authorized a $2.50 tax per passenger enplanement (not to exceed $10 per round-trip) to defray the cost of TSA security operations and investments in explosive detection systems and other screening devices and technologies. The revenues generated from this surcharge are expected to generate about $1.7 billion in FY 2004.[4]

The federal government's heightened security role is having and will continue to have far-reaching implications for airports as they try to integrate security with infrastructure and operations. As TSA deploys explosive detection systems and other screening and scanning technologies, airports will be required to accommodate them by providing floor space and supporting infrastructure (e.g., upgrades in electric power, blast-resistant areas where suspect bags can be examined). The Inspector General of the U.S. Department of Transportation estimates that about $3 billion will be needed just to integrate existing explosive detection technologies with baggage-handling systems and suggests that investments in more effective equipment and associated infrastructure will continue for many years. In FY 2002, airports used more than $560 million of AIP funds (17 percent of the total) for security-related projects, compared with $56 million in FY 2001.[5] Airports are facing many design challenges presented by changes in passenger flows in and

[4] See "Aviation Security Costs," statement of Inspector General of the Department of Transportation Kenneth M. Meade before the U.S. Senate Committee on Commerce, Science, and Transportation, Subcommittee on Aviation, February 5, 2003.
[5] See statement of Kenneth M. Meade.

around TSA-manned security checkpoints; the need for "meeter/greeter" halls outside the sterile gate areas (no longer accessible to nonticketed individuals); and uncertainties about future security requirements that may affect the configuration and location of ticket counters, parking garages, and access roads. These changes have yet to play out fully, but they will undoubtedly create many new airport challenges and problems in need of research.

On November 25, 2002, the President signed the Homeland Security Act, which transferred TSA to the new Department of Homeland Security, effective March 1, 2003. The shift of TSA to a federal department separate from FAA presents a major challenge to airport operators as they try to coordinate the various federal demands and requirements.

State and Local Roles

As discussed above, FAA has sole authority to control and restrict aircraft operations, and only in their role as airport owners can state and local governments exercise some control over aviation operations at airports. However, state and local governments exercise other controls that affect airport use and capacity. Many states have established their own environmental review processes for airport development projects. While these processes and their substantial requirements are often similar to those of NEPA, some states mandate review of additional topics and establish different standards for determining impact significance. For instance, some states have adopted ambient air quality standards that are more stringent in many respects than those of the federal government. In California, for example, environmental reviews may be required to include analyses of air toxic emissions and related human health risks that are not required in federal NEPA documentation.

With regard to local requirements, local land use planning and zoning are relied on to help control noise impacts and other environmental effects at airports. In most places, such zoning is handled at the county, municipal, or even submunicipal level. Thus, airport operators must often deal with a multiplicity of jurisdictions with authority to control land use within airport noise impact areas. The more jurisdictions involved, the greater the chance that some localities will not adopt planned land use controls, which can eventually result in noise complaints, noise nuisance lawsuits, and public opposition to airport proposals to expand. In turn, local political pressure can hinder an airport's ability to obtain state and local support for access roads and other needed infrastructure. Airport operators must therefore work

closely with local governments to limit adverse effects on neighboring communities while providing the levels of service desired by the larger region and fulfilling their integral roles in the national aviation system.

AIRPORT-RELATED RESEARCH

Because airports face so many operational, economic, social, and environmental issues, their owners, users, and regulators require much data, analysis, and technical knowledge. Research is therefore crucial to supporting sound airport planning and investing, ensuring safe and environmentally acceptable airport operations, and solving day-to-day airport problems. The federal government has a central role in financing and conducting research, and the operators of individual airports themselves sponsor specific studies and provide test beds for evaluating and demonstrating research results in the field.

Of course, defining what is encompassed by "airport-related" research is complicated by the fact that so much R&D activity can have results that are pertinent to airports. The broadest definition of airport-related research could include such topics as the effect of low-frequency noise on people living near airports, transferable highway and chemical industry R&D on paving technologies, and basic operations and human factors research, all of which are essential for designing and operating airports efficiently, safely, securely, and in an environmentally responsible manner. This broad view of airport-related research, though reasonable, has no practical bounds. The more manageable emphasis here, therefore, is on describing research activities—public and private—that are aimed specifically at meeting the identifiable needs of airports and the nation's airport system.

Federal Airport Research

In the civilian aviation sector, the two main federal sponsors of airport-related research are FAA and the National Aeronautics and Space Administration (NASA). As the federal agency most responsible for regulation, stewardship, and day-to-day operation of the nation's airspace system, FAA sponsors the largest and most varied set of supporting research activities. They range from individual studies to address the needs of a particular airport rulemaking to multiyear, multiproject programs aimed at furthering the state of major airport investment areas, such as runway pavements and visual aids. NASA's role is to promote research and development activities with

a longer-term potential for improving the national airspace system, including the airport component.

FAA Research

FAA research activities are spread out among a number of divisions, branches, and staff offices. Most of the agency's research is conducted in the Office of Aviation Research, which is funded primarily from the Research, Engineering, and Development appropriation. The office's budget in FY 2003 was approximately $124 million, which was used for research in support of FAA's varied functions and responsibilities, including managing air traffic, setting flight standards, increasing airport capacity, and certifying aircraft. FAA is budgeted to spend another $85 million on research funded through various offices and appropriations, including the Facilities and Equipment and AIP appropriations.

By and large, this dispersion in research activities reflects FAA's diverse policy-making, programmatic, and operational responsibilities, such as administering grants in aid, providing air traffic services, acquiring air traffic control technologies, establishing rules and standards for aviation safety, and mitigating the environmental effects of aviation. Each of these responsibilities requires supporting research. As an example, FAA's Office for Aviation Policy and Plans may undertake a study of airport noise measurement methods in support of a particular policy or legislative initiative. At the same time, the Office of Aviation Research may fund research on noise measurement and abatement methods through its program to reduce the environmental impacts of aviation. Consequently, there is no one place within FAA responsible for all "airport-related" research, nor is such a concentration of effort likely to be practical given the differing mission needs of individual FAA units.

The largest FAA research program centered on airports is carried out by the Airport Technology Research and Development Branch, which is a unit of the Airport and Aircraft Research Division of the Office of Aviation Research. The Airport Technology Research and Development Branch, located in the William J. Hughes Technical Center in Atlantic City, New Jersey, focuses on the development and evaluation of technologies and materials for airport pavements, airport lighting and marking, rescue and firefighting equipment and procedures, and wildlife management techniques. Its budget in FY 2003 was approximately $10.5 million, including $3 million for research on pavements mandated in legislation.

Much of the research carried out by the Airport Technology Research and Development Branch is intended to support revisions to FAA advisory circulars, as well as other FAA facility design, construction, and operations guidelines used by airport operators, consultants, and equipment makers. Among its accomplishments during the past 5 years, the Airport Technology Research and Development Branch has produced a manual on wildlife control methods, tested arresting systems to stop aircraft that have overrun runways, evaluated technologies to improve airfield lighting, and developed testing protocols for fire-extinguishing agents. Another major area of research is airport pavements. In cooperation with the Boeing Company, FAA operates the National Airport Pavement Test Facility at the Hughes Technical Center, which is used to conduct research to support standards for durable pavements. The federal emphasis on pavement research is justified on the grounds that runway and taxiway pavements are a major cost item for airports and are paid for largely with federal funds, and because the downtime for pavement repairs and maintenance can contribute to aviation system delays.

Various other divisions within the Office of Aviation Research support or perform research relevant to airports in areas such as weather prediction, system planning, and environment and energy. The Office of Aviation Research administers and distributes funds to the Air Transportation Centers of Excellence program, which consists of four university centers that specialize in particular research areas—pavement technology, aviation operations, GA, and airworthiness assurance. FAA may use the centers to perform research in their specialty areas as funds are available.

To better coordinate FAA's research and provide an avenue for users of the research results to have input on programming, Congress established the Research, Engineering, and Development Advisory Committee (REDAC) in 1989. REDAC, which consists of approximately 30 members representing trade associations, industry (including airport operators), academia, and government agencies, meets twice each year to review FAA's planned and ongoing research programs. It reports to the FAA Administrator on its findings and makes recommendations concerning aviation R&D needs, funding levels, and priorities. REDAC periodically holds joint meetings with NASA's Aerospace Technology Advisory Committee, which offer a means for FAA and NASA to better coordinate their aviation research programs. REDAC has also traditionally reviewed FAA's security-related research through its subcommittee

on aviation security. Although security responsibilities have been transferred to TSA, REDAC continues to provide the same review function.

NASA Research

NASA spends about $500 million per year on aeronautics research. It has set a goal to "revolutionize aviation" by pursuing a number of 10- and 25-year objectives to increase aviation safety, mobility, and capacity and reduce emissions and noise. To a large extent, NASA has a medium- to long-term time horizon for aeronautics research, compared with FAA's nearer-term focus on more applied research and technology development in support of its guidelines, standards, and current operational needs. NASA researchers working to reduce aircraft noise, for instance, are exploring new designs for jet engine inlets and nozzles and new ways to model airport community noise impacts. To increase aviation capacity and efficiency, researchers are examining decision-support tools for air traffic controllers and airlines to find shorter, time-saving routes. To increase personal mobility, NASA is examining new designs and technologies to make smaller aircraft more affordable and practical to use for transportation.

Precisely where this research will lead and how the results will be implemented in the field are difficult to assess. Nevertheless, any developments in these areas are likely to have a mix of direct and indirect effects on airports and how they are used.

Security Research

The Aviation and Transportation Security Act specifically called on TSA to "identify and undertake research and development activities necessary to enhance transportation security" and authorized $50 million for such activity. FAA's research responsibilities for security were therefore transferred to TSA, including the security-related work performed at the Hughes Technical Center. While the research, engineering, and development function at TSA is still being established, it will certainly include research and testing capabilities to support extensive technology programs in the areas of explosives detection, screening operations, container and vehicle hardening, and passenger and personnel identification.

The President's budget request for FY 2004 calls for an increase in TSA's budget for research and development to $75 million. In addition, the President requested $800 million in funds for the Department of Homeland

Security's Science and Technology Directorate, expected to be the department's main research and technology development arm. The Science and Technology Directorate will assist in the funding of research related to aviation and transportation security.

Other Federal Research Related to Airports

The Department of Defense owns and uses thousands of aircraft landing sites, and civil aviation airports are used by reserve and National Guard units. Accordingly, it has an interest in furthering research to improve the performance of these installations. Of course, many of the performance needs of the military, such as rapid repair of bombed runways, differ in kind from those of the civilian sector. Nevertheless, much of the research has application in both the military and the civilian domains.

USACE has lead responsibility for the construction and maintenance of military airfields, and it conducts pertinent research through its various laboratories. The Cold Regions Research and Engineering Laboratory, for instance, studies the effects of low temperatures on materials and equipment, which is helpful in developing runway pavements that are more resistant to freeze–thaw cycles and in improving airport snow- and ice-control operations. USACE's Geotechnical and Structures Laboratory has an airfield and pavements branch that serves as the Department of Defense's lead pavements research facility for roadways and airfields.

Research relevant to airports is conducted elsewhere in the Department of Defense and the federal government as a whole. As an example, numerous federal agencies, including the Department of Defense, NASA, the Department of Housing and Urban Development, and the National Park Service, are represented on the Federal Interagency Committee on Aviation Noise (FICAN) because each conducts research on aviation-related noise. Working through FICAN, these agencies often coordinate and sometimes jointly sponsor research on aviation noise effects, measurement, and abatement methods and technologies.

Research by Airport Operators and State Aviation Departments

The amount of research conducted by airport operators is difficult to quantify, although it can generally be characterized as highly applied and task-specific in nature. Much of the research is performed by consultants and conducted as particular needs arise. Nevertheless, aspects of these specific

studies may have broader application. For example, a consultant may be hired to collect and analyze data on traveler demographics, behavior, and destination selection to gauge the economic impact and financial feasibility of a proposed construction project or a new airport service. Whereas the specifics of such a study will need to be tailored to the individual airport and its market, determinations about data requirements and the most appropriate statistical, modeling, and analytical approaches may have general validity. Because the individual consultants are often hired on a case-by-case basis as needs arise, there is a tendency to "reinvent the wheel" in such research.

A major function of state aviation departments is airport system planning, some of which is conducted with AIP funds. Statewide planning normally entails preparation of aviation demand forecasts and studies of the interconnections between airports and surface transportation infrastructure, many of which are provided by state and local governments. A certain amount of research and technical support can be required for planning activities. For example, in developing its aviation system plan, California has sponsored a study of forecasting methodology by the University of California that proposes a framework for localities to develop aviation forecasts on a consistent basis (Caves and Gosling 1999, 232). California provides an example of how states typically sponsor aviation research—that is, by funding particular studies at state universities or providing a modest annual contribution to state university aeronautics and transportation research programs.

Private-Sector Research

As in all industries, the suppliers of products and services used at airports undertake proprietary research and development activities. These suppliers, in turn, buy products and services from other suppliers, some of which support their own R&D activities. The private sector is extremely large and contributes to the continual flow of new and improved technologies into the airport sector. And even though the makers of aircraft and aircraft components do not supply products directly to airports, their research has important implications for airports—for instance, by influencing the design of runways, taxiways, appurtenances, and other airport facilities. Private suppliers to airports number in the thousands, and their diversity makes it difficult to estimate the overall scale of private-sector R&D activity. However, it encompasses all aspects of airport planning, design, construction, and operations.

One source of research ideas and results is the many airlines, aircraft operators, and other users and tenants of airports. They all have a strong interest in ensuring that the design and operation of the terminal environment, airside facilities, and even access to and from the airport meet their needs. Thus, industry associations such as the Air Transport Association, the Regional Airline Association, the National Business Aircraft Association, and the Airports Council International maintain committees that help set industry standards. In doing so they identify key research needs. Professional associations such as the American Association of Airport Executives, the Aircraft Operators and Pilots Association, and the American Society of Civil Engineers also provide an informal forum for identifying research needs and disseminating results of research.

Together, the private suppliers and consultants, airport users, and various trade and professional associations play a critical role in identifying and meeting the research needs of airports. This highly dispersed process, however, can at times produce slow and uneven results and dissemination.

SUMMARY

More than 5,000 airports are open for public use in the United States. They range in size from small GA airports handling a few airplanes per day to large commercial-service airports handling hundreds of aircraft and thousands of passengers per hour. Together they form the national airport system, which is a key element of the nation's air transportation system. Nevertheless, they are very much a collection of autonomous entities—mostly owned and operated by local governments.

Recognizing the importance of airports in the national airspace system, the federal government regulates many aspects of their operations and provides them with funds for capital improvements. Airports are thus subject to many national requirements and standards governing their design, operations, safety performance, security, and finances. Airports are also subject to national environmental regulations. Hence, airport operators have much in common with one another and face many of the same problems and research needs. However, they lack a way to address these shared problems and needs that balances the many separate—and sometimes conflicting—requirements that they face.

Through FAA, NASA, and other agencies, the federal government sponsors and performs research related to airports. With the advent of TSA,

additional research related to airport security—and thus to facility design and planning—can be expected. Each agency funds research to fulfill its own mission and support its own policies and requirements. For the most part, the research does not provide airports with information and guidance sufficient to implement solutions to problems that stem from the requirements and demands of multiple federal, state, and local entities. Airport operators themselves do not have the capacity to undertake such research. Yet, it is in their interest and the interest of regulatory agencies and airport users to acquire this capacity.

REFERENCES

Abbreviations

ACI	Airports Council International
DOT	U.S. Department of Transportation
FAA	Federal Aviation Administration
NASAO	National Association of State Aviation Officials
TRB	Transportation Research Board

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2

Airport Research Needs

Airport-related research in the United States covers a wide spectrum of needs and topics. At one end of the spectrum, the Federal Aviation Administration (FAA), the Transportation Security Administration, the U.S. Environmental Protection Agency, and other federal agencies conduct research to support their own responsibilities in managing and overseeing the safety, security, and environmental compatibility of the national aviation system. This research can be characterized as mission- or function-oriented and is focused primarily on each agency's particular responsibilities. At the other end of the spectrum, research is more aptly described as problem- or product-based. It is the outcome of the work of thousands of airport operators, aircraft operators, consultants, and suppliers on site-specific issues, development of proprietary products, and practical solutions to everyday problems.

Largely missing from this mix is a middle layer of research that addresses problems shared by many airports, large and small. In particular, federal requirements present the nation's airports with many complex challenges. Examples are the need to find environmentally acceptable—but still safe, economical, and fast—aircraft deicing methods and the need to design airport terminals that both expedite passenger traffic and enhance security. Federal agencies conduct research to support their own requirements. Airport operators need research to solve the problems created by the multiple demands that are placed on them not only by several federal statutes and agencies but also by state and local governments, airlines, and other airport users.

The nation's airports represent a mostly public resource overseen, managed, and financed by all levels of government. Research that helps find and integrate solutions to shared airport problems can confer large public benefits by allowing more effective responses to government rules and requirements, more productive use of public resources, and better service to airport users. Inasmuch as the federal government alone collects billions of dollars each year from airport users and returns much of this money to state and local airport operators to reinvest in their facilities, both the public sector and the traveling public should have a keen interest in ensuring the performance of such research.

Some basic criteria for identifying kinds of airport research that are candidates for a national airport cooperative research program (ACRP) are offered in the next section. Specific examples of research needs are then given. The examples, which are not exhaustive or ranked in order of priority, reveal the nature and breadth of research needs.

RESEARCH SUITED TO A COOPERATIVE RESEARCH PROGRAM

Not all airport research needs are best addressed through cooperative means. For instance, the National Aeronautics and Space Administration's (NASA's) mission is to undertake longer-range research that is inherently risky but that has the potential to yield major aviation improvements. Much of the research conducted by NASA on topics such as quieter aircraft propulsion systems and artificial vision systems to display airport runways and obstructions would be poorly suited to an application-oriented, cooperative research program. By necessity, FAA's research is directed mainly at supporting its own regulatory activities, grant programs, and other mission requirements. Likewise, many of the product-oriented R&D activities of the commercial sector are not suitable for cooperative research. Indeed, proprietary R&D, which is crucial to the introduction of new airport products and procedures, is by no means being neglected by private industry. Airport operators rarely lack a wide selection of competing products and services. What they often do need is objective, research-based information to choose among the many product and service offerings.

The following questions are helpful to consider in trying to identify the kinds of research that are suited to a national ACRP.

- *Is the research need routinely overlooked by existing research programs?*

Certain topics receive limited attention because they do not relate directly to the mission of major sponsors of airport-related research. For example, FAA focuses much of its research on improving the airside features and functions of airports, which are major recipients of federal aid and directly relevant to the performance of the national aviation system. The agency undertakes comparatively little research on routine maintenance of passenger and cargo facilities, which is viewed primarily as a local responsibility. Even though operators across the country collectively spend hundreds of millions of dollars each year on maintenance and share many related problems, none of FAA's current airport research projects can be described as concerned with maintenance.

- *Will many airports benefit from the research and its results?*

Some operators will always need their own research capacity to address problems unique to their airports. National research, however, may be a more productive approach in addressing problems common to many airports across the country. For example, all airport operators are currently taking steps to strengthen security. As they do so, they are being presented with many similar problems, such as how to minimize crowding near security lines, strengthen perimeter protections around airfields, and retrofit terminal facilities to accommodate new passenger screening and explosive detection systems. As another example, many operators find themselves faced with similar challenges in attempting to meet federal environmental requirements. Addressing such needs through cooperative research would prevent duplication of effort and allow development of more widely accepted and transferable results.

- *Can the research be performed with a reasonable expenditure of time and effort?*

Meeting some challenges, such as reducing airport noise exposure in adjacent communities, will require much research over a long period of time. Broad problem areas, such as airport noise, may be a general category of cooperative research. However, the key to retaining the interest and participation of airport operators in the research is to focus on finding timely and practical solutions to well-defined problems—for instance, guidelines for retrofitting homes for noise abatement.

Some airport problems may already be well understood, and solutions may be available. The solutions may not have been adopted for a variety of reasons—political, institutional, or economic. Pricing as a means of reducing runway congestion is one example. In such cases, careful consideration will be required to ensure that the scope of the problem is narrowed so that the research can yield useful results.

- *Can the product of the research be well articulated?*

It is not possible to anticipate all the potential uses and benefits of research. Yet, definition of a tangible research product at the outset is crucial for an applied research program. A particular product in a particular format—for instance, a standards manual or a revision of a guidebook of best practices—is more likely to meet the practical needs of airport operators. Such applied research might take the form of technical studies in support of the development

and revision of specific FAA advisory circulars and airport industry engineering, maintenance, and operational guidelines, as discussed in the next section.

CANDIDATE RESEARCH TOPICS FOR AN ACRP

Commercial-service airports in particular can be large and complicated enterprises. Many employ hundreds or even thousands of personnel; maintain relations with scores of airlines, concessionaires, and suppliers of equipment and services; and are visited by thousands of airline passengers and other users on a daily basis. They often have multiyear planning, construction, and procurement programs for numerous facilities, ranging from access roads and parking garages to terminals, runways, and storage buildings. Some large airports are communities in their own right. They house or operate numerous parking facilities, public transportation systems, warehouses, fueling stations, fire and rescue services, police forces, road networks, medical facilities, restaurants, and hotels. The sheer size and complexity of many airport enterprises present a rich array of problems and research needs.

The following examples of research topics are intended to illustrate the diversity of needs in several broad research categories: operations and safety, maintenance, design of infrastructure and equipment, finance and administration, planning and environment, and security. The examples, which have the characteristics described in the preceding section, are well suited to being performed through an ACRP.[1]

Operations and Safety

Some large airports handle hundreds of aircraft landings and takeoffs in a single hour. Many different kinds of aircraft operating on multiple runways, taxiways, and parking areas and the movements of hundreds of tugs, baggage and cargo conveyors, passenger bridges and buses, refueling trucks, service vehicles, and other ground-support equipment and personnel are involved. Thousands of people may pass through a single terminal in an hour as they board and transfer to other flights, wait for arrivals, and are processed by security, customs, and immigration services. The orchestration of these airside and terminal operations, especially during peak periods and adverse weather,

[1] These examples were derived from a number of sources, including committee discussions and briefings (see Preface) and needs identified by technical committees of the Airports Council International and the National Association of State Aviation Officials.

requires planning and coordination among airlines, air traffic control, and airport operators.

As chief conductors of this large operation, airport operators need information to make the decisions and preparations to ensure smooth and safe performance. Many research needs arise involving what appear to be straightforward practices and procedures. For instance, the free movement of passenger traffic in terminals requires information on how best to set the speeds of escalators and moving sidewalks and how to design and locate "way-finding" signs that provide the necessary information to travelers without causing them to congregate in hallways. Such problems have been evaluated and addressed at individual airports throughout the world, and varieties of solutions have undoubtedly been found and implemented. Yet, no comprehensive source of information concerning the types of solutions devised, let alone their relative effectiveness, now exists. Research that collects information on these solutions and that evaluates them for effectiveness under a range of circumstances would likely provide guidance on ways to improve passenger traffic flow at many airports.

Airside operations also present many problems and research needs. Aircraft operations are managed by airline and air traffic control procedures that are outside the purview of airport operators. However, airport operations are affected by these procedures, and airport operators need to understand how they are affected in order to make the necessary adjustments in infrastructure and equipment. As an example, federal rules governing Terminal Instrument Procedures (TERPS), which are issued by FAA's Flight Standards Office, set forth certain obstacle clearance criteria in the approach and landing zone around runway ends. Slight modifications in these criteria, such as the treatment of taxiing aircraft as obstructions, can alter the distances aircraft must move from gates and taxiways to holding and runway positioning and affect the design and configuration of the runways and taxiways themselves. Such changes can have far-reaching implications, which aircraft operators must recognize and understand. The operators need to be involved in the modeling and other research performed to evaluate changes in TERPS and many other air traffic control procedures.

Research into other aspects of airport operations also holds the potential for improvements in efficiency and safety performance. For example, ways to enhance the safety of ground-vehicle operations, protect ramp workers from lightning strikes, and discourage perching by birds could be investigated. A

starting point for such investigations is to survey and synthesize current practices. The results will point out research needs and provide ideas for improving safety programs.

Virtually any element of the airport enterprise can affect airport operations and safety. For example, environmental rules governing the runoff and disposal of aircraft deicing materials, which are designed to safeguard bodies of water near airports, have significant impacts on aircraft deicing operations. Deicing operations, in turn, affect overall airport operations. Indeed, many of the research needs identified in the following research categories are germane to operations. They suggest the importance of having airport operations managers intimately involved in the research process.

Maintenance

Good maintenance is crucial to an airport's ability to provide efficient, safe, and reliable service. It also represents a significant expense. Maintenance materials, supplies, and services typically account for 20 percent or more of annual operating budgets and are often second only to personnel as the largest single expense item.[2] The neglect or deferral of maintenance can have significant long-run implications: it can present safety hazards that reduce airport capacity and require costly repairs and renovations. Yet federal aid, which can be used for capital improvements, seldom covers expenses associated with routine maintenance.[3]

As steward of the large federal investment in airport facilities, FAA has an interest in research that identifies and promotes sound maintenance practice. However, this interest is indirect, especially as it applies to passenger terminals and other landside facilities. FAA's concern with aircraft operations and safety does intersect directly with airport maintenance in the maintenance of airside facilities, especially runways. FAA sponsors research on runway paving materials, sealers, repair methods, and snow- and ice-control methods and materials. Airport operators have research needs even with regard to runway and taxiway maintenance, since they must evaluate the many products offered by commercial vendors to repair and maintain these facilities.

[2] FAA Form 5100-126 shows operating expenses by category and is submitted annually by airports applying for federal aid. A review of the Form 126 submissions (available on the Internet at www.faa.gov/arp/cats/) shows that, for most airports, maintenance accounts for between 10 and 35 percent of operating expenses—although individual airports may categorize expenses differently (for instance, contracted maintenance may be defined as a "service," which is a separate expense category).

[3] Federal aid can be used for most kinds of pavement repair and maintenance, with the exception of cleaning and minor repairs at primary airports.

Airport maintenance is a prime example of how operators would benefit from research providing them with objective information and means for evaluating commercial products and services. While the commercial sector is adept at offering proprietary solutions to maintenance challenges, airport operators do not always have the objective information to find the products that are best suited to their conditions and constraints. Even the apparently straightforward choice between types of terminal flooring material (e.g., carpet or terrazzo) can present an array of issues that require careful balancing of initial costs with durability and maintainability.

At a more general level, airports need better tools for managing their maintenance programs—for instance, monitoring the condition of their assets, prioritizing maintenance activities, and managing maintenance personnel and contractors. Given the large number of airports and maintenance practices, the biggest payoff in maintenance research may not be from the development of new maintenance materials, techniques, and equipment, but rather from a synthesis of the experience of airports and communication of that experience through handbooks and training materials.

Design of Infrastructure and Equipment

Various types of airside equipment and infrastructure are eligible for federal funding aid, such as field paving and lighting, security systems, snow and ice removal, noise abatement equipment, fire-fighting equipment, and weather monitoring stations. Funding eligibility is more restricted for terminals and other landside features, but federal aid can be used for public facilities that are directly related to the movement and processing of passengers, such as baggage-handling equipment, passenger boarding bridges, central waiting rooms, and security and inspection areas.[4]

FAA issues guidelines and standards governing the design of airport facilities and equipment paid for with federal assistance. In most cases, the airport grant recipient must comply with the specific design standards set forth in a series of FAA advisory circulars. The topics covered by many of these circulars are given in Table 2-1. FAA contractual agreements typically allow grant recipients to use alternative designs if convincing evidence that the alternative design is equivalent to or better than the one specified in the

[4] Excluded from coverage are areas that are primarily revenue producing, such as restaurants, concession stands, and ticketing areas. However, smaller airports are subject to fewer restrictions on the use of federal aid for revenue-producing facilities.

Table 2-1 FAA Advisory Circulars for Airport Planning, Design, Construction, and Maintenance

Advisory Circular Number	Title Topic	Date Last Revised	Required by FAA Regulation	Approved by FAA as Satisfying Regulatory Requirement	Required for Federal Aid	Notes
150/5200-30A	Airport Winter Safety and Operations	1/15/2002		x		
150/5200-31A	Airport Emergency Plan	9/30/1999		x	x	
150/5200-33	Hazardous Wildlife Attractants on or Near Airports	5/1/1997				
150/5200-34	Construction or Establishment of Landfills near Public Airports	8/26/2000				
150/5210-13A	Water Rescue Plans, Facilities, and Equipment	5/31/1991		x		
150/5210-14A	Airport Fire and Rescue Personnel Protective Clothing	7/13/1995		x	x	
150/5210-15	Airport Rescue and Firefighting Station Building Design	7/30/1987			x	
150/5210-17	Programs for Training of Aircraft Rescue and Firefighting Personnel	4/6/1995				
150/5210-18	Systems for Interactive Training of Airport Personnel	4/13/1994			x	
150/5210-19	Driver's Enhanced Vision System	12/23/1996			x	
150/5210-20	Ground Vehicle Operations on Airports	6/21/2002				
150/5210-2A	Airport Emergency Medical Facilities and Services	11/27/1984				
150/5210-5B	Painting, Marking, and Lighting of Vehicles Used on an Airport	7/11/1986			x	
150/5210-6C	Aircraft Fire and Rescue Facilities and Extinguishing Agents	1/28/1985				

150/5210-7C	Aircraft Rescue and Firefighting Communications	7/1/1999	x	x
150/5220-10C	Guide Specification for Water/Foam Aircraft Rescue and Firefighting Vehicles	2/28/2002	x	x
150/5220-13B	Runway Surface Condition Sensor Specification Guide	3/27/1991		x
150/5220-17A	Design Standards for an Aircraft Rescue and Firefighting Training Facility	11/24/1998		x
150/5220-18	Buildings for Storage and Maintenance of Airport Snow and Ice Control Equipment and Materials	10/15/1992		x
150/5220-19	Guide Specification for Small Agent Aircraft Rescue and Fire Fighting Vehicles	12/7/1993	x	
150/5220-20	Airport Snow and Ice Control Equipment	3/1/1994		x
150/5220-21B	Guide Specification for Devices Used to Board Airline Passengers with Mobility Impairments	3/17/2000	x	x
150/5220-22	Engineered Materials Arresting Systems for Aircraft Overruns	10/6/2000	x	
150/5220-4B	Water Supply Systems for Aircraft Fire and Rescue Protection	7/29/1992		x
150/5300-13	Airport Design	9/30/2000	x	x
150/5300-14	Design of Aircraft Deicing Facilities	8/31/2000		x
150/5300-15	Use of Value Engineering for Engineering and Design of Airport Grant Projects	9/9/1993		x
150/5300-9A	Predesign, Prebid, and Preconstruction Conferences for Airport Grant Projects	5/1/1985		

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Table 2-1 (*continued*) **FAA Advisory Circulars for Airport Planning, Design, Construction, and Maintenance**

Advisory Circular Number	Title Topic	Date Last Revised	Required by FAA Regulation	Approved by FAA as Satisfying Regulatory Requirement	Required for Federal Aid	Notes
150/5320-12C	Measurement, Construction, and Maintenance of Skid Resistant Airport Pavement Surfaces	3/18/1997			x	
150/5320-14	Airport Landscaping for Noise Control Purposes	1/31/1978				
150/5320-15	Management of Airport Industrial Waste	4/22/1997				
150/5320-16	Airport Pavement Design for the Boeing 777	10/22/1995				
150/5320-5B	Airport Drainage	7/1/1970				
150/5320-6D	Airport Pavement Design and Evaluation	1/30/1996				
150/5325-4A	Runway Length Requirements for Airport Design	1/29/1990			x	
150/5335-5	Standardized Method of Reporting Airport Pavement Strength	3/6/1987				
150/5340-14B	Economy Approach Lighting Aids	6/19/1970				
150/5340-17B	Standby Power for Non-FAA Airport Lighting Systems	1/6/1986				
150/5340-18C	Standards for Airport Sign Systems	11/13/1991			x	
150/5340-1H	Standards for Airport Markings	12/1/2000	x	x	x	Airports must follow marking standards
150/5340-21	Airport Miscellaneous Lighting Visual Aids	3/25/1971				
150/5340-23B	Supplemental Wind Cones	5/11/1990		x	x	

150/5340-24	Runway and Taxiway Edge Lighting System	9/3/1975		
150/5340-26	Maintenance of Airport Visual Aid Facilities	8/26/1982		
150/5340-27A	Air-to-Ground Radio Control of Airport Lighting Systems	3/4/1986	x	x
150/5340-28	Low Visibility Taxiway Lighting Systems	9/1/1998	x	x
150/5340-29	Installation Details for Land and Hold Short Lighting Systems	12/30/1999		x
150/5340-4C	Installation Details for Runway Centerline Touchdown Zone Lighting Systems	5/6/1975		
150/5340-5B	Segmented Circle Airport Marker System	12/21/1984		
150/5345-10E	Specification for Constant Current Regulator Monitors	10/16/1984	x	
150/5345-12C	Specification for Airport and Heliport Beacon	1/9/1984		
150/5345-13A	Specification for L-841 Auxiliary Relay Cabinet Assembly for Pilot Control of Airport Lighting Circuits	8/8/1986		x
150/5345-26C	Specification for L-823 Plug and Receptacle, Cable Connectors	4/17/2000		x
150/5345-27C	Specification for Wind Cone Assemblies	7/19/1985	x	
150/5345-28D	Precision Approach Path Indicator PAPI Systems	11/1/1991	x	
150/5345-39B	FAA Specification L-853, Runway and Taxiway Centerline Retroreflective Markers	12/9/1980		
150/5345-3E	Specification for L-821 Panels for Control of Airport Lighting	9/1/1998		x
150/5345-42C	Specification for Airport Light Bases, Transformer Houses, Junction Boxes and Accessories	10/29/1991		

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Table 2-1 (*continued*) **FAA Advisory Circulars for Airport Planning, Design, Construction, and Maintenance**

Advisory Circular Number	Title Topic	Date Last Revised	Required by FAA Regulation	Approved by FAA as Satisfying Regulatory Requirement	Required for Federal Aid	Notes
150/5345-43E	Specification for Obstruction Lighting Equipment	10/19/1995			x	
150/5345-44F	Specification for Taxiway and Runway Signs	8/23/1994			x	
150/5345-45A	Lightweight Approach Light Structure	12/9/1987				
150/5345-46B	Specification for Runway and Taxiway Light Fixtures	9/1/1998			x	
150/5345-47A	Isolation Transformers for Airport Lighting Systems	12/9/1987				
150/5345-49A	Specification L-854, Radio Control Equipment	8/8/1986				
150/5345-50	Specification for Portable Runway Lights	10/16/1978				
150/5345-51	Specification for Discharge-Type Flasher Equipment	8/14/1981				
150/5345-52	Generic Visual Glideslope Indicators	6/21/1988				
150/5345-53B	Airport Lighting Equipment Certification Program	9/15/2002				
150/5345-54A	Specification for L-884 Power and Control Unit for Land and Hold Short Lighting Systems	6/29/2001			x	
150/5345-7E	Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits	8/2/2001			x	
150/5360-12C	Airport Signing and Graphics	8/29/2001				Circular refers to and recommends industry publication "Guidelines for

						Airport Signing and Graphics," developed by ACI, AAAE, ATA, and ACC R&D Task Force
150/5360-13	Planning and Design Guidelines for Airport Terminal Facilities	4/22/1988				
150/5360-14	Access to Airports by Individuals with Disabilities	6/30/1999				Recommended to assist with ADA compliance
150/5370-10A	Standards for Specifying Construction of Airports	1/30/2001			x	
150/5370-11	Use of Nondestructive Testing Devices in the Evaluation of Airport Pavements	6/4/1976				
150/5370-12	Quality Control of Construction for Airport Grant Projects	9/6/1985				
150/5370-13	Offpeak Construction of Airport Pavements Using Hot-Mix Asphalt	8/27/1990				
150/5370-2D	Operational Safety on Airports During Construction	5/30/2002				
150/5380-5B	Debris Hazards at Civil Airports	7/5/1996		x		
150/5380-6	Guidelines and Procedures for Maintenance of Airport Pavements	12/3/1982				
150/5380-7	Pavement Management System	9/28/1988				

NOTE: ACI = Airports Council International; AAAE = American Association of Airport Executives; ATA = Air Transport Association; ACC = Airport Consultants Council; ADA = Americans with Disabilities Act.

circular is offered. For practical reasons, however, deviations are rare. Proving that an alternative design is comparable with the one specified can be time-consuming and risky because most of the design standards in circulars are not accompanied by clear performance specifications. Rather than take a chance on a novel design, most airport operators and their suppliers simply follow the design standards laid out in circulars.

FAA develops and revises its circulars by using its own technical staff and by adapting the codes of other standard-setting bodies such as the American Society of Civil Engineers and the National Fire Protection Association. The Airport and Aircraft R&D Division, headquartered at FAA's Hughes Technical Center, provides much of the technical support for the circulars. In addition, FAA occasionally relies on the technical work of industry, as exemplified by its recommended use of the Uniform Airport Signing and Graphics System for the content and placement of signs inside terminal buildings. This system was developed by a joint research task force of the Airports Council International, the American Association of Airport Executives, the Air Transport Association, and the Airport Consultants Council. The FAA circular does not require compliance with this system; instead, the recommendations are advisory in nature. About one-quarter of all airport-related advisory circulars are exclusively advisory.

A national ACRP could help FAA develop a stronger and more current technical basis for the guidance offered in its advisory circulars. In particular, research could be undertaken to survey and evaluate airport use of the circulars and to better prioritize those circulars that warrant early updating and further technical support. A number of circulars have not been updated in two or three decades, and in many cases the revisions have been modest (see Table 2-1). For instance, FAA's circular on the design of airport drainage systems was last revised in 1970. Although they are dated in many respects, these older circulars still provide crucial technical guidance to airport operators lacking other sources of information. Noteworthy examples in this regard are the design standards for taxiway centerlines, signage visibility, and wingtip clearances. These standards were introduced decades ago and were based on the heights, wheelbases, and wingspans of aircraft that are no longer in significant use, such as the DC-3 and DC-6. Although the standards have been modified to account for changes in the dimensions of modern aircraft, they have not been revised fundamentally

to account for such factors as improved aircraft controllability and visibility from the cockpit.

It is important for airport operators and users to have the most technically sound standards. To illustrate using the previous example, taxiway design standards that are too conservative—because they are based on simple extrapolations—may require airports to redesign or relocate taxiways at significant cost. Thus, airport operators, airlines, and FAA all have incentives to ensure that the standards are appropriate.

Finance and Administration

Modern airports of all sizes must be run by administrators with a variety of skills. The administrators must be able to maintain relations with workers, users, and suppliers, as well as the many elected officials of the communities they serve. They must be able to manage and account for public funds—even airports that derive significant revenues from tenants and concessions are responsible for public funds, and the services that airports provide with these funds are crucial to the community at large. Like executives in other industries, airport managers can draw on rules of thumb and conventional wisdom. However, as the airport environment has grown in complexity and airport managers face budgetary constraints and closer public scrutiny, research in support of sound management practices has become increasingly important.

Examples have already been given of research needs to better manage airport maintenance. Similarly, examples can be given of research needs for many other administrative and management functions. Airport managers, facing shortfalls in government aid, are increasingly expected to tighten budgets and find innovative sources of financing. They need standardized metrics to compare, or "benchmark," their financial and operational performance and to evaluate alternatives. The possible uses of congestion-based pricing for financing airport capacity enhancements, strategies for reducing bond and insurance expenses, and more effective airport property and concession management are other examples of research topics that are likely to be of interest to these administrators, as well as their boards of directors. More specifically, individual research projects might address such topics as the handling of federal "buy America" requirements, life-cycle costing for bid evaluations, and the use of design–build methods for project development, management, and finance. Collectively, individual airports have experience

with a range of innovative financing techniques. Systematic surveys and syntheses of how innovations such as design–build have fared and the circumstances under which they have been used would likely prove beneficial to operators across the country.

Because personnel are crucial to nearly all airport activities, research on such human-resource topics as worker safety, recruitment and retention strategies, low-stress working conditions, and incentives to reduce absenteeism is likely to be of interest to airport managers. Although such concerns are widespread, airport operators face many new human-resource challenges. More demands are being placed on airport workers as security concerns have heightened, while airport managers face a potentially diminishing supply of eligible and interested workers. Other industries, such as nuclear power, have had to adopt personnel recruitment and retention strategies commensurate with a security imperative. Research that systematically surveys and synthesizes such practices, both within and outside the aviation sector, can provide airport operators with much-needed insight and information.

Planning and Environment

Airports are planned with regard to both local needs and their function within the overall aviation system. Because so many elements of an airport are interdependent, a single airport capability—such as limited ground access—can influence an airport's overall capacity. In turn, this can affect the performance of the larger system of airports that serves a metropolitan area, region, or the entire country. Consequently, FAA has long allowed operators to use federal funds for master planning and state and metropolitan planning organizations to engage in system-level airport planning. Yet, FAA research in support of its master planning guidance has tended to be piecemeal. As a practical matter, it is more difficult for the agency to justify significant expenditures on research aimed at improving airport planning capabilities than to justify expenditures on research promising tangible new products and technologies, such as improved runway markings or fire-extinguishing agents.

Airport planning, especially the longer-range planning needed for major capital projects, involves a great deal of uncertainty. Operators must anticipate how their facilities will be used decades from now by an aviation sector that has been characterized by dynamic changes in technology, consumer demands, and industry business practices. Few operators, if any, anticipated the

rapid introduction of larger jet airliners during the 1960s, the shift to hub-and-spoke air carrier networks and the emergence of express air package services during the next decade, and the sharp decline in private general aviation (GA) activity during the 1980s. More recently, airports have had to accommodate the replacement of turboprops by larger regional jets (RJs), the expanded use of business aircraft resulting from fractional ownership programs, and a heightened focus on airport security. To illustrate just one of the economic implications of such uncertainty, the growth in the use of RJs by airlines has forced investment in new passenger bridges that can serve these lower-profile jets—bridges that can be difficult to design to work from existing terminal facilities while also meeting other requirements such as those of the Americans with Disabilities Act. Similarly, the introduction of very large aircraft can affect the design, configuration, and size of passenger waiting areas; runway and taxiway geometry; passenger loading bridges; and even the design and layout of seats in passenger lounges (which are typically designed for 10-year service lives).

In this environment, airports need reliable and timely information derived from research for both longer-range master planning and shorter-range planning in support of individual projects and procurements. The focus need not be exclusively on such broad topics as modeling passenger and cargo demand (which FAA can be expected to research), but on the practical needs of planners. Examples of research that airports are likely to find useful for planning are studies of passenger counting technologies and methods, alternative ways to measure customer satisfaction and service quality, and means to improve ground access through changes in terminal curb and garage functions.

Environmental issues are especially important considerations in planning airport projects. Again, FAA offers federal funds for assessing environmental impacts and mitigating them. While aircraft noise has been the subject of much federal research, airport operators must address many other environmental issues that require careful planning and evaluation. Operators must plan ways to curtail and manage not only noise, but also air pollutant emissions, groundwater and soil contamination, wetlands degradation, and habitat loss. Credible ways to measure these environmental effects and technical information on mitigations pertinent to airport settings are essential for conducting environmental impact assessments in conformance with federal, state, and local environmental laws and regulations. Yet, such information is often not available or is incomplete.

Environmental effects that are the subject of federal laws and regulations are often topics of federal research programs, but they are not the only environmental effects that operators must understand and alleviate. As noted in Chapter 1, low-frequency noise and vibration are gaining the attention of state and local governments, and airports are being asked to evaluate and ameliorate these impacts of airport operations. Operators in California and elsewhere are currently being required to evaluate the effects of airport development projects on emissions of air toxics, such as the aldehydes in aviation fuel that are potential carcinogens, and the potential health risks associated with such emissions. Confronted with a limited base of research on these subjects and a lack of accepted protocols for conducting the studies, airports have little reliable guidance on which to base the evaluations they are required to undertake (see Box 2-1 for more details on this example research need).

Box 2-1

Air Toxics Emissions, Measurement, and Risk Evaluation: A Growing Airport Research Need

Air pollutant emissions from jet aircraft engines include substances known as toxic air contaminants or hazardous air pollutants. Exposure to these air toxics in sufficient atmospheric concentrations can adversely affect human health, since some air toxics are known carcinogens and others have been linked to both acute and chronic noncancer health effects.

FAA does not require evaluation of air toxic emissions in environmental documentation for airport development proposals prepared in compliance with the National Environmental Policy Act. However, in recent years potential increases in air toxic emissions from aircraft and related health risks have become an issue in proposed airport development projects; for instance, it has been raised in state environmental reviews of development proposals at major California airports, including the master plan update at Los Angeles International Airport and Oakland International Airport's development program. Moreover, airport air toxics studies have been prepared in cases where communities near airports have raised concerns about exposure to air toxics from

(continued)

Box 2-1 (*continued*) **Air Toxics Emissions, Measurement, and Risk Evaluation: A Growing Airport Research Need**

ongoing airport operations (e.g., Chicago O'Hare, Santa Monica, Seattle–Tacoma).

Despite widespread and rapidly growing concern about air toxics at airports, fundamental data deficiencies and uncertainties about appropriate analytic models and methods make such evaluations highly problematic. The following are among the fundamental issues that have not been resolved and on which more research is needed:

- The emissions factors and speciation profiles available to estimate toxic emissions from aircraft engines are based on extremely limited tests.
- The results of the few engine tests that have been conducted are subject to serious questions concerning the validity of the sampling procedures used.
- The behavior of emissions from jet aircraft engines is poorly understood for several reasons, which complicates analysis of air toxics dispersion and estimates of atmospheric concentrations of the toxics. Aircraft are mobile sources of emissions, which makes their emissions generally more difficult to analyze than emissions from a stationary source such as a smokestack. Unlike other mobile sources whose movements can essentially be represented in two dimensions, aircraft operations must be analyzed in three dimensions and with allowance for changes in atmospheric conditions due to changes in altitude. In addition, because of wake turbulence, the dispersion characteristics of exhaust from airborne jet aircraft are extremely complex and have not been systematically studied.
- Human health risk assessment procedures introduce additional analytic problems. Toxicity factors are generally derived from animal studies or epidemiological studies of exposed worker populations; then, with additional safety factors assumed, they are extrapolated to low-level exposure conditions for other human populations. Typically, health risk assessments incorporate extremely conservative assumptions including "worst-case" emissions, meteorological conditions, and exposure. [The exposure scenario is based on the hypothetical "maximally exposed individual," who is assumed to be continuously exposed (24 hours per day, 365 days per year) over a 70-year period to the highest air toxics concentrations.] Estimates of risk for actual populations are then derived from the results of the worst-case analysis.

Environmental scrutiny has been increasing at all jurisdictional levels, and litigation associated with federal and state environmental documentation processes has been growing. Thus, the list of environmental issues that will present further modeling, evaluation, and planning challenges for airports across the country can be expected to grow. To the extent that operators of individual airports are obliged to address such issues as air toxics and associated health risks on a case-by-case basis, there is the potential for inconsistent analyses and conclusions. In turn, the difficulty of establishing scientifically reliable and legally defensible methods to evaluate the problem may increase.

Security

Security is a major concern of airports and the federal government. It pervades all aspects of airport operations, planning, and development. Moreover, a new federal agency, the Transportation Security Administration (TSA), has been given primary responsibility for ensuring aviation security. Fast-changing security demands and new institutional arrangements and responsibilities have presented major challenges at airports, where most of the security changes must be implemented. Security is now enmeshed in airport decision making. It must be factored into all airport plans and actions along with economic, environmental, safety, and operational effects. Operators must be responsive to the needs and expectations of TSA while also meeting those of FAA, the U.S. Environmental Protection Agency, other federal agencies with relevant regulatory responsibility, and state and local governments.

Airport operators have research needs that cut across the traditional boundaries of individual agencies. All parties have a fundamental interest in attaining the desired levels of security while performing other transportation functions, but airport operators have a pressing need to achieve these goals on a daily basis. Whereas some measures to enhance security may adversely affect an airport's ability to meet one or more of its other objectives, other measures may accommodate multiple needs. Airports have a strong incentive to find these mutually beneficial solutions.

As an example, TSA has placed signs at airports instructing travelers on security procedures. Operators have extensive knowledge of how travelers react to and interpret signs and of their effects on crowding and traffic movements throughout the airport. Cooperative research by operators and TSA on

the design, content, and placement of signs could strengthen security processing while ensuring that airport functions are not impaired.

In the case of GA airports, finding cost-effective ways to secure the airfield perimeter and based aircraft is a key security challenge. Before the attacks of September 11, 2001, the concern of many smaller airports was in preventing theft and vandalism; today, the managers of these airports—as well as officials of TSA and FAA—are also concerned about securing their airfields and aircraft to prevent acts of terrorism. More research is needed to identify effective and affordable technologies and procedures for securing the country's thousands of small airports.

The recent challenge of deploying explosive detection systems (EDS) for scanning checked luggage in all commercial airports provides another example of how cooperative research can have far-reaching benefits. In planning for EDS deployment, TSA developed passenger and baggage flow models for use in airports. Unfortunately, TSA did not have at its disposal mechanisms to work with airport operators and airlines in developing the models, which led to a lack of confidence by some of those who would need to implement the models. Consequently, many operators and airlines performed their own modeling and analytic studies, which were essential in assessing longer-term infrastructure investment planning. A joint development effort, bringing to bear the accepted research and expertise of the various parties, will likely result in a useful product for the continuation of TSA capital programs to improve airport security.

FAA has its own requirements for the design of passenger terminals. A research effort of the type just described would benefit from FAA's involvement to ensure that resulting methodologies and guidelines do not conflict with FAA requirements. In designing passenger facilities, airports must now factor in the added space and layout requirements of passenger screening and EDS, the introduction of more "meeter/greeter" halls outside sterile areas, blast-containing structures for housing explosive detectors, the availability of secure passenger evacuation areas, and the design of spaces that reduce vulnerable passenger crowding and provide broad fields of vision for surveillance. Not only must security be considered in all aspects of the design of passenger terminals, it must also be factored into plans for such services and facilities as air cargo terminals, fuel depots and on-airport storage and distribution systems, parking garages, and utilities. Security is especially important for the communications, navigation, and surveillance facilities at and

near airports. Even the designs for airport drainage systems are candidates for reevaluation in light of security concerns. Indeed, the determination of instances in which security ought to be given more explicit consideration in the development of airport and aviation facilities is a general example of where cooperative research is needed.

SUMMARY

Much of the airport-related research conducted at the national level is aimed at supporting the specific operational, regulatory, and policy-making requirements of the individual federal agencies that sponsor it (e.g., FAA, TSA, U.S. Environmental Protection Agency). From the perspective of individual operators, however, the requirements and expectations of these federal agencies are intertwined with those of state governments, local communities, and airport users. The result is that operators must seek and implement solutions to problems that stem from a complex mix of constraints, challenges, and demands. A national cooperative research program offers the potential for operators to identify and prioritize research needs from their own perspective as practitioners and problem solvers.

As large and complex operations, airports have many research needs involving a number of disciplines. Operators need practical and reliable results that can be applied quickly. A number of examples of research needs are identified in this chapter, from airport operations and design to finance, administration, and environmental protection and planning. The challenges that all concerned parties face in trying to ensure security while continuing to operate safely, efficiently, and conveniently exemplify these practical research needs. For instance, in planning new facilities, operators need information and guidance on designs that can simultaneously expedite passenger movements and facilitate security screening and processing—and they often need to be able to achieve these goals under tight budgetary constraints.

By having a research capability that can focus on problems from this implementation perspective, airport operators stand a better chance of meeting the varied demands and expectations placed on them—a desirable outcome for operators, government agencies at all levels, and airport users. Specific options for achieving such a research capability are considered in the following chapters.

3

Overview of the Highway and Transit Cooperative Research Programs

In the preceding chapter, examples are given of problems that airports share and that are not being well addressed today. These problems are candidates for research through a cooperative program involving airport owners and operators, federal agencies, airport users, and others in the aviation industry. In this chapter, characteristics of cooperative programs that will be important in meeting such research needs on a continuing basis are identified. How the program is governed, financed, and managed will be central concerns. The means chosen will fundamentally influence the kinds of problems researched, the quality and credibility of the research, and the probability of the results being applied in the field.

The legislative request for this study calls for an examination of the structure and effectiveness of two existing cooperative research programs in transportation: the National Cooperative Highway Research Program (NCHRP) and the Transit Cooperative Research Program (TCRP). These two programs are examined in detail below, with a particular focus on the means by which they are governed, financed, and managed. The insights gained from these reviews will be helpful in conceptualizing a cooperative program to meet research needs concerning airports.

PROGRAM ORIGINS AND STRUCTURE

The operation and maintenance of highways have been government responsibilities since the Colonial era. The federal government did not begin to play an important role in their planning and finance until after World War II. Urban transit systems, which were once mostly private entities, are now owned mainly by state and local governments, and they have received significant amounts of capital assistance from the federal government since the 1960s. By comparison, most airports did not receive significant amounts of federal aid for infrastructure improvements until enactment of the Airport and Airway Development Act in 1970.

Despite the federal government's expanded role in all three cases, the nation's airports, highways, and transit systems remain decentralized. They are owned and administered mainly by state and local entities. Sometimes several jurisdictions own them as part of regional transportation authorities, but more often than not they are owned by individual states, counties, and municipalities. In all cases, the federal government's primary means of influencing their development and operations is through financial incentives and regulation. In some respects, this decentralized transportation infrastructure appears to be at odds with the evolution of these systems into national networks. Indeed, the federal government has involved itself in system planning and funding largely on the grounds that national defense and national and international commerce warrant greater uniformity and interconnectivity of these many components. While accepting federal assistance, state and local governments have sought to retain primary control over their systems.

The appeal of cooperative research programs in the highway and transit modes is related to the desire of state and local governments to retain authority over their transportation systems. Even though they face many similar problems, states and localities realize that they have unique circumstances, and they want the flexibility to adopt appropriate solutions. NCHRP and TCRP are means by which the highway and transit communities have attempted to strike a balance between national cooperation and state and local autonomy in the area of research.

The highway and transit cooperative research programs have much in common. Their basic approach is to rely on the owners and operators to identify common problems and prioritize research projects to address them. Both emphasize research results that have identifiable applications, such as the development of guidelines, product evaluation manuals, and handbooks of best practice. The programs differ in some important ways, most notably in how they are financed. Program similarities and differences are described below. Each program has advantages and disadvantages that deserve consideration in examining options for an airport cooperative research program.

National Cooperative Highway Research Program

Program Inception

One reason highway agencies conduct their own research is to find efficient solutions to pressing problems. However, the results of research in one state can have application elsewhere, since most highway problems are not unique.

As research needs increased following the advent of the Interstate highway program in the 1950s, the state-by-state approach to research became less practical. Through their national association, the American Association of State Highway Officials (AASHO),[1] state highway agencies had long worked together and with other relevant organizations (such as the Bureau of Public Roads, the National Association of County Officials, and the American Society of Civil Engineers) to set uniform guidelines for all aspects of highway design, construction, and operations. However, they lacked a systematic and ongoing means of undertaking research in support of these efforts.

An AASHO survey of state highway agencies during the late 1950s revealed more than 100 specific problems shared by many states concerning topics ranging from highway finance and safety to design and traffic operations (HRB 1960). At the time, federal law required state highway agencies to devote at least 1.5 percent of their annual federal highway aid to research and planning. Consequently, a great deal of highway-related research was undertaken, but with much duplication of effort, a wide range of quality, and limited dissemination of results. Recognizing these shortcomings, AASHO often helped states pool resources to coordinate some of this research, but each instance required the negotiation of new cooperative agreements and structures for overseeing the research.[2] The survey of research needs convinced AASHO and its member states of the value of creating a continuing means of pooling resources for research on a national basis.

NCHRP was established in 1962 as a result of an agreement among AASHO, the Bureau of Public Roads [later to become the Federal Highway Administration (FHWA)], and the National Research Council's Highway Research Board [later to become the Transportation Research Board (TRB)]. The agreement called for participating states to allow the federal government to withhold distribution of 5 percent of each state's 1.5 percent share of federal-aid funds that must be used for research and planning. The funds would be transferred to the National Research Council, which AASHO described as having "recognized objectivity and understanding of research practices," to manage the program (AASHO 1964, 116–119). Individual states could elect to participate or not, and the agreement would have to be re-signed every year on a state-by-state basis.

[1] AASHO changed its name to the American Association of State Highway and Transportation Officials (AASHTO) in 1974 to reflect the reorganization of many state highway agencies into transportation departments.

[2] A history of early AASHO research activities and steps leading to the creation of NCHRP in 1962 can be found in *AASHO: The First 50 Years* (AASHO 1964, 116–119).

Each contributing state was given the opportunity to submit problem statements to AASHO's Standing Committee on Research (SCOR), which was composed entirely of state highway agency representatives. On the basis of these statements and those from other AASHO technical committees and the Bureau of Public Roads, SCOR would select the problems that would be the subject of NCHRP research projects that year. Each project needed to be approved by two-thirds of the states participating in the program.

The National Research Council was charged with administering the program by convening expert panels for each project. The panels drew from specialists in universities, industry, and predominantly the state highway agencies themselves. Project panels were tasked with defining the project scope, soliciting and selecting qualified researchers to perform the work, and reviewing the research in progress and the end results. Research results were to be published in a series of reports made available to the public. The first formal NCHRP report, "Evaluation Methods of Replacement of Deteriorated Concrete in Structures," was published in 1964.

Program Today

NCHRP's purpose and its methods of financing, governance, and management are fundamentally the same today as they were following its creation. The program is still intended to provide products and procedures that are readily applicable to current or emerging problems. A cursory review of publication titles indicates as much: many products are described as "guidelines," "manuals," "handbooks," and "evaluation methods." The typical project is completed within 2 to 3 years and is funded at $300,000 to $400,000, although some are smaller than $100,000 and a few have funding in excess of $600,000.

Aspects of the program that have changed since its inception are the variety of research results and the means by which they are disseminated. Since its first report nearly 40 years ago, NCHRP has published nearly 500 reports in 25 problem areas, ranging from pavement design to transportation planning. In addition, the program has published more than 300 "synthesis" reports that are based on surveys of highway practice; more than 300 research results "digests," including a special series on legal issues; and more than 50 "Web" and CD documents that contain specialized information and software applications. The digests and Web documents are intended to promote early awareness of project results to encourage implementation.

In the early 1990s, NCHRP joined with FHWA in setting aside approximately $1,000,000 per year for projects in its IDEA ("ideas deserving exploratory analysis") program. This program funds exploratory projects based on the ideas of innovators and entrepreneurs; the aim is to spur the application of new and unconventional technologies and processes to current highway problems. This is the only part of NCHRP that is open to unsolicited proposals. Currently, all IDEA funding is provided in the NCHRP budget.

Table 3-1 provides summary information on NCHRP project areas and products, as derived from annual progress reports to the state sponsors and the general public. These progress reports describe ongoing NCHRP work as well as the results of completed projects. The progress reports describe the end products of each project and give examples of their use in the field.

Funding for NCHRP continues to be based on voluntary participation by states. The contribution is now 5.5 percent of the 2 percent share of total federal aid that must be devoted to research or planning activity. Since 1962, individual states have elected to withhold contributions to NCHRP in only a handful of instances, and all have rejoined the program within 1 to 2 years. FHWA has also remained an active participant. Although it does not have a vote in the programming of funds, it appoints liaison representatives to SCOR and other AASHTO committees, and FHWA experts serve on all NCHRP project panels and can submit problems for consideration.

The NCHRP annual budget, which is based on a percentage of federal appropriations for highways, has grown with the increase in federal aid over time. The program's annual funding has risen from about $15 million in the early 1990s to $31.5 million in FY 2002. About 79 percent of the annual program budget is allocated to research contracts, 16 percent to program staffing and related costs, and the remaining 5 percent to panelist travel and report publication and dissemination expenses.

This budget enabled NCHRP to program 43 major research projects (each funded at $200,000 or more) for FY 2003. The projects were drawn from 121 problem statements submitted to the program. The program also used $9 million in funds for 17 smaller research projects and ongoing activities.

Key Program Characteristics

The fact that it has been funded by all 50 states (plus the District of Columbia and Puerto Rico) on a voluntary basis for more than 40 years suggests that NCHRP has achieved success in addressing the research needs of the nation's

Table 3-1 Summary of Research Areas and Products of the National Cooperative Highway Research Program, 1962–2001

Research Field	Problem Areas Covered	Number of Projects[a]	Examples of Final Products
Administration	Economics, law, finance	35	Effect of Highway Landscape Development on Nearby Property; Valuation of Travel Time and Predictability of Congested Conditions for Highway User Cost Estimation; Theory and Practice in Inverse Condemnation; Budgeting for State Highway Departments (research results digest)
Planning	Forecasting, impact analysis	74	Improving Transportation Data for Mobile Source Emissions Estimates; Guidelines for the Development of Wetlands Replacement Areas; Multi-modal Transportation Planning Data; Travel Estimation Procedures for Quick Response to Urban Policy Issues; Criteria for Evaluating Alternative Transportation Plans
Design	Pavements, bridges, general, roadside, vehicle barrier systems	136	Smoothness Specifications for Pavements (Web document); Guidelines for Recycling Pavements; Recommended Specifications for Large-Span Culverts; Bridge Rating Through Non-Destructive Load Testing (research results digest); Guardrail Design; Intersection Sight Distance
Materials and construction	General, bituminous, specifications, procedures, practices	134	Evaluation of Water Sensitivity Tests (also available on CD); Design of Emulsified Asphalt Paving Mixtures; Guidelines for Longitudinal Pavement Profile Measurement; Use of Polymers in Highway Concrete; Long-Term Rehabilitation of Salt-Contaminated Bridge Decks
Soils and geology	Soils testing and implementation, soils properties, soil mechanics and foundations	31	Instrumentation for Measurement of Moisture; Reinforcement of Earth Slopes and Embankments; Expert System for Stream Stability and Scour Evaluation; Evaluation of Metal Tensioned Systems in Geotechnical Applications; Load Factor Design Criteria for Highway Structure Foundations
Maintenance	Snow and ice control, equipment, maintenance of ways and structures	31	Evaluation and Development of Methods for Reducing Corrosion of Reinforcing Steel; Economic Evaluation of the Effects of Ice and Frost on Bridge Decks; Evaluating Deferred Maintenance Strategies; Maintenance Contracting; Maintenance Levels-of-Service Guidelines
Traffic	Traffic operations and control, illumination and visibility, traffic planning, safety	115	Guidelines for Medial and Marginal Access Control of Major Roadways; Optimizing Flow on Existing Street Networks; Determination of Stopping Sight Distance; Highway Fog; Effects of Highway Standards on Safety; Traffic Barrier and Control Treatments for Restricted Work Zones; Methods for Evaluating Highway Safety Improvements

[a] Projects completed or ongoing from 1962 to 2001.

highway agencies. Some of the key characteristics of the program's governance, finance, and management approaches that appear to have accounted for this success are described below.

Governance

- Because the program is directed exclusively by state highway agencies, it remains focused on the practical needs of users and on disseminating the results in accessible formats.
- Each project is selected by a cross section of state highway agencies and is subject to the approval of two-thirds of the participating agencies. This arrangement ensures that the research program addresses problems shared by highway agencies. Parochial problems that are best addressed locally seldom find support, and emerging problems in the field can be identified quickly and investigated.
- Because they help develop the research agenda, state highway agencies are often willing to assist in its conduct (e.g., by providing test beds and participating in surveys), and they are keenly aware of and eager to apply the results.

Financing

- Because they voluntarily finance the program, state sponsors are committed to ensuring that the program produces useful results, that it is responsive to their needs, and that it operates efficiently. By contributing funds to NCHRP after the federal-aid apportionments have taken place, the states have effectively insulated the program from efforts at the federal level to exert control over the research agenda.
- Broad-based financing ensures that research will address a wide range of needs and that no single interest can dominate the agenda.
- Though funds are provided voluntarily by states, the federal-aid research apportionment provides a stable base from which to derive this funding. The financing structure has enabled the program to grow over time to keep pace with the overall federal highway program.

Management of the Program and Individual Projects

- The contract-based approach to research, as opposed to the in-house approach, allows the program to retain a high degree of flexibility and to limit overhead. For instance, the program is not committed to pursuing a

particular area of highway research as a result of past investments in specialized laboratory facilities or development of in-house research expertise. The program can therefore respond quickly to the changing needs and priorities of its sponsors.

- Contract research prompts competition among research institutions for NCHRP projects, which promotes greater efficiencies in the program and the ability to fund more projects each year. Approximately 36 percent of problem statements (43 of 121) submitted by sponsoring highway agencies were selected for major research projects in FY 2003.
- The use of volunteer experts on technical panels to guide and oversee the research enhances the credibility of the program and its results. Because special panels are convened for each project and are disbanded afterward, the panelists remain focused on completing the project and developing a useful product.
- The program is managed by an independent organization devoted exclusively to research, which helps keep the program focused on producing quality results. The independence of the research organization is helpful in attracting volunteer experts to serve on project panels and in providing a neutral venue for the views of all participants. This adds to the acceptance of the research findings.

Transit Cooperative Research Program

Program Inception

Transit systems tend to be discrete entities that serve single communities or larger metropolitan areas. Unlike highways, they are seldom linked to one another to form broader regional or national transportation systems. Partly as a result of this orientation, the federal government viewed transit systems, and thus transit-related research, as local and state prerogatives. Not until the late 1960s did the Federal Transit Administration (FTA, then known as the Urban Mass Transportation Administration) start conducting significant amounts of research, coincident with its new role in providing transit planning and capital assistance. Research helped the agency develop the technical knowledge necessary to guide its growing financial contribution to transit infrastructure and equipment. Moreover, federal policy makers began to recognize that efficient and well-used transit systems could help the nation

achieve other goals, such as improving air quality, reducing highway congestion and energy use, and providing low-income workers with transportation to jobs.

At the time, FTA was spending a large percentage of its research budget on the development and demonstration of advanced technologies, including such futuristic concepts as moving sidewalks, automated guideways, and personalized rapid transit. Meanwhile, transit systems across the country were experiencing a growing need for research as their aging fleets and infrastructure—upgraded with the help of federal funds during the 1960s and 1970s—became more costly to operate and maintain. Rather than seeking revolutionary changes, transit agencies were interested in finding ways to improve, even if only incrementally, existing technologies and practice.

A 1987 TRB study committee consisting of transit operators and other research and industry experts noted the absence of problem-solving research in the transit industry. The committee concluded that new mechanisms were needed for such work to be undertaken in a continuing and concerted fashion (TRB 1987). It recommended that an operator-guided research program with many of the same characteristics as NCHRP be created and that transit operators take the lead in setting the program's research agenda through majority representation on the program's governing board. The committee called for a cooperative research program that would be financed from a mandatory ½ percent set-aside of federal transit funding; would emphasize applied, problem-solving research; and would fill the gaps in FTA's technology-oriented R&D program.

With the collective support of the transit industry reached through the American Public Transportation Association (APTA), Congress authorized funding for a national Transit Cooperative Research Program in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA; Public Law 102-240). The act called for the program to be governed by an independent board and managed by TRB.

In following through on the provisions of the act, FTA charged APTA with appointing TCRP's independent governing board under the auspices of the association's nonprofit Transit Development Corporation. Named the Transit Oversight and Project Selection (TOPS) Committee, the 24-member board consisted of 16 members appointed from public transit agencies and 8 appointed from transit suppliers, consultants, and universities. The committee was given responsibility to solicit research needs, formulate the annual

research portfolio, and monitor project and program progress. TRB was tasked with managing the program in a manner similar to its management of NCHRP—by convening independent technical panels to select and oversee the work of outside contract researchers.

In authorizing TCRP, Congress originally specified funding for the program equivalent to 0.3 percent of total federal transit funding during the 6-year authorization period. Had this funding scheme been implemented, it would have provided the program with nearly $90 million in total, ranging from $8.9 million the first year (FY 1992) to $21 million in the last year of ISTEA authority (FY 1997). Congress appropriated $8.9 million for the program's first year. However, in subsequent years, it disregarded the original percentage formula and continued to appropriate about $8 million per year to the program. Appropriations over the 6 years were equivalent to about 55 percent of the original amount authorized.

TOPS organized the program into nine research fields ranging from transit operations to human resources and administration. It then held a series of workshops to identify and screen candidate research problems. TOPS allowed submissions of problem statements from all interested parties, including FTA, universities, and transit suppliers and consultants. This was a departure from the practice of NCHRP, which solicits problem statements only from state highway agencies, AASHTO committees, and FHWA. During its first 6-year authorizing period, TOPS received more than 800 project problem statements, and it was able to fund about 12 percent.

In the same manner as NCHRP, TCRP projects were designed to produce full reports, abbreviated digests of research results, and survey-based syntheses of practice. The first TCRP report, "Artificial Intelligence for Transit Railcar Diagnostics," was published in 1994, and 138 reports of various kinds were produced during the program's first 6-year authorization.

Program Today

In 1998, Congress reauthorized TCRP for fiscal years 1998 to 2003.[3] In doing so, it formally abandoned the idea of a percentage-based funding formula and, instead, set annual funding at "not less than $8,250,000." Hence, in real terms the program continued to experience a decline in funding, which has fallen by more than 30 percent after adjustment for inflation since 1992.

[3] Section 5338(d) of the Transportation Equity Act for the 21st Century, Public Law 105-178.

Moreover, the federal funding for TCRP was appropriated as a line item in the overall FTA research program. Therefore, FTA has responsibility for distributing the funds to TCRP through an annual grant agreement. As a line item, the TCRP funds have been susceptible to diversion through congressional earmarking. Because distribution of the funds is controlled by FTA, the agency could influence the program and its agenda. Much of FTA's own research budget is earmarked by Congress, and thus TCRP offers a means for the agency to shift some research toward its own pressing needs. Viewing TCRP as a federal research program, FTA sought successfully for its administrator to become a voting member of TOPS in 1998.

Despite growing federal involvement in the program, TCRP remains an industry-driven and -guided enterprise. Without the active support and involvement of the transit industry, the program would not exist. Since 1992, TCRP has received approximately 1,600 problem statements, and about 32 percent of these statements have originated from public transit agencies. The second- and third-largest sources of project ideas are transit consultants (16 percent) and universities (13 percent). FTA has contributed about 10 percent. Problem statements are also routinely submitted by TRB standing committees, APTA committees, and state transportation agencies. For the most part, TCRP's open process for soliciting problem statements has proved successful in generating a diverse selection of project ideas.

Since its beginning 10 years ago, TCRP has funded more than 300 research projects. Table 3-2 summarizes the research output, which included, as of November 2002, 90 published reports, 70 digests, and 45 syntheses of practice. Like NCHRP, TCRP emphasizes applied research, and its report titles often contain the words "handbook," "user manual," and "guidelines." It has also diversified its products and its means of dissemination to include Web documents, software, and CDs. Like NCHRP, it sponsors an IDEA program to encourage innovative thinking on transit problems.

TCRP's $8.25 million budget permitted funding of 10 new major projects (each in excess of $200,000) in FY 2003. This represents about 12 percent of the 81 problem statements submitted, compared with funding of about 36 percent of problem statements submitted to NCHRP. Concerned about the relatively small share of problems capable of being funded by the program, the APTA Board of Directors is urging Congress to increase funding for TCRP in the next 6-year reauthorization of the federal government's surface transportation program to $27.93 million in FY 2009 (*TEA-21 Reauthorization*

Table 3-2 Summary of Research Areas and Products of the Transit Cooperative Research Program, 1992–2001

Research Field	Problem Areas Covered	Number of Published Project Reports, Digests, and Syntheses[a]	Example Products
Operations	Scheduling, vehicle operations, control systems, fare collection, safety and security	50	Transit Scheduling—Basic and Advanced Manuals; Safe Operating Procedures for Alternative Fuel Buses; Integration of Light Rail Transit into City Streets; Emergency Preparedness for Transit Terrorism (synthesis of practice)
Service configuration	System planning, specialized services, service performance, marketing	36	A Handbook of Proven Marketing Strategies for Public Transit; Transit Advertising Revenues—New Sources and Structures (synthesis of practice); Workbook for Estimating Demand for Rural Passenger Transportation; ADA Paratransit Eligibility Certification Practices (synthesis of practice); Improving Public Transportation Access to Large Airports
Vehicle engineering	Buses, vans, rail cars, people-mover vehicles, vehicle components	24	Understanding and Applying Advanced On-Board Bus Electronics; Low-Floor Transit Buses (synthesis of practice); Hybrid-Electric Transit Buses—Status, Issues, and Benefits; Wheel and Rail Vibration Absorber Testing and Demonstration
Engineering of fixed facilities	Buildings, rail operating facilities, passenger stations, bus stops	11	Track Design Handbook for Light Rail Transit; Visual Impact of Overhead Contact Systems for Electric Transit Buses; Performance of Direct-Fixation Track Structure Design Guidelines and Software (available on CD)

Maintenance	Vehicle servicing, vehicle inspections, repairs, rebuilding, maintenance of facilities, maintenance management	7	Application of Artificial Intelligence to Rail Car Maintenance; Closing the Knowledge Gap for Transit Maintenance Employees; Demonstration of Artificial Intelligence for Transit Railcar Diagnostics
Human resources	Recruitment, training, job classification, salary administration, labor relations	20	Identification of the Critical Workforce Development Issues in the Transit Industry (research results digest); A Challenged Employment System: Hiring, Training, Performance Evaluation, and Retention of Bus Operators (synthesis of practice); Part-Time Transit Operators: The Trends and Impacts; Drug and Alcohol Testing—A Survey of Labor-Management Relations (research results digest)
Administration	Finances, procurement, risk management, law, management information	16	Alternative-Fuel Transit Bus Hazard Assessment Model (software on CD); The Role of Performance-Based Measures in Allocating Funding for Transit Operations (synthesis of practice); Measuring Customer Satisfaction and Service Quality—A Handbook for the Transit Industry
Policy and planning	Policy analysis, planning, economics, environmental analysis	39	Transit Capacity and Quality of Service Manual (Web document and on CD); Integrating School Bus and Public Transportation Services in Non-Urban Communities; Management Toolkit for Rural and Small Urban Transportation Systems; Improving Public Transportation to Large Airports

[a] Through 2001.

Recommendations: An Investment in America, September 22, 2002). At that level, program funding would represent about 0.25 percent of projected federal transit expenditures, compared with about 0.12 percent of such expenditures today.

Key Program Characteristics

As the program has matured, certain characteristics of TCRP have proved crucial in meeting the research needs of the transit industry—while some others have presented challenges.

Governance

- The program is governed by a diverse oversight and project selection board consisting of transit operators, suppliers, consultants, university professors, transit labor representatives, and the FTA administrator. Transit operators are a majority of the board's members. The 14 general managers who serve on the board come from large and small, urban and rural, and rail and bus transit systems. The board's diversity has enabled the program to attract wide-ranging participation from the transit industry, and it has enhanced the quality and quantity of problem statements. The transit agency majority ensures that the problems selected for research are responsive to the needs of practitioners.
- The diverse governing board, and its reach into the transit community, has heightened the visibility and credibility of the program within the industry, which increases the prospects of the application of research results in the field. The board's diversity has become a distinct asset.

Financing

- Because it is financed through annual congressional appropriations, TCRP has been susceptible to earmarking and diversion of funds for other FTA purposes. The program's budget has also been constrained, which has limited the share of problem statements funded as major research projects. However, the single federal source of funding relieves the program of the administrative burden of eliciting contribution agreements each year from the hundreds, or even thousands, of individual transit agencies across the country.
- The federal appropriation for the program may diminish the "sense of ownership" of the program among transit operators. Nevertheless, as a

practical matter, federal funding may have broadened the transit community's participation in and commitment to the program. Federal funding ensures greater participation of the diverse industry. A program funded through transit agencies would likely exclude the many smaller systems with limited ability to contribute funds. No single sector of the industry can dominate the program's research agenda by exerting financial control.

Program and Project Management

The way the program and projects are managed is basically the same for TCRP as for NCHRP: research is contracted out through a competitive process, technical experts are convened to choose the contractor and guide the work, and the program is managed by an independent research organization with expertise and experience in disseminating results to practitioners. The emphasis is on producing credible research results in an efficient manner and with maximum accessibility by users.

SUMMARY OF KEY FEATURES OF NCHRP AND TCRP

NCHRP and TCRP are structured to find research solutions to the shared problems of highway and transit operators, respectively. Each attempts to do so in the same basic way (see Box 3-1). In the case of NCHRP, state highway agencies cooperate by identifying research needs and voluntarily pooling funds to address them. In the case of TCRP, the federal government provides the funding for the research program, while transit operators and other stakeholders in the transit industry cooperate in identifying research needs and participating in research projects.

The two programs are guided by practitioners, who identify shared research needs, ensure that the research agenda is focused on meeting these needs and producing useful results, and assist with the conduct of the research and dissemination of results. Both are financed by setting aside funds for research that might otherwise have been distributed to operators for other purposes. Such a funding philosophy provides operators with a sense of ownership of the research program and commits them to the production of practical results. The programs are also designed to produce research results that are credible, of high quality, and responsive to the needs of users, primarily through the use of expert panels that guide the work of contract researchers selected on a competitive basis for each research project. Approximately three-quarters of each program's budget is spent on the conduct of research

Box 3-1

Key Features of Highway and Transit Cooperative Research Programs

Features That Enable the Program to Do the "Right" Things

1. Program mission clearly defined; problem-oriented, applied research
2. Emphasis on stakeholder involvement
   - Participating actively in steering the program, having a sense of ownership (has intangible benefits, brings together stakeholders and overseers)
   - Soliciting, identifying, and prioritizing research needs; managing the portfolio generally
   - Selecting and defining the scope of specific projects and programming the funds annually across research fields (e.g., human resources, operations, maintenance)
   - Evaluating overall program effectiveness; developing strategic plan

Features That Enable the Program to Do the "Right" Things Well

3. Credibility: quality control through research competition and guidance by panels of experts and practitioners
   - Competition to obtain best proposals from researchers
   - Merit review of proposals (involving stakeholders or their technical representatives)
   - Avoidance of duplication of work
   - Guidance for the development, execution, and peer review of work
4. Useful results: emphasis on implementation of results in the field
   - Active participation of stakeholders (users) in the process, which creates a ready market and built-in promoters
   - Dissemination of results
   - Hand-off to appropriate organizations for testing, endorsement, specifications, and standard setting

by the contractors, while the remainder covers the expenses associated with expert panel meetings, program administration and secretariat support, and report publication and dissemination.

The two programs differ in other important respects, mainly related to the specifics of their funding. Differences in funding mechanisms have had important effects on the growth, stability, and autonomy of the programs. NCHRP is financed by the 50 state highway agencies (plus the District of Columbia and Puerto Rico), who voluntarily contribute a percentage of their federal-aid funds each year. This contribution takes place after the federal funds are appropriated, which gives the state sponsors exclusive control over NCHRP programming.[4] The percentage-based funding formula has allowed NCHRP to grow over time at a rate commensurate with the growth in the overall federal-aid highway program. TCRP, by comparison, serves a much more dispersed transit industry, consisting of thousands of operators, hundreds of which receive federal funds in any given year. While NCHRP funding has risen to enable the program to fund research to address more than one-third of problem statements submitted by sponsoring highway agencies each year, TCRP's budget, which is determined at the federal level, has remained static and capable of funding only about 10 percent of problem statements submitted by the transit industry each year. Collecting voluntary contributions from these operators would be far more complicated and costly than collecting contributions from state highway agencies. The alternative of relying on Congress to set aside federal-aid funds each year has subjected the program to greater volatility in funding and to greater influence by FTA in determining how the funds are to be used.

The programs demonstrate that careful consideration must be given at the outset to how a cooperative research program is structured. A single model will not serve the research needs of all transportation modes, even though they may share certain structural and functional elements. Initial decisions about how the program is to be governed, funded, and managed are crucial. TCRP and its funding experience should be carefully considered as a possible model for structuring an airport cooperative research program. Airports are similar to transit agencies in two important respects: there are many of them and they vary greatly in size and resources. The voluntary contribution

[4] Of course, FHWA has a stewardship role in ensuring that the federal funds are used for legitimate research purposes.

of program funds by operators—and the program control that such funding provides—is likely to be as difficult for airport operators to achieve as it has been for transit operators.

REFERENCES

Abbreviations

AASHO	American Association of State Highway Officials
HRB	Highway Research Board
TRB	Transportation Research Board

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4

Options and Proposal for an Airport Cooperative Research Program

Important features of governance, funding, and management that have led to successful cooperative research programs in the highway and public transportation modes were described in Chapter 3. These features are summarized in this chapter, and other cooperative research programs are considered as possible models for an airport program. The review suggests that no single program structure can achieve all of the desired features of a cooperative program. However, certain program features, such as processes that result in credible and applicable research results, are crucial. A number of options for governing, financing, and managing an airport cooperative research program (ACRP) are examined below with such considerations in mind. The chapter concludes with a specific proposal for governing, funding, and managing an ACRP.

GOVERNANCE

All research programs need to be guided by a well-articulated mission—whether it is to find solutions to pressing problems or to gain the knowledge needed for longer-term technological advances. Keeping a program focused on its mission is typically the responsibility of a governing board. Much like the board of directors of a corporation, the governing board's role is to establish the policies and strategic direction of the program so that it can best achieve its mission. The board typically has the following responsibilities:

- Establish the program's strategic direction and monitor the direction the research is taking (for instance, whether the research is leading to progress in solving a particular set of problems).
- Ensure overall quality and relevance of the research.
- Articulate expected research products and assist with dissemination of research results.

- Coordinate with other research and development programs that have complementary functions (for instance, research programs engaged in medium- and longer-term research).

Setting up a governing board for an ACRP will require that many important decisions be made about who shall appoint the board members, the size and composition of the membership, and board voting and decision-making procedures. To ensure that the program focuses on the needs of operators, a majority of the board's voting members may have to be drawn from the airport operator community. Decisions as to the mix of participating airport operators would have to consider such factors as geographic location, airport size, and type of operations [general aviation (GA), commercial service, cargo]. Because of their large numbers, small airports may need to be represented in part by a broader entity such as a state aviation department. Ultimately, the size, composition, and voting rights of members of the board will be affected by the financial participation of the industry segments represented.

Whatever form the board takes, the link between operators and the research should remain strong, and the program must remain focused on addressing the research needs of operators. Thus, involvement of the operators in identifying research needs, prioritizing projects, assisting in the conduct of research, and applying the results in the field will be the governing board's overarching responsibility. The governing board will have various other tasks, such as screening individual project ideas and monitoring the financial performance of the program, but the central responsibility to keep the program focused on airport needs deserves the most attention in examining alternative governance models.

Models of Governance

Existing cooperative research programs offer various models of governing boards, each structured differently but with many of the same essential functions. The National Cooperative Highway Research Program (NCHRP) provides a model of a governing board made up exclusively of operators. Its 18-member board is composed entirely of highway and transportation agencies. Like members of the American Association of State Highway and Transportation Officials itself, members of the Standing Committee on Research are all from state highway and transportation agencies; hence, highway operators retain exclusive control over the direction of NCHRP and its research agenda.

The NCHRP mode of governance ensures that operators have a strong sense of ownership of the research results, which is an important advantage. Operators are responsible for identifying research needs and for directing research funds to priority problem areas. As users of the research results, they are in a position to aid with dissemination and provide feedback on the quality of the research. A disadvantage of this governance scheme is that the views and expertise of other parties interested in research may be neglected. Suppliers, manufacturers, system users, academic researchers, and government agencies can have important roles in helping to conduct research and in applying the results. Hence, their limited involvement in program governance can come at some cost.

The governing board of the Transit Cooperative Research Program (TCRP) is composed mostly of operators but is supplemented by other interests, including federal agencies, transit suppliers, and university researchers. The 28-member Transit Oversight and Project Selection panel is appointed by a nonprofit entity created by the American Public Transportation Association, whose membership includes transit operators, suppliers, consultants, and other public agencies. This model of governance, in which operators make up a slight majority but not the entirety of the board, provides an opportunity for a wide spectrum of the industry to participate in the program. Whereas transit operators can exercise their majority control of the program, coalitions of transit operators and other interests can also emerge to help guide TCRP.

On the one hand, this open approach to governance can enlarge the scope of ideas for research and enhance support for the program within the industry. Governing board members can elevate the program's prominence within the industry by serving as "missionaries" or "ambassadors." On the other hand, operator influence on the program could become diluted, which is a drawback. The program's research priorities could drift away from solutions to the practical problems of operators and toward the needs of others.

Other models for a governing board are available. One is that of the Health Effects Institute (HEI), which is a nonprofit research institution sponsored cooperatively by the U.S. Environmental Protection Agency and more than two dozen automobile manufacturers and suppliers. HEI is chartered to conduct impartial, science-based research on the health effects of motor vehicle emissions. It is guided by a governing board of six to eight members made up exclusively of distinguished individuals, believed to be independent and

beyond reproach, who serve in a stewardship capacity for the program. A distinctive feature of this board is that its members are not direct users of the research. The board's main role is to ensure the integrity of the research program, because the results are intended to influence public policy.

HEI's "third-party" form of governance shields the program from concerns that research results are biased or advocacy-oriented. Neutrality is an especially important quality for research aimed at influencing policy, especially in contentious matters such as environmental and health policies that can have significant economic implications. A credible and science-based research process is important to all research programs. However, third-party governance runs the risk of the program becoming so remote from practitioners that it fails to recognize their pressing needs. Moreover, a research program that is aimed at solving day-to-day problems—such as finding a better runway deicer—is probably not generally vulnerable to concerns about an underlying political or social agenda. Thus, it may not demand the kind of independence and insulation that a third-party form of governance provides.

An example of a cooperative research program with a strong emphasis on applied research is the Construction Industry Institute (CII). This program is sponsored by construction-related contractors, architectural firms, suppliers, and public agencies. Its mission is to conduct research that can be translated directly into improved construction practices in the field. Its governing board consists entirely of sponsoring members. Dues-paying members are entitled to serve on the board, regardless of the member's status as a construction contractor, supplier, or participant from another industry segment.

CII's approach to governance ensures that the research program addresses the needs of those who are both the funders and the ultimate users of the research. Those who pay for the program are directly responsible for selecting the research agenda. If the research does not provide useful results, the sponsors can withdraw funding. A shortcoming of this approach is that the research agenda may ultimately be driven by the interests of those most able to pay for the research. This could lead to a research portfolio emphasizing certain problem areas to the exclusion of others that may be equally important from a public policy perspective. Such an approach may work well for private enterprise. However, airports are operated by public agencies, and many airport operators may be less able than other industry segments to afford membership status on the governing board. Thus, their views may be overlooked or marginalized.

The Electric Power Research Institute (EPRI) offers another hybrid model of a governing board. EPRI is a nonprofit organization that performs research for the electric power industry. It is sponsored by electric utilities and their suppliers and users. It is directed by two governing boards working in tandem. One is composed of program sponsors and the other of external advisors from public utility commissions, environmental groups, universities, and government agencies. The board consisting of program sponsors proposes the research agenda, and the second board reviews the proposals. This form of governance combines the practical direction of a board made up of sponsors and users of the research (much like the CII board) with the stewardship role of a third-party entity (much like the HEI board). This example demonstrates the variety of potential models of governance.

Hybrid forms of governance, as exemplified by EPRI, can combine desirable attributes, such as ensuring that the program is both acting in the public interest and meeting the practical needs of operators and other users of the research. However, multiple governing boards may become unwieldy, slow to make decisions, and costly to organize and administer.

Summary Assessment of Governance Options

The two modes of governance that appear best suited as models for an airport-oriented research program are those of NCHRP and TCRP. Under both approaches, operators make up a majority of the governing board and are therefore assured significant roles in guiding and prioritizing the research. This outcome is crucial to ensuring that the programs address the practical problems of operators, and it will be equally important to an airport-oriented program. Moreover, because both programs are financed with public funds, their governance is designed to ensure that unbiased results are produced. If an ACRP is financed in a similar manner—that is, with significant support from public funds—a commitment to involving a broad spectrum of operators and users in the program's governance will be essential.

The NCHRP model—in which operators are solely responsible for program governance—may be uniquely applicable to the highway mode, because 50 state agencies operate much of the system. This is a manageable number of operators to organize. By comparison, there are hundreds of commercial airports and thousands of GA airports, which vary significantly in size and services. This situation resembles that of the transit industry. A more open form of governance, as exemplified by TCRP, may therefore be more fitting.

FINANCE

The means by which the program is funded is critical in ensuring that the program stays focused on the needs of operators, the results of the research are viewed as objective, and the program operates efficiently. Whatever financing scheme is selected, it will be important that the funding have the following attributes:

- It should be reliable, and its magnitude should be generally predictable from year to year. This will allow longer-range planning of research and will help develop a constituency of users who can depend on the research results.
- It should be sufficient to maintain the continuity of the program, which is necessary in attracting staff to manage the program and in disseminating results.
- It should be sufficient to support multiyear research efforts covering a range of problem areas of interest to many users. Otherwise, funds may be stretched over a large number projects with limited potential for progress, or they may be focused on projects appealing to a narrow subset of users.
- Operators of all sizes and types of airports should have a sense of ownership of the program and a stake in seeing it work, and the sources of funding should reflect this.
- The funding should be tied to the continuing efficient and effective management of the program.
- The funding of research should not be contingent on the research supporting a desired outcome or advocating a particular position.

A strong funding scheme would incorporate these features to the extent possible. What is most important is that the base funding be sufficient in size and reliability, remain insulated from outside influences, and prompt broad constituent participation, especially by airport operators.

Of course, the program may permit special or supplemental funding for particular projects of interest to individual government agencies, airport operators, and users. Indeed, the program may be well suited to performing such activities, since it will have a respected research structure in place. However, should the program become dependent on such specialized activities to support itself, it may gradually shift its emphasis away from problem

areas that are important to many airport operators. The program could also become administratively costly and subject to large fluctuations in activity and resources. A stable funding base is therefore desirable.

Finance Options

Both NCHRP and TCRP are financed with federal funds. The key difference between the two programs is that states voluntarily redirect to NCHRP a share of funds that have already been appropriated. In the case of TCRP, Congress appropriates funds directly to the program through the Federal Transit Administration.

Thus, an NCHRP-like option for funding an airport research program would entail airports and state aviation departments voluntarily setting aside a percentage of their federal aid to be pooled for common research needs. By doing so, airport operators would retain direct control over the program. If operators do share many important research problems, they might be expected to willingly pool some of their federal aid for cooperative research.

NCHRP has demonstrated for more than 40 years that such voluntary funding compels program responsiveness to the needs of users and a strong connection between the research and specific applications. However, this voluntary approach has some notable shortcomings for an ACRP. Any effort to obtain funds from the thousands of airports receiving federal aid will require costly collection procedures and produce a high level of uncertainty about program size and sustainability from year to year. In addition, Congress may need to enact legislation permitting airports to pool a percentage of their federal-aid funds for cooperative research.

Another finance option, similar to that of TCRP, is for Congress to authorize and appropriate funds directly for the program. The funds may be derived from a single source, such as the Aviation Trust Fund, or from multiple sources, such as the trust fund and a share of other federal funds devoted to specific airport activities, such as security. Such a funding scheme could better ensure that the program covers a wide range of research needs shared by many airport types and would avoid the costly process of collecting voluntary contributions from thousands of airports. Since the federal government has much at stake in ensuring that airports operate and maintain their facilities efficiently, federal support could be readily justified. An important drawback of this option—as experienced by TCRP—is that congressional appropriations are often accompanied by earmarking of funds and increasing

federal control over the research agenda. An ACRP financed in this manner could face a loss of programming autonomy and the uncertainties associated with the federal appropriations process.

Some airports differ from highway and transit properties in that a large share of their operating revenues is derived from sources other than government aid. This is especially true of the nation's largest airports, which earn significant revenues from landing fees, airline tenants, car rental agencies, and parking concessions. Hence, one option is that airports contribute a portion of their nongovernmental revenues to help fund a cooperative research program. Congress would likely need to enact legislation allowing the use of some, or all, of these revenues in this manner, since federal grant assurances now limit how airports may spend the revenues they generate. Another drawback of this approach is that only the nation's busiest airports would be candidates to fund the program. The large number of smaller airports that do not generate significant commercial revenues would not have ample funds to contribute. Funding of the program by the busiest airports would imply governance by these same airports, and interest in the research needs of thousands of smaller commercial and GA airports might be limited.

Summary Assessment of Finance Options

The most desirable means of financing an operator-oriented research program is for a large number of airport operators to voluntarily contribute funds in support of the program. By doing so, the operators can maintain control of the program's scope of activity to ensure that their research needs are met. As a practical matter, however, such financing presents many problems. Too few airports are likely to have the resources to commit funds to such a program on a sustained basis, and the process of collecting voluntary payments from hundreds, or even thousands, of airport sponsors is likely to prove unwieldy and costly. An alternative that does not require mass voluntary contributions from airports but that maintains a connection between airport operators and users as program sponsors is likely to be required.

Federal funding for an airport-oriented research program is an option with great practical advantage, but it raises the prospect of annual appropriations being diverted or not keeping pace with research needs. A funding scheme based on a percentage of federal-aid distributions from the Aviation Trust Fund, which is itself financed through user fees, may provide a stronger connection between the research agenda and the needs of airport operators.

PROGRAM MANAGEMENT

In addition to receiving guidance from a strong governing board and active participation from airport operators, the program must be well organized. The management organization will provide the day-to-day program administration and contact with the researcher community, sponsors, and users of the research. It will be responsible for processing contracts and research agreements, supporting and arranging meetings of the governing board and technical panels, administering program funds, involving users in the program, and disseminating the results of research.

The choice of an organization to manage the program involves a number of considerations. The host organization must demonstrate a capacity to manage a sizable research program and inspire confidence in the objectivity and soundness of the research. Its potential to meet these requirements can be gauged by considering the following questions:

- Can the organization coordinate the involvement of many stakeholders while being perceived as fair and not having an inherent bias toward one group or industry segment?
- Is the conduct of research an important mission of the organization and likely to be accorded priority, or is it a side activity that could be viewed as a distraction from the organization's main mission?
- Can the organization bring to bear administrative and technical expertise from a range of disciplines that will be needed to define, oversee, and ensure quality control for research projects covering many problem areas?
- Does the organization have the capability to disseminate research results through a wide variety of means that will be accessible to users?

Numerous other issues will need to be addressed. For instance, the organization must be able to accept and administer federal funds. If a new organization is established, consideration must be given to the start-up expenses and time associated with creating it and to the challenges involved in building a trusted "brand name" within the research and user communities. Another consideration is whether the program is best managed by a single entity or under a more decentralized format, such as a consortium of research institutions.

With these considerations in mind, what kinds of research organizations and processes are best suited to an airport research program? In requesting

this study, Congress specifically cited TCRP and NCHRP as models for managing an airport program. Both programs are managed by the Transportation Research Board (TRB) of the National Academies, an independent, nonprofit research organization. TRB is widely recognized as impartial by the research community, the transportation industry, and government. Because TRB's core mission is to facilitate the conduct of research and the dissemination of research results, it has an experienced staff of research managers and an extensive publication and research dissemination capacity. It has developed a wide constituency in the researcher and practitioner communities. It can draw on this constituency for technical experts and practitioners to serve on project oversight panels, perform research, and disseminate the results. All of these attributes represent advantages. However, this model is not an inexpensive approach to research. Convening technical panels to oversee projects, soliciting and reviewing proposals from contractors, and maintaining a professional staff of research managers all require a financial commitment.

Other management options warrant consideration. One general option is to create an independent organization to manage the research program. Its structure and management processes could be tailored to fit the specific needs of the airport research program, which would be an important advantage. By their very nature, new organizations are unencumbered by past associations and have the opportunity to build confidence and trust. Of course, these opportunities present challenges. The creation of a new organization can entail significant start-up costs and time. Achieving widespread recognition of the program, establishing stakeholder ties, and building confidence in the research would take even more time. For these reasons alone, the creation of a new organization to manage an airport research program—itself new—appears risky.

An apparently more practical option is for the program to be managed by an existing professional society or industry association with established ties to airport operators. The American Association of Airport Executives (AAAE), the Airports Council International (ACI), and the National Association of State Airport Officials (NASAO) all have strong ties to airport operators. They can use these connections to ensure participation by operators in the research program and to disseminate research results to them through many existing avenues, such as association conferences, training programs, and publications. The widespread recognition and participation that such organizations enjoy within the industry are important qualities. However, they lack a core

research mission and the management structure that would support a significant research program. Each would need to make a substantial investment in research management staff and quality control methods. In addition, professional and industry associations have particular missions and constituencies, and they may not be able to engender the confidence or attract the participation of individuals and organizations outside these traditional constituencies. The latter deficiency would present a major challenge and may by itself make this option undesirable.

The nation's universities present another option. The research program could be administered by a single university research institute or by a consortium of institutes with some centralized management. An advantage of this option is that research is a core mission for universities, and the research results are generally viewed as objective. However, close ties to the user community, which are essential for an applied research program, are missing from a university setting. Another possible drawback is that university researchers are themselves likely candidates to perform much of the contract research. Conducting research, rather than managing and disseminating it, tends to be the strength of universities; the mixing of these roles may prove problematic and counterproductive.

Finally, it is conceivable that the existing federal airport research enterprise could host a program created to meet research needs identified by airport operators. The Federal Aviation Administration's (FAA's) airport research activities at the Hughes Technical Center are programmed with some input from airport operators, and this input might be formalized and strengthened for at least part of the research program. However, FAA's role in hosting an ACRP would almost certainly detract from the sense of ownership of the program by airport operators and industry. The program might become subject to FAA's budgetary pressures and to the restrictions associated with federal procurement, contracting, and hiring. These drawbacks make the federal option unappealing.

PROPOSAL FOR AN ACRP

Congress requested this study of the desirability of a national cooperative research program for airports. In so doing, it asked for an assessment of the applicability of the financing and administrative approaches used by NCHRP and TCRP. An outline of an ACRP that draws on the key features of these two

programs is given below. The features are modified where necessary to accommodate the differing circumstances of the airport and aviation sectors. It is assumed that the resulting program will be managed in a manner consistent with NCHRP and TCRP.

Program Funding

An allocation by Congress of 0.2 percent of annual Airport and Airway Trust Fund revenues (approximately $10 billion per year) would generate approximately $20 million at current revenue levels for core funding of an ACRP. This percentage is comparable with what the federal government provides for research by highway and transit operators. For instance, state highway agencies are required to spend at least 0.5 percent of the $30 billion they receive in federal aid each year on research, whereas TCRP accounts for about 0.12 percent of annual federal expenditures on public transportation. In fact, the nation's public transit operators are urging Congress to double this percentage so that a higher share of their research needs can be met.

A contribution equivalent to 1.5 cents from the $2.50 airline passenger surcharge for airline security (which is expected to generate about $1.7 billion annually) would provide an additional $10 million to the research program. The result would be an annual research budget of about $30 million.

At the moment, future sources and levels of revenue for aviation and transportation security remain unknown. They will be determined in part by funding for the Department of Homeland Security. However, the country will certainly spend billions of dollars over the next several years on airport security equipment, infrastructure, and operations, and these investments will have to be well integrated into the airport environment. As noted in Chapter 1, airport operators used more than 17 percent of Airport Improvement Program funds for security-related project in FY 2002. Research that involves airport operators and that is coordinated with other airport research activities will thus warrant a significant role in the program and funding on the part of the Transportation Security Administration (TSA) and the Department of Homeland Security.

Of course, additional program funds could be sought from other sources (for example, revenues generated by the airports that are not subject to spending restrictions) to help finance individual research projects approved by the program's board of governors.

Program Governance

Before a means of program governance is suggested, it is emphasized that any specific proposal will involve judgments about the appropriate number of representatives, their balance, and the range of interests and expertise represented. With such considerations in mind, a governance structure is proposed in the form of a governing board similar to those of NCHRP and TCRP. The proposal is offered as a starting point for initiating an ACRP, and many of the organizations identified in the proposal must have instrumental roles in the program's formation.

The following concerns underlie the proposed governing board:

- The program must respond to the needs of airport operators, since they face problems and must field the solutions.
- It must involve major regulators and funders of airport infrastructure and airport-related research, since they must work with operators and with one another to define research needs, set research priorities, and ensure that the result are useful.
- It must recognize the perspective and needs of airport users, who will ultimately be the beneficiaries of the research.

Another important concern is that the board be large enough to engage varied perspectives and expertise but not be so large and unwieldy as to preclude effective decision making.

The board proposed below represents a balance of these concerns. In the committee's view, airport operators must make up a majority of the members, and they must represent a cross section of airports. GA airports are a majority of the nation's public-use airports; however, commercial-service airports—particularly large and medium hubs—account for nearly all passenger travel and air cargo movements. Operators of large, medium, and small airports have many similar and many different interests and perspectives—indeed, the nation's large airports are often part of regional airport systems that include GA airports. No single set of interests or perspectives should dominate.

The proposal calls for participation by representatives of four specific federal agencies, because they have crucial roles in airport funding, regulation, and research. With regard to airport users, most of the public travels on airlines, and this travel generates most of the revenues that support the nation's

airport and aviation system. The proposal calls for airlines to participate on the board. With the need for a board that is of manageable size in mind, the committee also suggests avenues for the participation of other airport users and individuals knowledgeable about airport infrastructure, operations, and research.

As a first step, a nonprofit research institute will need to be designated to appoint and host an Airport Research Governing Board responsible for setting the policies and providing guidance for ACRP research. This institute could be established jointly by ACI, AAAE, and NASAO.

A majority of the board should be drawn from airport operators. A 23-member board, whose members would be appointed by the host organization, is proposed. The members would be chosen by the following process:

- ACI would name ten members, including six officials from large hub airports, two from medium-size hub airports, and two from small hub airports.
- NASAO would name four members, two from nonhub or GA airports and two from state aviation departments.
- AAAE would name two members from nonhub or GA airports.
- The Air Transport Association would name one member.
- The administrators of FAA, the National Aeronautics and Space Administration (NASA), and the U.S. Environmental Protection Agency would each name one member.
- The Undersecretary of Transportation Security would name one member.
- The organization hosting the board or managing the program would nominate two members who are interested in and knowledgeable about airport infrastructure, operations, safety, security, and environmental impacts. These nominations should be rotated periodically among air travelers, GA operators, air cargo carriers and shippers, airport consultants and suppliers, and researchers.

The board would convene one to three times per year and would have the following responsibilities and functions:

- Solicit problem statements and serve as a focal point for research needs identified by airport operators, users, and regulators.

- Set the annual research agenda by identifying the highest-priority research themes, screening candidate projects, defining project funding levels, and articulating expected products of research.
- Guide and monitor the overall quality and strategic direction of the program over the course of several years.
- Determine the technical objectives of all research projects.
- Coordinate with other research programs, including university and private-sector activities and the federal R&D programs at FAA, TSA, and NASA.
- Develop dissemination plans and ensure the dissemination of results.
- Utilize the expertise and research ideas of airport users and regulators.

In addition to carrying out these functions, the board may be charged by Congress with conducting periodic assessments of the performance of the program and reporting the results. The report shall be made available to the public, the federal agencies providing and administering the funds, and Congress.

Program Management

The board will need staff support. Under NCHRP and TCRP, such support is provided by TRB, which serves as secretariat to the board. Secretariat activities include soliciting research needs, scheduling and preparing agendas for board meetings, collecting and tabulating board member ballots on research priorities and other matters related to the research program, and preparing and circulating board meeting notes.

Day-to-day management responsibilities, also fulfilled by TRB, include

- Appointing and coordinating the expert technical panels with responsibility to direct, monitor, and peer-review the research progress;
- Developing, distributing, and processing requests for proposals;
- Executing, monitoring, and closing out contractual agreements with selected researchers; and
- Editing, publishing, and disseminating research reports approved by technical panels.

The use of expert panels to guide research projects provides the strength of TRB's approach for managing cooperative research programs and is perhaps

a unique capability of this organization. Panels are chosen for their technical expertise within the specific problem areas. They provide technical advice and counsel during all phases of the project. Panel members serve voluntarily and without compensation. They are appointed as individuals possessing expertise in specialized areas, not as representatives of the organizations by which they are employed.

An important concern of TRB and its parent organization, the National Academies, is appropriate balance and the avoidance of conflicts of interest. Panel members cannot act as individual consultants or advisors to the researchers and are prohibited from submitting proposals on research projects under their purview. It is largely the National Academies' status as a nonprofit, nonadvocacy research institute chartered by Congress to advise the government that enables TRB to convene these voluntary panels, which are integral to ensuring the quality and integrity of the cooperative research programs. As discussed in Chapter 5, this capability makes TRB a candidate to manage an ACRP.

5

Conclusions and Recommendations

The key findings of this report are summarized in this chapter. The committee believes that the findings

- Justify the creation of a national research program focused on the needs of airport operators;
- Reveal how such a program can play a role in helping airport operators meet the many demands of federal agencies, state governments, local communities, and airport users; and
- Provide guidance on governing, funding, and administering an airport research program.

JUSTIFICATION FOR A RESEARCH PROGRAM FOCUSED ON AIRPORTS

Some 5,000 airports scattered across the country are open to public use in the United States, including more than 500 that offer airline service. They vary in size from more than 50 square miles to a few dozen acres and accommodate aircraft ranging from 500-seat jet airliners to single-engine props. They form a key component of the country's heavily used aviation system. Unlike the centralized air traffic control enterprise, which is run almost entirely by the federal government, the nation's airports are a collection of independent entities owned and operated by thousands of mostly public agencies.

The diversity and decentralization of the airport system are strengths. Competition among airports for the business of airlines and other aircraft users prompts efficiencies and innovations in products, processes, and services. At the same time, individual airports are elements of regional and national transportation networks; they are interconnected and dependent on one another. For aviation users—whether airline passengers, shippers, or general aviation (GA) operators—the vast airport network with its many origin and destination points is what makes the nation's aviation system so useful.

Recognizing the importance of building and maintaining a nationally integrated aviation system, the federal government has long played an important role in providing assistance to thousands of airports run by state and local governments. During the past three decades, it has granted more than $30 billion to operators for improvements in runways and taxiways, terminal facilities, noise mitigation, safety equipment, security, and air navigation and guidance systems. Most of the revenues to fund these investments stem from federal taxes and other levies on aviation users maintained in the Airport and Airway Trust Fund.

To protect the large federal investment in the nation's airport infrastructure and ensure its safe and efficient use, the Federal Aviation Administration (FAA) has established various standards governing major aspects of the design, construction, maintenance, and operations of airport facilities. In supporting the development and implementation of these standards, FAA sponsors research on topics ranging from pavement durability to noise modeling and mitigation.

Yet, from the standpoint of airport operators, different research needs are apparent. For example, an increase in an airport's operations must be carried out without significantly increasing noise, air pollution, or other environmental impacts. Security must be strengthened without unduly burdening and possibly driving away users. Federal restrictions on how airports can generate revenues from landing fees and other user charges—restrictions that accompany most federal grants—must be balanced against demands by state and municipal owners that airports seek out new revenue sources to become self-supporting. In the end, it is up to the airport operators themselves to find ways to meet these many demands.

Operators face a growing challenge in responding to these demands. New agencies with jurisdiction over airports, such as the Transportation Security Administration, are imposing new requirements. Others, such as the U.S. Environmental Protection Agency and its state counterparts, have gradually expanded their authority into the realm of airport planning, construction, and operations. Thus, what may appear to be straightforward requirements from the perspective of a single agency can result in many uncertainties and problems for airport operators. At the moment, operators do not have a research capability to address these uncertainties and solve the resulting problems.

The airport research enterprise does not currently provide a means for operators to cooperate among themselves and with other interested parties to

find solutions to shared problems or to seek new ideas to improve airport operations. The federal government has much at stake in ensuring that such research is undertaken and that it is of the highest quality. Airports with fewer problems are more likely to use their resources efficiently and to require less federal assistance. They are more likely to be able to respond effectively to the requirements of federal agencies—whether to strengthen security, protect the environment, or increase capacity. And they are more likely to be able to meet the demands of airport users, which will ultimately benefit travelers and shippers depending on safe, secure, and efficient air service.

Cooperative research activities confer many other benefits that can be difficult to gauge. The National Highway Cooperative Research Program (NCHRP) and the Transit Cooperative Research Program (TCRP) have demonstrated that regular collaboration of practitioners, public officials, researchers, and technical experts can provide opportunities for the exchange of information and ideas. Moreover, practitioners who are actively involved in research gain skills and expertise that strengthen the industry's professional capacity and help attract talented individuals to the field. Of course, research performed at universities is essential for training students and interesting them in the airport management and engineering professions.

UNIQUE ROLE OF AN AIRPORT COOPERATIVE RESEARCH PROGRAM

The mission of a national airport cooperative research program (ACRP) must be clear and well articulated so that the program complements, and does not duplicate or detract from, existing research activities. An ACRP, unlike any current program, will provide an opportunity to address problems that

- Many operators share but that tend to be too costly or complex for a single operator or a small group of operators to research;
- Receive limited attention because of a lack of funding or incompatibility with the mission and institutional requirements of federal agencies and others that traditionally perform airport-related research; and
- Can be researched with a reasonable expenditure of time and effort to yield results that can be readily implemented by airport operators and users.

The following are examples of airport needs in several common problem areas. They illustrate the kinds of research questions that could be addressed through a national ACRP.

- Operations and safety
  - What is a safe and efficient speed for escalators and moving sidewalks in airport environments that are often crowded with hurrying passengers carrying luggage?
  - How are proposed changes in air traffic control and area navigation rules, such as terminal instrument procedures, likely to affect the configuration, placement, and capacity of airport taxiways and runways? What effects are these changes likely to have on overall airport capacity?
- Maintenance
  - What methods are most suitable for choosing among alternative maintenance products and practices for use under different airport conditions?
  - What tools do operators have—and how effective are they—for monitoring the condition of assets, prioritizing maintenance activity, and managing maintenance personnel and contractors?
- Design of infrastructure and equipment
  - How do airports currently use FAA's advisory circulars? Which circulars are most urgently in need of updating to give airports better design guidance?
  - To what extent have changes in the dimensions, controllability, and visibility of modern aircraft been accounted for in FAA design standards for taxiway geometrics, signage visibility, and wingtip clearances, and what modifications of these standards are warranted?
- Finance and administration
  - What experience do airport operators have in this country and abroad in using design–build–finance techniques for expediting construction of new facilities? What have been the positive and negative results of these efforts? What can be learned from experiences in public works and other modes of transportation?
  - What are the emerging challenges that airports face, in light of heightened security concerns, in recruiting and retaining qualified personnel and reducing workplace stress? What can be learned from the practices of other industries facing similar challenges?
- Planning
  - What changes in aircraft types, dimensions, and uses can be expected in the medium and near terms, and how can these changes be accommodated in capital planning for airport facilities?

  - What changes in demand-forecasting methodologies are needed to better assess future facility requirements given the uncertainties now affecting the entire commercial aviation sector?

- Environment
  - What alternative aircraft deicing methods and materials are available? How well do they balance the needs for safety assurance, environmental protection, affordability, and compatibility with operational requirements?
  - What are the data and modeling requirements to analyze emissions of air toxics associated with health risks at airports in a manner that is scientifically credible and useful in decision making?
  - What changes in the current regulatory framework for airports would be required to streamline the planning and environmental documentation process for critically needed airport improvements?

- Security
  - What cost-effective changes in terminal designs and features (e.g., "wayfinding" signs) are available to facilitate security processing, avoid crowding, and expedite the movement of passenger traffic through terminals?
  - How can passenger and baggage flows be modeled accurately to assist in the longer-term infrastructure planning for the design and location of explosive detection systems and for deployment of security personnel?

Although this list is not comprehensive, it reveals a diversity of research needs. Specific research interests will undoubtedly vary by airport size, location, use patterns, and other factors. Operators of GA airports, for instance, may be more interested in research on the kinds of asphalt pavements found on short-field runways than on the more rigid concrete structures used for paving runways that can handle large commercial jets. Likewise, northern airports will have a greater interest in research on snow- and ice-control methods and materials, while commercial-service airports will be the most interested in research to improve the efficiency of passenger and cargo flows.

The wide scope of research needs suggests that a cooperative research program must be responsive, rigorous, objective, and capable of involving practitioners and researchers with expertise from many disciplines. Insights gained from reviewing the experiences of NCHRP and TCRP indicate that how a program is governed, financed, and managed will have a large bearing on these capabilities.

PROGRAM GOVERNANCE, FINANCE, AND MANAGEMENT: LESSONS FROM NCHRP AND TCRP

A research program's overall design and organizational characteristics have a fundamental influence on the research needs addressed, how the research is carried out, the quality of the results, and the extent to which the results are applied. The committee's review of NCHRP and TCRP suggests that the following characteristics will be especially important in guiding the establishment of an airport research program.

Governance

Airport operators must integrate the demands of multiple federal agencies, state and local governments, and airport users. The challenges and problems they face result in research needs and priorities that differ from those making the demands. Operators, therefore, must have a primary role in setting the research agenda, defining the expected products of research, and ensuring the timeliness and applicability of the research results. In doing so, they must cooperate closely with the federal agencies and users of airports, all of whom have an interest in ensuring that the operators succeed.

The experiences of NCHRP and TCRP suggest that an ACRP will require a strong and committed governing board. The board should consist of top executives from a cross section of the nation's airports as well as representatives from federal agencies, industry organizations, and airport users. The governing board must define the research priorities and ensure overall quality and relevance of the research. It must articulate expected research products and assist with dissemination of research results. Finally, it must coordinate with other research programs that have complementary functions.

Financing

The federal government, the private sector, and airport operators collectively spend hundreds of millions of dollars each year on airport-related research and technology development. The committee did not examine whether these funds are allocated appropriately or have been successful in achieving their objectives. However, the study indicates that airports do not currently have a way to fund urgent, short-term research to meet their needs. While the immediate and near-term problems of airport operators are not intrinsically more important than those being addressed by established research programs, they differ in nature and urgency, and thus they deserve explicit attention.

The experiences of NCHRP and TCRP suggest the importance of having finances dedicated to cooperative research. Dedicated funding can provide a base that is sufficiently large to address a range of research needs and reliable enough to sustain interest in the program. A program that is limited to a narrow set of research problems because of limited finances is likely to become marginalized. Airport operators in particular must view the program as a dependable source of ideas and information. They must have a sense of ownership of the program—a commitment to ensuring that the program addresses airport needs and is run efficiently. Because the ultimate beneficiaries of the research will be airport users, financing of the program through aviation user fees can provide these critical stakeholder connections.

Management

NCHRP and TCRP are managed by TRB. Their experience demonstrates that the organization managing the research program must provide more than accounting and administrative services. It must refine the research needs, establish objective means of selecting competent researchers, ensure that research results are technically sound, and disseminate the results widely within the appropriate communities. It must have experience in managing a research program covering a number of disciplines.

Both NCHRP and TCRP use competitively selected contractors to perform the work. Contract-based research offers the greatest flexibility in utilizing the varied expertise and facilities needed for a diverse research portfolio. It also requires competent managers to develop requests for proposals, screen competing researchers with regard to their qualifications, and administer the contracts. The managers must be able to draw on both technical experts and practitioners to define projects, participate in merit review to select capable researchers to perform the work, and peer-review the quality and applicability of the results. Above all, the management organization must be viewed as impartial, independent, and committed to undertaking quality research and disseminating the results.

MODEL ACRP AND NEXT STEPS

Congress requested this study of the desirability of a national cooperative research program for airports. In so doing, it asked for an assessment of the applicability of the financing and administrative approaches used by NCHRP and TCRP. The committee believes that these programs offer an organizational

model well suited to meeting the research needs of airport operators and proposed means of governing, financing, and managing an ACRP in Chapter 4. A proposal for a trial program is outlined in Box 5-1. It embodies the key characteristics discussed above:

- The program would be governed and guided by the top managers from a cross section of the nation's airports in collaboration with representatives of federal agencies, airport users, and others.
- It would be financed with revenues derived from aviation users. Such financing would bring about a research agenda that is focused on producing solutions with direct application to airport problems and would thus prompt a strong commitment to the program on the part of the airport and aviation communities.
- Its management would be structured to ensure that the research products meet the highest applicable standards and are accessible to users.

This model is derived from the NCHRP and TCRP structures. It provides a first step toward creating an ACRP. The experience of TCRP—established only a decade ago—provides insights into subsequent steps. Convinced of the merits of a cooperative research program, transit agencies took it upon themselves to broaden awareness and build consensus for a cooperative research program. They acted through industry associations to clarify the organizational structure of the desired program, outline a legislative proposal, and mobilize support for it. Top transit managers have remained active in the program since its inception. The nation's airport operators will need to commit themselves to a similar effort.

Box 5-1

Proposal for Financing, Governing, and Managing an ACRP

Finance

- Congress allocates 0.20 percent of annual revenues to the Airport and Airway Trust Fund to ACRP funding, which would generate approximately $20 million per year.
- Congress allocates an amount equivalent to 1.5 cents from the $2.50 passenger security tax to ACRP funding, which would amount to about $10 million per year.

Governance

- The Airports Council International (ACI), the American Association of Airport Executives (AAAE), and the National Association of State Aviation Officials (NASAO) establish a nonprofit organization to create and formally appoint members to the ACRP Governing Board.
- The Governing Board consists of 23 members:
  - ACI names ten members: six officials from large hub airports, two from medium-size hubs, and two from small hubs.
  - NASAO names four members: two officials from nonhub or GA airports and two from state aviation departments.
  - AAAE names two members: one official from a nonhub and one from a GA airport.
  - The Air Transport Association names one member.
  - The administrators of FAA, the National Aeronautics and Space Administration, and the U.S. Environmental Protection Agency each name one member.
  - The Undersecretary of Transportation Security names one member.
  - The organization hosting the Governing Board or managing the program nominates two members who are interested in and knowledgeable about airport infrastructure, operations, safety, security, and environmental impacts. These nominations should be rotated periodically among air travelers, GA operators, air cargo carriers and shippers, airport consultants and suppliers, and researchers.
- The Governing Board will serve as the focal point for the identification of research needs shared by airport operators, users, and regulators. It

(continued on next page)

Box 5-1 (*continued*) **Proposal for Financing, Governing, and Managing an ACRP**

will set the annual research agenda by identifying the highest-priority research themes, soliciting problem statements, screening candidate projects, defining project funding levels, and articulating expected products of research. It will guide and monitor the overall quality and strategic direction of the program, determine the technical objectives of all research projects, and coordinate with complementary public- and private-sector research programs. It will develop dissemination plans and ensure the dissemination of results. It will be responsible for conducting periodic assessments of the performance of the program in meeting the critical research needs of airports in a timely, credible, and efficient manner.

- The Governing Board will report annually on the program's progress. After 3 years, the board will report on the state and accomplishments of the program and advise on future program funding beyond this trial period.

Program Management

The program will be managed in a manner consistent with the management of the National Cooperative Highway and Transit Cooperative Research Programs, which are administered by the National Academies' Transportation Research Board.

Study Committee Biographical Information

James C. DeLong, *Chair*, is Manager of Aviation for Louisville International Airport. From 1993 to 1998, he was Director of Aviation at Denver International Airport. He was previously Director of Aviation at Philadelphia International Airport, Deputy Director of Aviation for the Houston Intercontinental Airport System, and Manager of Houston Intercontinental and Hobby Airports. He began his career in airport administration as General Manager of Wichita Mid-Continent Airport. He has served as Chairman of the Airports Council International–North America and on the Board of Directors of ACI-World. He is a past president of the American Association of Airport Executives' Northeast and South Central chapters. He was a member of the Transportation Research Board (TRB) Executive Committee and the Board of Directors of the Denver Metro Convention and Visitors Bureau. He earned a B.A. from Colgate University and an M.A. from the University of Southern California. He was a pilot in the U.S. Air Force and is type-rated in a number of turbojet aircraft.

Marlin Beckwith retired in 2000 as Manager of the Aeronautics Program in the California Department of Transportation (Caltrans). He began his career with Caltrans in 1964 and held a series of administrative and management positions of increasing responsibility. As manager of the aeronautics program, he oversaw the state's airport grant and loan program and supervised the permitting and inspection of helicopter facilities and public-use airports. He also worked with local governments concerned about airport noise and was responsible for ensuring the integration of state and national aviation system plans. He earned a B.A. from the University of Idaho and was an officer in the U.S. Army before joining Caltrans.

James M. Crites is Executive Vice President of the Operations Division of Dallas–Fort Worth International Airport. In this capacity, he oversees the activities of Airport Operations, Airport Maintenance, Department of Public Safety and Environmental Affairs. He was previously the airport's Director of Planning and Marketing Research. Before his service at Dallas–Fort Worth, he worked for American Airlines in several management positions, including Managing Director for Airport Services and Managing Director for Financial Planning. He is Chairman of TRB's Committee on Airspace–Airfield Capacity and Delay. He earned a bachelor's degree from the University of Illinois and a master's degree from the Naval Postgraduate School in Monterey, California.

Barry J. Dempsey is Professor and Director of the Center of Excellence for Airport Pavement Research at the University of Illinois. He joined the faculty of the University of Illinois in 1969 and became Professor of Civil Engineering in 1979. He specializes in airport facilities design, pavement design and materials, transportation soils engineering, and geotextile materials. He has published extensively in technical journals and is well known for his research on pavement subdrainage and the use of geosynthetic materials in pavement design and construction. He received a Ph.D. from the University of Illinois at Urbana-Champaign.

Edward L. Gervais is a Technical Fellow in the Boeing Airport Technology Group. He began his career with Boeing in 1966 and has been involved in production, engineering, or support of all Boeing commercial airplanes currently being produced. He has specialized in pavement design and evaluation and is responsible for evaluating airport compatibility requirements for Boeing commercial aircraft. He is a member of the American Society of Civil Engineers (ASCE) Airfield Pavement Committee, TRB's Committee on Aircraft/Airport Compatibility, and the Airports Subcommittee of the Federal Aviation Administration's Research, Engineering and Development Advisory Committee. He earned a B.S. degree in civil engineering from the University of Washington.

Angela Gittens is Director of the Miami–Dade Aviation Department. In this position, she is responsible for the operations and management of Miami International Airport and five general aviation airports. Before joining the Miami–Dade Aviation Department, Ms. Gittens was Vice President of TBI Airport Management, a company that manages airport facilities under contract. Prior to that, she directed Hartsfield Atlanta International Airport. She began her aviation career as Deputy Director for Business and Finance at San Francisco International Airport. She was previously Deputy Administrator at San Francisco General Hospital and Assistant Vice President of the New York City Health and Hospitals Corporation. She has served on the Federal Aviation Administration's Research, Engineering and Development Advisory Committee. Ms. Gittens earned a bachelor's degree from Fairleigh Dickinson University.

Adib Kanafani is Edward G. and John R. Cahill Professor of Civil Engineering and Chairman of the Department of Civil and Environmental Engineer-

ing at the University of California at Berkeley. Since joining the faculty at Berkeley in 1970, he has taught and conducted research on transportation systems, transportation engineering, airport planning and design, and air transportation economics. He has contributed to air transportation in the areas of demand analysis, airport capacity analysis methods, and airline network analysis. In 1997 he was founding Co-Director of the National Center of Excellence in Aviation Operations Research (NEXTOR), a university/industry partnership funded by the Federal Aviation Administration and headquartered at Berkeley. He served as Director of Berkeley's Institute of Transportation Studies from 1983 to 1998. He is a recipient of numerous awards, including ASCE's Walter Huber Research Prize in 1982, the Horonjeff Award in 1988, and the James Laurie Prize in 2000. He was elected to the National Academy of Engineering in 2002. Professor Kanafani earned his Ph.D. in transportation engineering from the University of California at Berkeley.

Carolyn S. Motz is Manager at Hagerstown Regional Airport in Hagerstown, Maryland. The airport offers scheduled regional airline service and is heavily used by general aviation. She joined the airport in 1984 as a Commission Member. Before being promoted to Airport Manager in 1995, she served as Manager of Operations and Security Coordinator. Security is a major concern for Hagerstown Airport, which is the largest commercial-service airport in the vicinity of Camp David. She is a private pilot, a member of the American Association of Airport Executives, and Charter President of the Maryland Airport Managers Association.

George P. Vittas is Senior Vice President, DMJM Aviation, Inc. He has 35 years of experience in the planning, engineering, and administration of air transportation infrastructure and facilities projects. His prior experience includes 18 years with American Airlines, where, as chief airport–aircraft compatibility engineer, he was responsible for systemwide planning, design, and construction of airport and aviation facilities. He earned a bachelor's degree in civil engineering from Worcester Polytechnic University and a master's degree in transportation planning from Polytechnic University of New York.

Daniel T. Wormhoudt is Vice President of Environmental Science Associates (ESA) and Director of its Airports and Ports Facilities Business Group. Before

joining ESA, he was president of MAP, Inc. Both firms specialize in environmental, land use, and transportation and energy facility siting issues. He has led numerous studies of the noise and other environmental impacts associated with both large and small airports. He is Chair of TRB's Task Force on the Environmental Impacts of Aviation and is active in many airport-related organizations, including the Airport Consultants Council. He earned a master's degree from the University of California at Berkeley.

Airport Research Needs: Cooperative Solutions

Whether small or large, in urban or rural areas, or serving airlines or general aviation, the nation's airports share many of the same problems and have many of the same research needs. Airport operators, however, do not have a direct role in advising federal agencies on research nor a ready way to pool research ideas and resources to develop and disseminate solutions to common problems.

This report examines the idea of creating an applied research program—similar to those successfully serving highways and transit—that focuses on the shared needs and problems of airport operators. The authoring committee urges Congress to establish a national airport cooperative research program and proposes the means for financing, governing, and managing the initiative.

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