United States General Accounting Office

GAO

Report to the Chairman, Committee on Commerce, Science, and Transportation, U.S. Senate

July 1998

AIRFIELD PAVEMENT

Keeping Nation's Runways in Good Condition Could Require Substantially Higher Spending

GAO/RCED-98-226

GAO United States
General Accounting Office
Washington, D.C. 20548

B-276930

July 31, 1998

The Honorable John McCain
Chairman, Committee on Commerce,
Science, and Transportation
United States Senate

Dear Mr. Chairman:

In response to your request, this report discusses runway conditions at national system airports and provides cost estimates for maintaining and rehabilitating these runways over the next 10 years. This report contains recommendations to the Secretary of Transportation to assist the Federal Aviation Administration in better targeting funds for the Airport Improvement Program.

We will send copies of this report to appropriate congressional committees, the Secretary of Transportation, the Administrator of the Federal Aviation Administration, and other interested parties. We also will make copies available to others upon request.

If you or your staff have any questions about this report, please call me at (202) 512-3650. Major contributors to this report are listed in appendix VI.

Sincerely yours,

Gerald L. Dillingham

Gerald L. Dillingham
Associate Director,
Transportation Issues

Executive Summary

Purpose

Since 1982, the Airport Improvement Program (AIP) has provided about $2.2 billion in federal grants for rehabilitating and maintaining airport runways. Administered by the Federal Aviation Administration (FAA), this program is a major source of runway rehabilitation funding for the 3,300-plus airports that constitute FAA's national airport system—the primary network of airports throughout the country. At the request of the Chairman of the Senate Committee on Commerce, Science, and Transportation, GAO addressed the following issues concerning this program: (1) the current condition of the nation's airport runways, (2) the likely cost of rehabilitation and preventive maintenance for these runways over the next 10 years, (3) FAA's basis for setting priorities among requests for AIP grants for runway rehabilitation and maintenance, and (4) the results of the demonstration project authorized by the Congress in 1996 to address concerns that a lack of funding was hampering runway maintenance at small airports.

GAO developed a comprehensive picture of runway conditions by assembling a detailed database covering about 35 percent of the airports in the national system and determined, using statistical methods, that conditions at the remaining 65 percent of the airports were comparable. The airports in the database represent a cross section of all sizes of airports. Although this approach allows systemwide estimates about current runway conditions, the lack of detailed information on pavement conditions at 65 percent of the airports prohibited any generalization about their future conditions or the cost to rehabilitate or maintain their runways.

Background

Runways, like highways, are prone to deterioration from weather and usage. Left unchecked, such deterioration can eventually pose safety risks to planes that are taking off or landing. FAA considers airport runway conditions to be so important that rehabilitating aging pavement is among its highest priorities for awarding an AIP grant. Rehabilitation projects typically involve adding a strengthening layer to an existing surface that has not deteriorated to the point of needing complete replacement. Preventive maintenance projects, which are lower on FAA's priority list, are designed to forestall the need for runway rehabilitation. Generally, however, AIP grants are not available for routine maintenance unless such maintenance is associated with an eligible repair project. In 1996, the Congress authorized FAA to implement a pavement maintenance pilot project to preserve and extend the life of airfield pavements at small airports by allowing AIP grants to be used for stand-alone routine maintenance projects. To obtain additional information to support a decision to maintain or rehabilitate a runway, many airports conduct surveys on pavement condition that produce a pavement condition index (PCI). The PCI survey consists primarily of a rigorous visual inspection of the pavement surfaces for signs of deterioration. The PCI rates pavements on a scale of 100 (excellent) to 0 (failed) but clusters the numeric rankings into seven categories: "excellent," "very good," "good," "fair," "poor," "very poor," and "failed." FAA also has runway pavement information obtained as part of its inspections under the Airport Safety Data Program (designed to collect and disseminate information about airports to pilots and other users). The information collected during these inspections is the result of a quick look at the runways and a subsequent rating of "good," "fair," or "poor" and was not designed to support airports' decisions about pavement management.

FAA's national airport system includes about 547 airports that handle a significant amount of commercial passenger activity; the rest, called "general aviation" airports, serve primarily privately owned aircraft. General aviation airports particularly depend on AIP funding, while busy commercial service airports generally have more access to other funding sources, such as bonds or passenger facility charges added to the cost of airline tickets.

Results in Brief

Most runway pavement is currently in generally good condition. About three-fourths of the runways included in GAO's database on pavement condition (which provides a numerical score based on a visual inspection that indicates the pavement's condition) were rated good to excellent, while one-fourth were rated fair to poor. A statistical model predicted that most of the runways not in GAO's database were also in good to excellent condition. However, in the next 10 years, many airports in GAO's database will face substantial work keeping runways in generally good condition, particularly in doing so at the least cost. FAA and pavement experts believe that the most economical way to lengthen pavement life at many airports is to rehabilitate runways when they are still in good condition. Waiting often increases costs because more expensive methods must be used. In all, about 26 percent of the runways in GAO's PCI database had already reached or passed the point at which they could be rehabilitated most economically, and a statistical model predicted that about 17 percent of the runways not in GAO's PCI database are at the same point.

The cost of keeping runways in generally good condition over the next 10 years will be beyond the average $162 million historically spent in the Airport Improvement Program for this purpose each year. For the 35 percent of national system airports in its database, GAO estimated future costs in two ways. First, assuming that airports could fund projects before runway pavement deterioration accelerated to the point at which more expensive approaches would have to be used, an estimated $1.38 billion would be needed at these airports over the next 10 years. These airports could then choose a less expensive rehabilitation option, such as an overlay, rather than a more costly reconstruction method. However, as much as $774 million of this amount could be used in the first year because a number of runways have already deteriorated to the point at which more expensive approaches would have to be used. This amount is 5 times the current level of spending for runway rehabilitation systemwide. Second, assuming that these airports would have about $162 million per year in federal funds to spend (the amount historically spent systemwide), they would face an unmet need of $2.37 billion after 10 years, even though they had spent $1.62 billion, a higher amount than under the first estimate. Total costs are much higher under the second estimate because many projects would have to be deferred beyond the first year, and pavement would continue to rapidly deteriorate and become more expensive to rehabilitate.

FAA's system for setting priorities among grant applications gives runway rehabilitation projects higher priority than most other projects, enhancing the likelihood that the projects submitted for approval by FAA's regional offices will receive funding. However, FAA does not have an accurate, consistent source of information about detailed runway conditions at all airports in the national system to consider during this process. Data gathered during PCI inspections provide more detailed information that could be used to make grant decisions; however, less than half of the airports in the national system choose to obtain the more rigorous inspection.

For fiscal years 1997 and 1998, the states and local airport authorities have shown limited interest in participating in the pilot program authorized by the Congress for pavement maintenance grants at nonprimary airports. The reasons for not participating ranged from difficulties with the application process to a desire to spend the limited dollars in the Airport Improvement Program on projects considered to be of higher priority. In fiscal year 1997, FAA received expressions of interest from 14 airport owners and states that provide assistance to airports within their borders and awarded grants to 1 airport owner and 3 states. Six candidates—three of the original four awardees plus three more states—expressed interest in participating in the second year of the program, and FAA so far has awarded three grants (to three original participants). A GAO survey of state aviation departments revealed no dominant reason for the limited amount of interest.

Principal Findings

Most Airport Runways Are in Generally Good Condition

The airports in the national system have runways that are in generally good condition. Seventy-seven percent of the runways in GAO's runway pavement database were ranked in the three highest categories—excellent, very good, and good. Eleven percent were rated fair; the remainder were rated in the three lowest categories—poor, very poor, or failed. Using various statistical techniques,[1] GAO concluded that most airports not in the database had runways that were likely to be in similar condition.

However, a small but significant portion of runway pavement may need immediate attention: 12 percent of the runways in the database were rated poor or below. Even more important in assessing future work, however, is the fact that airports need to consider rehabilitating runway pavement long before it has deteriorated to poor condition. Rehabilitating pavement in poor condition may cost 2 to 3 times as much as rehabilitating pavement in good condition because more expensive methods may be used. About 33 percent of the airports in the database and about 26 percent of the airports not in the database had at least one-third of their runways at (or past) the point at which more expensive rehabilitation methods would have to be used.

Airports Will Likely Need to Increase Spending on Runways

Any estimate of future rehabilitation costs must be based on a set of assumptions—such as how much money will be available and when airports will decide to undertake particular projects—that can only partially reflect the timing and type of rehabilitation to be undertaken. GAO developed two estimates of rehabilitation and preventive maintenance

[1]GAO collected detailed PCI data from about 35 percent of the airports eligible for federal funding and used the data to create a runway pavement database. The remaining 65 percent of the airports eligible for federal funding did not have PCI information available. To predict the likely runway pavement conditions at these airports, GAO developed a model based on other airport characteristics (such as age, the type of pavement, climate, and the number of takeoffs and landings).

costs for those airports contained in the database. The first scenario showed an estimated cost of $1.38 billion over 10 years. This estimate assumed that airports would be able to conduct work before runway pavement deteriorated to the point that more expensive approaches would have to be used. Because 26 percent of the runways in our database were already at that point, the first-year expenditure of $774 million would far outstrip the historical annual level of federal AIP money available for such work at all eligible airports ($162 million).

A second estimate assumed that these airports would have about $162 million a year—the estimated historical spending of AIP funds for runway maintenance and reconstruction for all airports in the national system—to spend on rehabilitation. This assumption may still be optimistic, given that $162 million is for rehabilitation for all airports in the national system, not just the 35 percent in GAO's database. Even though more money would be spent under this second scenario in 10 years ($1.62 billion), not all airports would receive funding at the point that it would be most economical to rehabilitate their runways. Under this scenario, the cost of unfunded runway projects would be about $2.37 billion because deferred rehabilitation costs so much more. This higher cost illustrates the importance of knowing the point of deterioration at which more expensive approaches would have to be used.

FAA's Method for Funding Runway Projects Could Benefit From Better Information

The National Priority System, FAA's primary method for determining which AIP grant applications from individual airports should be funded, establishes a priority rating on the basis of factors such as the purpose and type of the project. Runway rehabilitation projects fare well in this system and are typically funded ahead of most other types of projects. Most applications for such projects received funding in fiscal year 1997, according to FAA officials. However, local FAA officials said that they forward only those applications they are relatively certain will be funded.

FAA's priority system is not well equipped to determine which proposed rehabilitation projects will deliver the best return for the dollars spent. Waiting to rehabilitate a runway until the pavement has seriously deteriorated can mean that rehabilitation will cost 2 to 3 times as much as it would have if rehabilitation had occurred earlier. The key to identifying the best time to conduct rehabilitation is having comprehensive knowledge of pavement conditions. Currently, fewer than half of the airports in the national system have information systems that will provide this knowledge. Furthermore, when allocating AIP funds, FAA does not evaluate the cost-effectiveness of the rehabilitation projects it approves.

FAA could obtain the needed information either by improving its existing information on runway condition or by obtaining PCI information from all airports. FAA's existing runway information, obtained during its inspections under the Airport Safety Data Program, provides only the most general of pavement assessments for all runways. This information is designed to inform airport users of the overall conditions of the airports, not to serve as a pavement management tool. These assessments are made by safety inspectors who receive little training in how to examine pavement conditions. Moreover, FAA officials acknowledge that the criteria used for the inspections are vague and open to interpretation. Improving its existing information would require FAA to take such actions as developing sufficient rating criteria and providing more in-depth training for inspectors. On the other hand, the PCI rating was designed to be used as a pavement management tool to help decisionmakers determine when pavements need maintenance or rehabilitation. However, less than half of the airports in the national system have PCI ratings. If FAA were to rely on PCI ratings to make funding decisions, it would need to require all airports to submit PCI-based justifications as part of the airport master planning or project application process, and it would need to take steps to ensure that airports had comparable data.

Nonprimary Airports' Participation in Pilot Project for Pavement Maintenance Grants Is Limited

FAA implemented the demonstration project as a program for adding stand-alone crack sealing, a relatively inexpensive maintenance item, to the list of projects eligible for AIP funds at nonprimary airports.[2] In fiscal year 1997, 10 states that provide assistance to airports within their borders expressed an interest in this funding, as did four airport owners. FAA awarded grants totaling about $566,000 to three states and one airport owner. It determined that about half of the applicants did not meet the guidelines established for participation, such as a preference for proposals that would apply to multiple airports and a preference for locating at least two of the pilot projects in states with no large commercial airports. The approved projects are all for stand-alone crack-sealing projects and other types of related maintenance. In 1998, three of the four original awardees again received pilot program grants, and FAA hopes to award the remaining pilot program grants before the end of fiscal year 1998.

[2]Maintenance projects, including stand-alone crack sealing, are traditionally not eligible for AIP grants.

GAO contacted every state to determine why so few had expressed interest in the pilot program. Their responses varied greatly, from not having enough time or staff to apply to having their own programs to pay for such work. The relatively limited number of applications suggests that few states and airports may be interested in using AIP funds for this purpose. At the same time, however, the successful applicants said they would not have been able to finance this maintenance in other ways.

Recommendations

To enable FAA to make the most cost-effective decisions when awarding Airport Improvement Program grants for runway rehabilitation projects, GAO recommends that the Secretary of Transportation direct the Administrator of FAA to evaluate options for improving the quality of information on airfield pavement conditions for national system airports. These options include, but are not limited to,

- improving FAA's existing information on pavement conditions by reviewing and revising rating criteria and providing adequate training for inspectors;
- requiring airports to submit index ratings on pavement condition as part of the support for their master plans and applications for relevant discretionary grants under the Airport Improvement Program; and
- requiring all airports in the national airport system to submit index ratings on pavement condition on a regular basis and using this information to create a database on pavement conditions for evaluating the cost-effectiveness of project applications and forecasting anticipated pavement needs.

Because of the limited interest expressed to date in the pilot program for pavement maintenance, the Secretary of Transportation should direct the Administrator of FAA to review the need for a separate pilot for airfield pavement maintenance. To accommodate applicants interested in using Airport Improvement Program funds for stand-alone crack-sealing projects, the Administrator should determine if it would be necessary to seek legislation before adding stand-alone crack- sealing projects to the regular list of eligible projects for the Airport Improvement Program.

Agency Comments

GAO provided copies of a draft of this report to the Federal Aviation Administration (FAA) for review and comment. GAO discussed the report with FAA officials, including the Director, Office of Airport Safety and Standards, and the Manager, Airport Financial Assistance Division. FAA generally agreed with the report's findings, conclusions, and recommendations. With regard to the recommendations, FAA said it would consider options for developing a pavement management system and would explore the possibility of making crack-sealing eligible for Airport Improvement Program funding. FAA also provided some technical comments, which GAO incorporated into the report as appropriate.

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Appendixes

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Abbreviations

AIP	Airport Improvement Program
CIP	Capital Improvement Plan
FAA	Federal Aviation Administration
PCI	pavement condition index
PMS	pavement management system
NPIAS	National Plan of Integrated Airport Systems

Introduction

The federal government assists with funding for rehabilitating and maintaining runways at U.S. airports. It does so through the Airport Improvement Program (AIP), which provides grants for many types of projects at more than 3,300 airports nationwide. The Federal Aviation Administration (FAA) administers AIP and is responsible for distributing program funds.

Federal Funding Efforts Focus on 3,300 Airports in the National System

The United States possesses the largest, most extensive aviation system in the world, with more than 18,000 airports. These airports range from large commercial airports, such as Chicago's O'Hare International Airport, to small, privately owned grass landing strips that may serve only a few aircraft a year. About 3,300 of these airports are designated as part of a national system providing a network of air transportation to every part of the country.[1] National system airports are of two types: 547 that handle regularly scheduled commercial airline traffic (called commercial service airports) and 2,767 that are used primarily by privately owned aircraft (called general aviation airports). All of these airports, whether commercial service or general aviation, are eligible for federal funding through AIP grants. A federal statute and FAA's rules establish which types of airport development projects are eligible for AIP funding.[2]

Runway Pavement: Terms and Concepts

As soon as they are built, runways, like other airfield pavements,[3] begin a gradual deterioration attributable to the effects of weathering and the action of aircraft traffic. Left untended, such deterioration may affect the safe operation of aircraft take-offs and landings. Proper runway construction and maintenance enhances the longevity of the pavement.

Runways can be constructed of flexible (asphalt) or rigid (concrete) materials. Concrete, a rigid pavement that can remain useful for 20 to 40 years, is typically found at large commercial service airports and at airports that formerly were military bases, according to the manager of FAA's Engineering and Specifications Division. Concrete runways can be laid out in square or rectangular slabs that may be divided by joints to allow for expansion and contraction as the weather changes. This official also noted that asphalt, a flexible pavement that can deteriorate very

[1]This national system is described in the National Plan of Integrated Airport Systems (NPIAS).

[2]These development projects are listed in the AIP Handbook (FAA Order 5100.38A).

[3]Other airfield pavements include taxiways, which provide access between runways and terminals; hangars, or other areas where aircraft are parked; and aprons, which are the paved areas around terminals or hangars.

quickly in cold climates and more slowly in mild ones, is the runway pavement at most small airports. With proper design, construction, and maintenance, an asphalt runway can last 15 to 20 years or more before needing rehabilitation.

Types of Pavement-Related Problems and Corrective Actions

Both concrete and asphalt runways are subject to wear from two main factors—usage and weather. This wear causes "distresses"—cracks and other types of damage. Both concrete and asphalt runways are also subject to disintegration, distortion, and wear that gives aircraft less traction. In concrete pavements, these distresses include, for example, the hairline cracking of the slabs and the buildup of rubber deposits from tires. Asphalt pavement distresses include the wearing away of the pavement surface (raveling) and ruts in the wheel paths.

A number of actions can be taken to repair the distresses that occur in concrete and asphalt pavements. The determining factor in selecting an action is the degree to which the pavement has deteriorated. Less deteriorated pavements generally require maintenance, while more extensively deteriorated pavements require rehabilitation. FAA defines maintenance as "any regular or recurring work necessary, on a continuing basis, to preserve existing airport facilities in good condition, any work involved in the care or cleaning of existing airport facilities, and incidental or minor repair work on existing airport facilities." A typical maintenance repair is crack-sealing. FAA defines rehabilitation as the "development required to preserve, repair, or restore the functional integrity" of the pavement. One example of a rehabilitation project is a structural overlay (laying more asphalt on the runway surface). In FAA's AIP Handbook, work items eligible for funds under airfield paving focus on construction and rehabilitation, including the reconstruction and repair of runways, taxiways, and aprons. Stand-alone crack-sealing and other minor maintenance items are generally not eligible.[4]

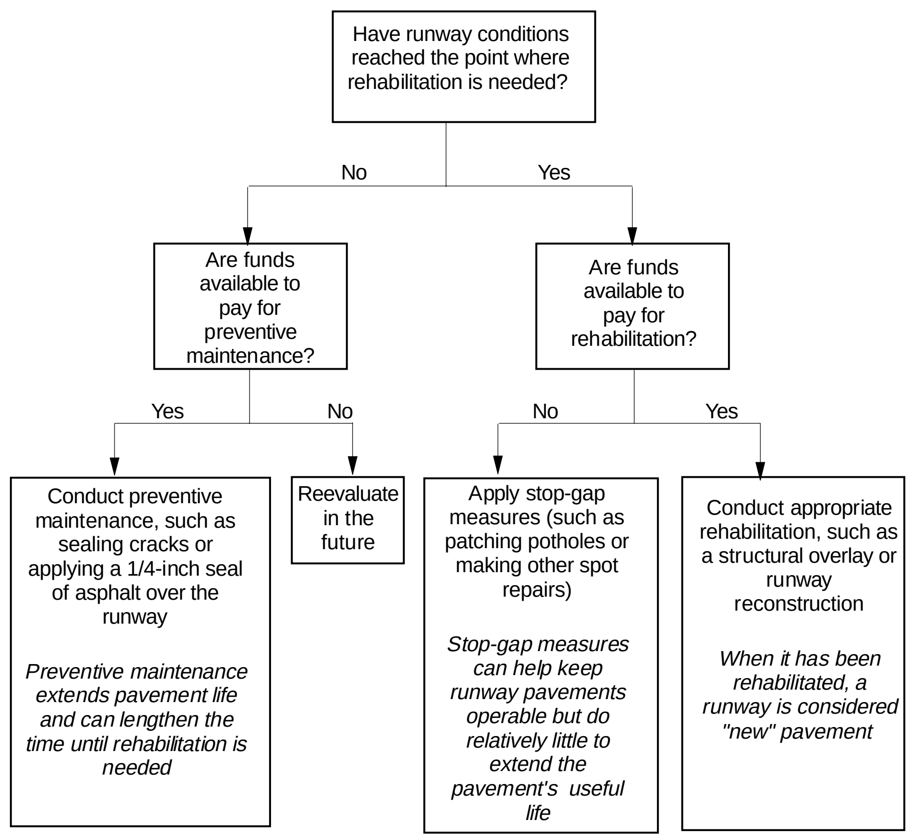
Key Pavement Management Principles and Approaches

Though approaches to repairing pavements may differ, some experts note that appropriately timed maintenance and rehabilitation forestalls the need to replace the pavement entirely—a far more expensive step. Figure 1.1 illustrates the decision-making process—with budget considerations taken into account—for ensuring that a pavement lasts as long as possible before it needs to be replaced. Maintenance and repairs, such as

[4]In some circumstances, routine maintenance items are eligible for funding if associated with an eligible repair project. In addition, FAA's pilot maintenance program allows selected airports to use AIP funds for stand-alone crack-sealing projects.

crack-sealing, can minimize pavement deterioration. Similarly, rehabilitation, such as a structural overlay, can extend the time needed until the pavement must be replaced. On the other hand, not conducting such work at the proper time can shorten pavement life. As FAA notes in its guidance on airport pavement maintenance, "a delay in repairing pavements may allow minor distresses to progress into major failures."[5]

Figure 1.1: Decision-Making Process to Ensure a Long Pavement Life



Note: This figure was developed with the following assumptions in mind: (1) budget considerations are always a factor in determining repair options; (2) pavements do not face some special circumstances that would require repair before they reach the point of needing rehabilitation; and (3) if a lack of funds precludes work from being done, the option to do something in the future will be reevaluated.

Source: Adapted from M.Y. Shahin, Pavement Management for Airports, Roads, and Parking Lots (New York, NY: Chapman & Hall, 1994).

[5]Federal Aviation Administration, Guidelines and Procedures for Maintenance of Airport Pavements (Advisory Circular 150/5380-6, Dec. 3, 1982).

Because of the importance of good pavement management, the Congress and FAA have taken steps to ensure that airports receiving federal funds have a pavement maintenance program in place. Since AIP's inception, the Congress has required airport officials to assure FAA that they will maintain their airport and all its facilities, including pavements, and since 1995, the Congress has required the recipients of grants to rehabilitate airport pavement to provide assurance that a maintenance management program for their airport is in place.[6] FAA issued advisory circulars on the maintenance of airport pavements in 1982 and pavement management systems in 1988.

In fiscal year 1995, FAA issued guidelines recommending the elements that should be included in management programs to maintain pavement. These guidelines state that, at a minimum, any maintenance programs should include a pavement inventory, inspections, and records documenting the inspections' findings and the maintenance that has been scheduled or performed.

Some airports and state-level agencies that coordinate airport-related activity have chosen to obtain additional pavement information by conducting surveys on pavement condition that produces a pavement condition index (PCI). The PCI survey consists primarily of a visual inspection of the pavement surfaces for signs of pavement deterioration caused by the environment and the level of aircraft traffic.[7] The PCI index rates pavements on a scale of 100 (excellent) to 0 (failed) but clusters the numeric rankings into seven categories: "excellent," "very good," "good," "fair," "poor," "very poor," and "failed." Airports can use PCI information as a pavement management tool to identify pavement sections that could require maintenance or rehabilitation. Once problem sections are identified, airports can conduct more extensive pavement testing to determine the type of maintenance or rehabilitation that would be most appropriate. (Chapters 2 and 4 of this report discuss aspects of this approach in more detail.)

FAA currently has some information on runway surface conditions for each airport in the country that it has collected as part of its inspections under the Airport Safety Data Program. This program is designed to meet FAA's statutory requirement to collect and disseminate airport information to

[6]See 49 U.S.C. section 47105(e).

[7]FAA's Guidelines and Procedures for Maintenance of Airport Pavements (AC: 150/5380-6, Dec. 3, 1982) and American Standard Test Method Designation D 5340-93 outline methods for conducting PCI surveys.

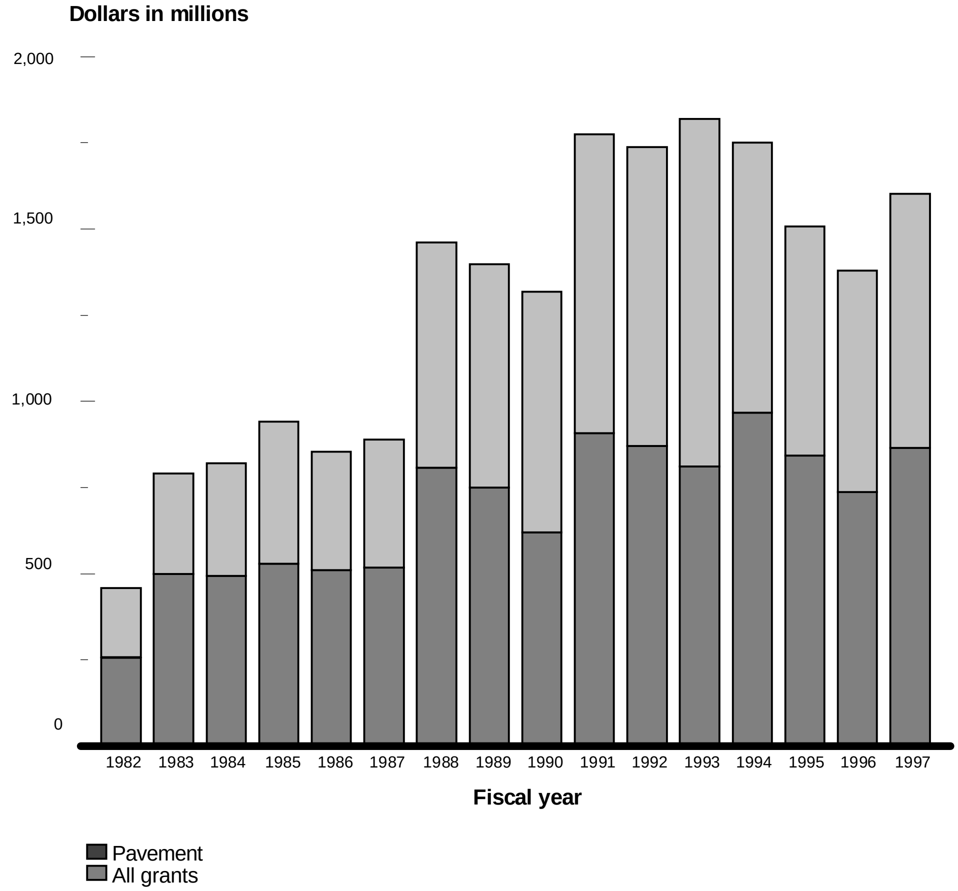
ensure the safe and efficient use of the airport by airport users. Inspections catalogue all aspects of the airport, including the runway condition, but, unlike the PCI rating, these inspections were designed to be a quick look at the pavement surface—not a detailed inspection.

Role of AIP in Funding Airfield Pavement Projects

AIP is the primary source of federal assistance to airports. AIP grants are funded through the Airport and Airway Trust Fund, which is financed by taxes on domestic airline tickets,[8] international air travel from the United States, domestic cargo transported by air, and noncommercial aviation fuel. During fiscal years 1982 through 1997, FAA awarded more than $20 billion in AIP grants—about $1.6 billion of it in fiscal year 1997. AIP grants can be used for a wide variety of projects, but not for everything. For example, runways, lighting, navigational aids, access roadways, and pedestrian walkways are eligible, but hangars and the revenue-producing areas of terminals (such as ticket counters or concessions) are not. During fiscal years 1982 through 1997, more than $10 billion, or about 54 percent of the total amount of AIP grants, went for pavement-related projects, such as rehabilitating or constructing runways or taxiways. (See fig. 1.2.)

[8]These taxes are different from passenger facility charges, which are charges that public agencies controlling commercial service airports can, with FAA's permission, levy on enplaning passengers using the airport.

Figure 1.2: Pavement-Related Grants as a Portion of All AIP Grants, Fiscal Years 1982-97

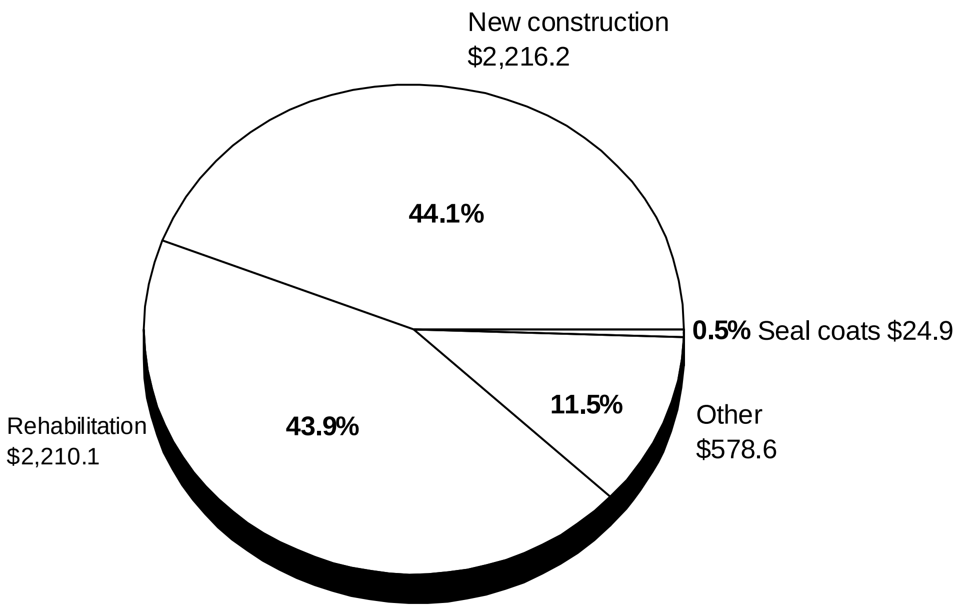


Source: FAA data.

Of the $10 billion awarded for pavement-related projects, about $5 billion was for runways. Grants for rehabilitating runways totaled more than $2.2 billion—about the same amount as grants for building new runways. (See fig. 1.3.) Grants categorized as "seal coats" (a top coat of asphalt applied to the runway surface) totaled about $25 million, or less than 1 percent of the total.[9] About $580 million went for other projects, such as grooving runway pavements to provide more traction.

[9]Under FAA's Handbook, these types of pavement repair projects are eligible when periodic pavement surveys reveal trends in deterioration and it is determined that a repair will retain the serviceability of the pavement.

Figure 1.3: Allocation of AIP Runway-Related Project Grants, Fiscal Years 1982-97



Note: Other projects include grooving, friction treatments, helicopter landing areas, noise compatibility (as a consequence of a runway project), miscellaneous safety areas, and environmental mitigation construction (as a consequence of a runway project).

Source: FAA data.

AIP has two categories of grant funding—apportionment and discretionary. Apportionment funds are distributed by formula to commercial service airports and the states, while discretionary funds are awarded by FAA on a project-by-project basis. For some airports, runway projects involve a combination of both apportionment and discretionary AIP funds. Any airport in the national system is eligible to apply for a discretionary grant. (The process FAA uses to consider these applications is discussed in ch. 4.) All airports receiving AIP funds must agree to provide a financial share, ranging from 10 to 25 percent of the total cost of the project, before FAA will award a grant.[10]

[10]Airports rely on a number of sources for these funds, including airport revenue, federal and state grants, passenger facility charges, state and local contributions, and tax-exempt bonds. For more information on these other sources of airport capital development revenue, see Airport Financing: Funding Sources for Airport Development (GAO/RCED-98-71, Mar. 12, 1998).

To provide additional help for nonprimary airports, a pavement maintenance pilot program was authorized under the Federal Aviation Reauthorization Act of 1996.[11] Beginning in fiscal year 1997, the FAA Administrator was authorized to fund up to 10 pilot projects for pavement maintenance at nonprimary airports "to preserve and extend the life of airport runways, taxiways, and aprons." FAA implemented the pilot program to make stand-alone crack-sealing temporarily eligible for AIP funding.

Objectives, Scope, and Methodology

At the request of the Chairman of the Senate Committee on Commerce, Science, and Transportation, we addressed the following issues concerning the AIP: (1) the current condition of the nation's airport runways, (2) the likely cost of rehabilitation and preventive maintenance for these runways over the next 10 years, (3) FAA's basis for setting priorities among requests for AIP grants for runway rehabilitation and maintenance, and (4) the results of the demonstration project authorized by the Congress in 1996 to address concerns that a lack of funding was hampering runway pavement maintenance at small airports.

To determine the condition of the nation's runways, we first evaluated a variety of data sources on pavement condition, including FAA's Airport Safety Data Program, PCI information detailing specific information about airports' runway pavements, and similar indexes developed by some states and airports. While PCI inspections provide information only about the surface condition of the runway, we determined that it was the best source of information for our purposes. To collect PCI data, we contacted all primary (large, medium, small, and nonhub) airports and the states to determine whether they had PCI inspection data for their airports. On the basis of this information, we created a PCI database for 35 percent of the airports eligible for federal grants. (Information on the airports included in the database is available upon request.) Using the database in conjunction with pavement management software, we projected runway conditions for the years 1998 and 2007. Using this database, we also conducted a regression analysis to determine which airport-specific variables were likely to predict a runway's PCI rating. We then used this information to estimate the pavement condition index for airports with similar characteristics but without any current information on pavement condition. We also visited 80 airports of various sizes to confirm that the information we had on pavement condition was accurate and to discuss pavement maintenance and rehabilitation with various airport and state

[11]See 49 U.S.C. section 47132.

aviation officials. (For information on the construction of the database or the regression analysis used to predict condition for airports, see app. I; for a list of the airports visited, see app. II.)

To determine the likely cost of maintaining and reconstructing runways over the next 10 years, we used pavement management software to project maintenance and reconstruction costs for each runway section in our database for two financing scenarios. We were unable to predict the likely cost of maintaining or reconstructing the runways for which we had no PCI data because the forecasting model required specific information about the particular distress problems in the runway in order to determine the appropriate treatment. (For additional information on the construction of the financing scenarios, see app. I.) We obtained assistance in interpreting the condition and cost data from a panel of airport pavement advisors. The panel included representatives from the asphalt and concrete industry, airport maintenance officials, state aviation officials, and consultants. (For a complete list of the panel members, refer to app. V.)

To determine the basis on which FAA ranks requests for pavement-related AIP grants, we examined FAA's current system for ranking projects and interviewed FAA headquarters, regional, and district officials about their procedures for ranking projects. In addition, we developed options for FAA to more appropriately time the funding of maintenance and rehabilitation projects.

To determine the results from the pilot program for pavement maintenance, we surveyed the 50 state aviation programs by mail in September 1997. The questionnaire asked the states whether they had applied for the pilot program and, if they had not, what their reasons were. (See app. III for a copy of this questionnaire). We also surveyed 23 of the 24 FAA offices responsible for airports by telephone in October 1997 to determine whether any states or airport owners in their jurisdictions had applied for maintenance grants under the pilot program.[12] If any had applied, we tried to determine which applications were denied and why. We achieved a 100-percent response rate for both surveys. We also visited all four awardees that had received pilot program grants in fiscal year 1997.

Our work was done from May 1997 through July 1998 in accordance with generally accepted government auditing standards.

[12]We did not include the FAA regional office covering Alaska because the climate and conditions under which Alaskan airports operate differ considerably from the rest of the country.

Most Airport Runways Are in Generally Good Condition, but Airports Still Face a Need for Considerable Rehabilitation Work Over Next 10 Years

Our database analysis and statistical modeling indicates that most runway pavements are in generally good condition. About three-fourths of the runways included in our database are currently rated in good to excellent condition.[1] By applying statistical modeling, we were able to conclude that the runways without detailed pavement data were likely to be similar to those that had specific data on their pavement conditions. Although the runways are in generally good condition, considerable work will be required to keep them that way. FAA and pavement experts believe that the most economical way to lengthen pavement life is to rehabilitate runways when they are still in good condition. Applying this approach, about 26 percent of the runways in our database are at the point where rehabilitation is appropriate, and within 10 years, this figure could rise to more than 50 percent.

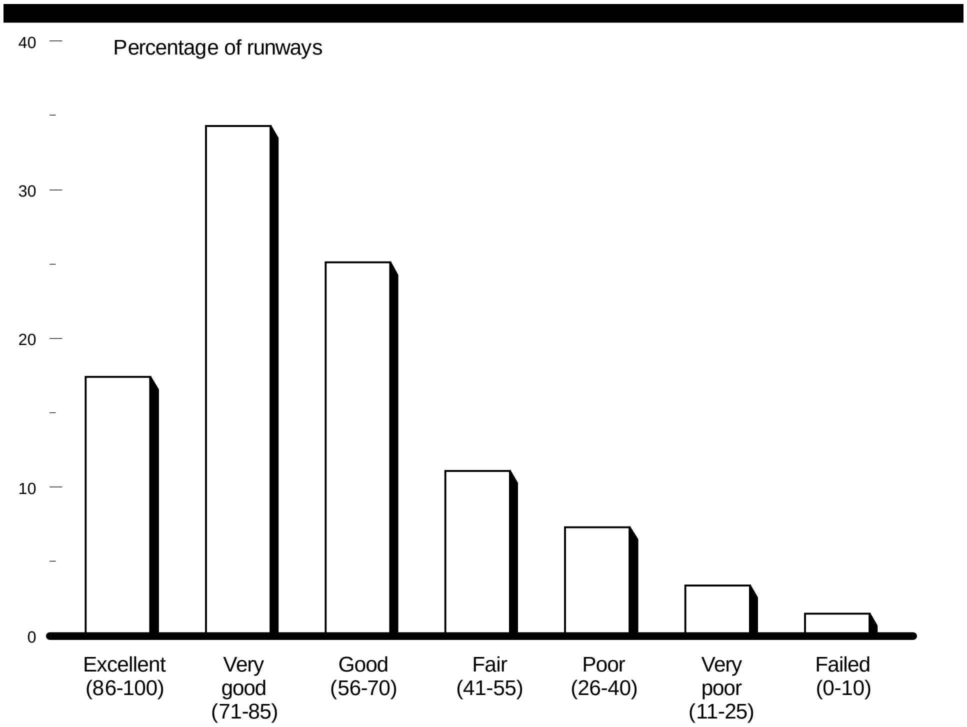
Current Runway Conditions Are Generally Good

Overall, the PCI ratings for the runways in our database were good to excellent in 1998 (see fig. 2.1).[2] About 77 percent of all runways were within the categories of “good,” “very good,” and “excellent.” The rest were divided between “fair” and “poor” and lower, as shown in figure 2.1.

[1]We collected detailed PCI data from about 35 percent of the airports eligible for federal funding and used these data to create our database. The remaining 65 percent of the eligible airports did not have PCI data available (or was unusable), and we predicted their condition by using a model based on other airport characteristics. Our approach, which is explained in further detail in app. I, was to use the section-by-section PCI information contained in our database to create weighted average PCI ratings for entire runways, weighing by section area.

[2]Our database contained information on runway pavement condition for 1,154 airports. These airports had 1,647 runways. We were not able to include data for 520 airports with PCI ratings because of various difficulties, such as problems with the PCI software, incomplete or inconsistently assembled information, data generated prior to 1990, and data entry errors. App. I, which explains our methodology, discusses these problems in further detail.

Figure 2.1: Classification of PCI Scores for Runways at 1,154 National System Airports in 1998



Source: GAO's analysis of PCI data. See app. I for a more detailed description.

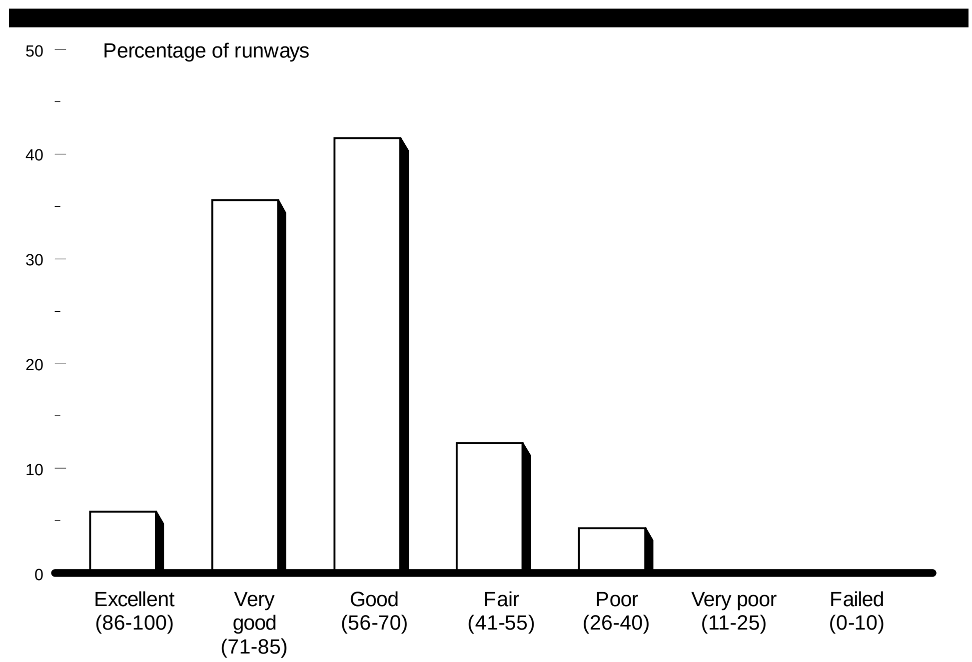
To determine if the condition of runways at airports without detailed PCI data was likely to differ substantially from the condition of runways with usable PCI data, we developed a model using characteristics that tended to be predictive of conditions at airports with PCI data (see app. I for more detailed information). Our analysis of the two groups showed that they were similar in terms of the type and age of runway pavements, the size and volume of airports, past and planned future spending, and the type of climate.[3] We analyzed the relationship between the weighted average runway PCI scores and various airport characteristics, and used the results to estimate PCI ratings for runways at airports that did not have PCI data.[4]

[3]While there are 2,177 airports in the non-PCI group, our analysis is restricted to 1,705 airports. We eliminated 299 airports for one of several reasons—the airport does not exist (is planned or had closed) or is outside of the continental United States. An additional 173 airports were eliminated from our analysis because of insufficient data.

[4]Our approach is explained in further detail in app. I.

Predicted ratings for airports without PCI data showed that about 80 percent of the runways were in the categories of "excellent," "very good," and "good" (see fig. 2.2). The distribution is similar to weighted average runway ratings, discussed earlier, at airports that had PCI data (see fig. 2.1).

Figure 2.2: Estimated Runway PCI Ratings for Airports Without PCI Data, 1998



Note: These are estimated PCI ratings we developed for illustrative purposes, not ratings based on actual PCI data collected at these airports. See app. I for an explanation of how we derived the estimates.

Source: GAO's analysis.

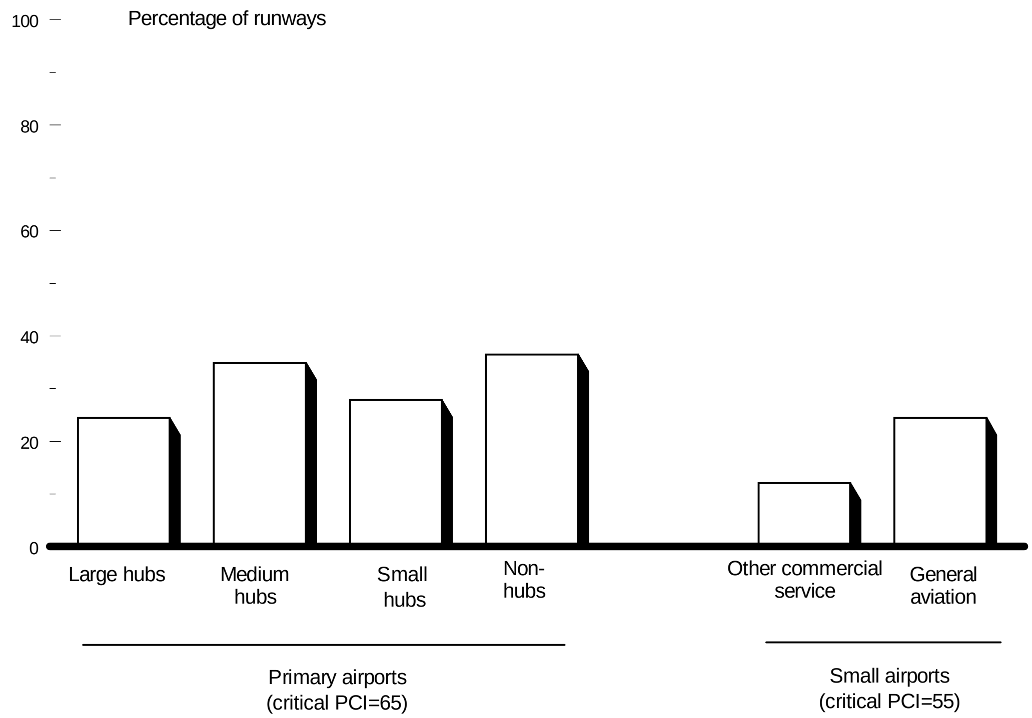
Over the Next 10 Years, Many Runways Will Need Rehabilitation

Although most runways have favorable PCI scores, many will need rehabilitation—including the rehabilitation of pavement that may still be in good condition—within the next 10 years. About 26 percent of the runways in our database were at or below the relevant critical threshold, meaning that they had already reached (or passed) the most cost-effective point for rehabilitation. Of the airports in our database, 361, or 31 percent, had at least one runway that had already reached this point.

If rehabilitation is done on pavement before it deteriorates substantially, the pavement's useful life can be extended with methods that are not as expensive—for example, with a thick overlay rather than with complete rebuilding. For airports that use the PCI approach, the point at which rehabilitation can be done most cost-effectively is referred to as the "critical PCI." For small airports (general aviation and commercial airports not considered to be hubs), this critical PCI is generally considered to be about 55, which is the cutoff between "good" and "fair." For primary (large, medium, small, and nonhub) airports, which must accommodate heavier planes and greater traffic loads than small airports, the critical PCI is often set at 65, which is considered "good" according to our advisory panel.[5] As figure 2.3 shows, the percentage of runways that were at or below the critical PCI of 65 at most categories of primary airports was higher than the percentage of runways that were at or below the critical PCI of 55 at small airports.

[5]Some airports set an even higher threshold. For example, Tulsa International Airport expects its air carrier runways to have a PCI of 70.

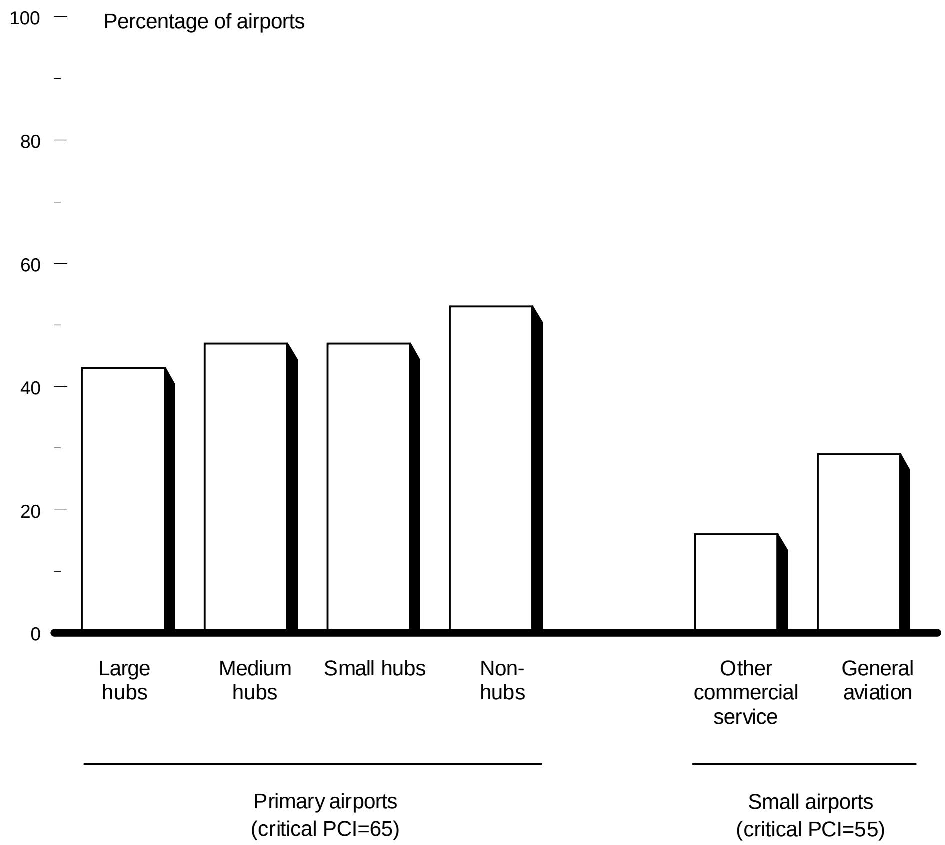
Figure 2.3: Percentage of Runways at or Below Critical PCI for Runways at 1,154 National System Airports in 1998



Source: GAO's analysis of PCI data. See app. I for a more detailed description.

Figure 2.4 shows that, overall, 31 percent of the airports in our database had at least one-third of their runways at or below the critical PCI, ranging from 53 percent at nonhubs to 16 percent at other commercial service airports. Again, primary airports are affected more than small airports.

Figure 2.4: Percentage of Airports With at Least One-Third of Their Runways at or Below Critical PCI for Runways at 1,154 National System Airports in 1998



Source: GAO's analysis of PCI data.

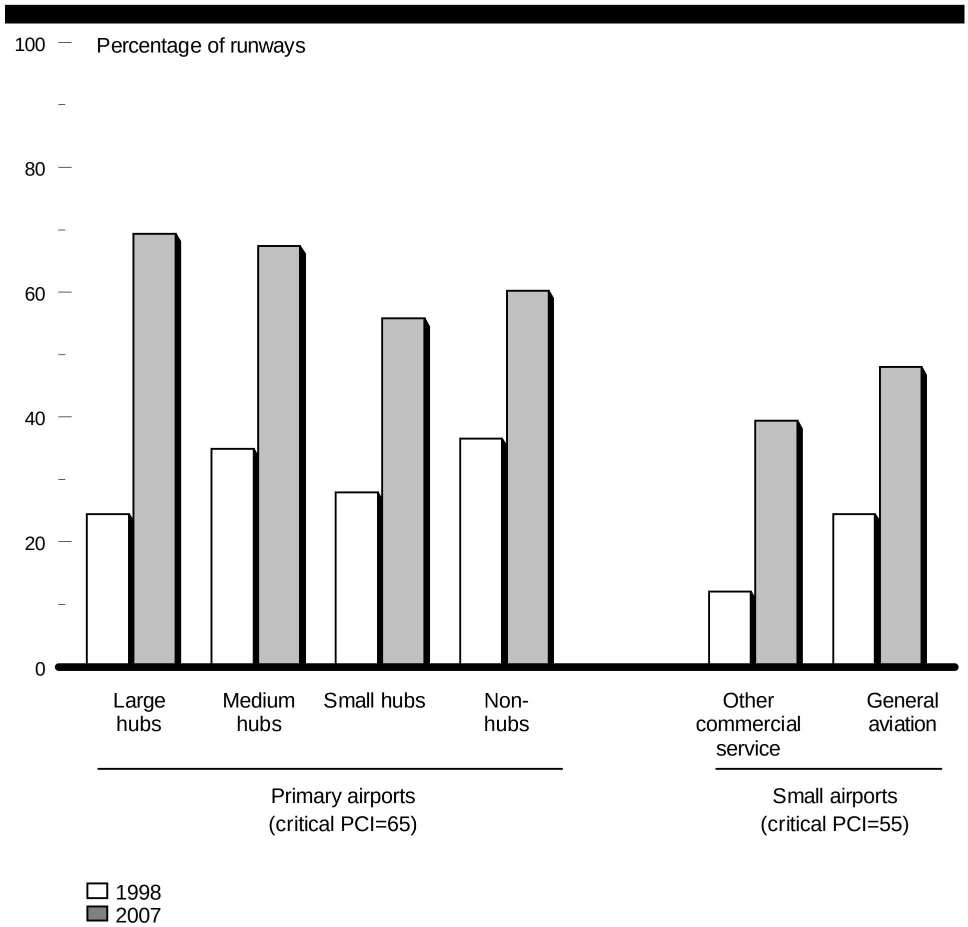
We predicted that about 26 percent of the airports that were not included in the database had at least one-third of their runways at or below the critical PCI, ranging from 50 percent at nonhubs to 7 percent at large hubs. As with those airports in the database, the primary airports not included in the database were affected more than small airports not included in the database.

We also projected the number of additional runways that are likely to reach their critical PCI within the next 1 to 10 years.[6] As figure 2.5 shows,

[6]These PCI projections are based upon how similar pavement in similar climates at similar airports deteriorates over time and assumes that no major maintenance will occur during this period.

within 10 years, the number of runways that could reach the point at which rehabilitation is appropriate could rise from 26 percent in 1998 to 50 percent in 2007. Primary airports face the prospect of a higher percentage of runways reaching their critical PCI by 2007 than do small airports, in part because of the type and amount of aircraft using runways at the primary airports.

Figure 2.5: Number of Runways at or Below Critical PCI in 1998 and 2007 for Runways at 1,154 National System Airports



Source: GAO's analysis of PCI data.

Nation's Airports Will Need to Increase Spending on Runway Rehabilitation Over Next 10 Years

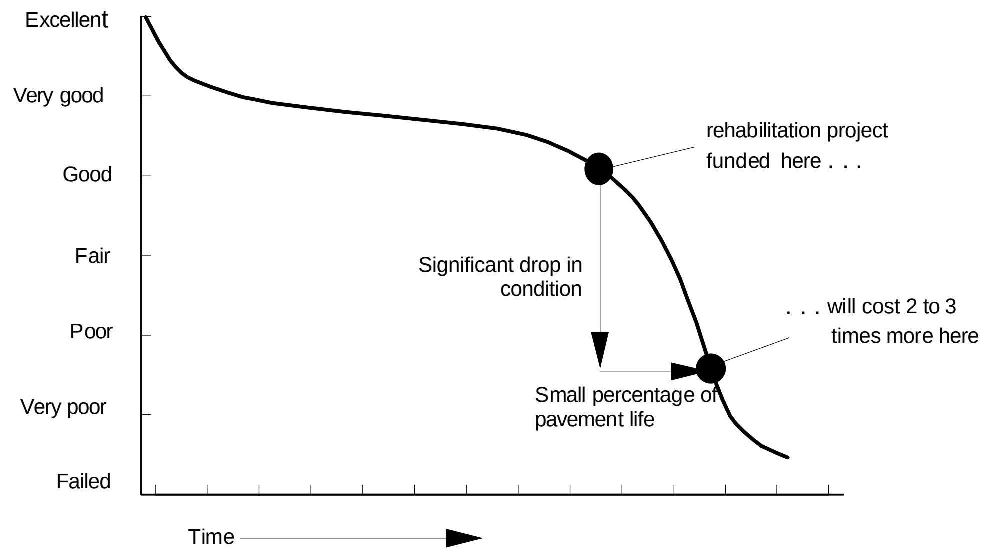
Over the next 10 years, keeping runways at or above generally good condition could require more money than is currently being spent for runway rehabilitation systemwide. We developed two estimates of rehabilitation and preventive maintenance costs for those airports in our database.[1] The first estimate of $1.38 billion over 10 years assumed that these airports would have no budget restrictions and could conduct rehabilitation and maintenance work before runway pavement deteriorated to the point at which more expensive approaches would have to be used. However, these airports would need to spend about $774 million in the first year—well beyond the historic level of spending—if they chose to immediately undertake major reconstruction of all runways that have begun to deteriorate rapidly. The second estimate, $1.62 billion over 10 years, assumes that airports would have a fixed amount to spend on maintenance and rehabilitation each year that is close to the actual amount historically allocated through AIP for all airports. Because sufficient funding is not available to address the immediate need in this scenario, many projects would have to be deferred, making them more expensive. As a result, even after spending more money in total than under the first estimate, these airports would have $2.37 billion of unmet need.

Cost of Rehabilitating Runways Depends Heavily on How Far the Pavement Has Deteriorated

The cost of preventive maintenance and rehabilitation work on airport runways depends heavily on airports' decisions about when to do the work. As figure 3.1 shows, the typical runway pavement will deteriorate from excellent to poor condition over time—usually a gradual decline at first, followed by a steep decline later.

[1]Our database represents 35 percent of those airports eligible for federal funds. The other 65 percent were not included in our estimates.

Figure 3.1: Conceptual Illustration of Pavement Condition Life-Cycle



Source: Adapted from M.Y. Shahin, Pavement Management of Airports, Roads, and Parking Lots (New York, NY: Chapman & Hall, 1994).

For the PCI-based pavement management system we used in this analysis, the point at which rehabilitation can be done before the steep decline occurs is called the critical PCI (explained in ch. 2)—set at 65 for primary airports and 55 for nonprimary airports. If the work is done before deterioration accelerates, the cost of rehabilitation can be reduced. For example, an examination of the deterioration rates of runway pavements at general aviation airports in a northwestern state showed the total reconstruction of the runways could be required when the pavements were about 28 years old and had a PCI of 30, at a cost of $20 a square yard. However, if the airports chose to apply slurry seal coats every 10 years at a PCI slightly higher than the critical PCI, the PCI would rise 10 points with each application, at a cost of $2.25 a square yard. In this scenario, the airports would apply three slurry seal coats in 30 years at a total cost of $6.75 a square yard, obtaining a PCI between 70 and 80, instead of reconstructing a runway in 30 years, at a cost of $20 a square yard to obtain a PCI of 100.[2] In another example, an examination of the

[2]To obtain additional information on maintenance and rehabilitation costs, see app. I.

deterioration rate of a runway at a medium hub airport in the Southwest showed that total reconstruction could be required at 20 years, at a PCI of 30, at a cost of about $45 a square yard. However, if the airport chose to overlay the runway every 11 years, when the pavement reached the critical PCI of 65, the cost would be $19 a square yard. Over a 40-year period, the airport would either totally reconstruct the runway twice at a total cost of $90 a square yard or overlay it 2.5 times, at a total cost of $47.50 a square yard, with the same effect of resetting the PCI to 100.

For the 1,154 Airports Studied, Conducting Maintenance and Rehabilitation Projects at the Critical PCI Point Would Require $1.38 Billion Over 10 Years

Our analysis shows that to keep the runways in our database in generally good condition by maintaining and rehabilitating runways as they reach their critical PCI, the 1,154 airports would need to spend about $1.38 billion over the next 10 years.[3] About 28 percent of the funding need under this scenario would be for primary airports and 72 percent for small airports (see table 3.1). Among individual airport categories, the largest need was for projects at general aviation airports, followed by nonhub airports.

[3]As explained in ch. 2 , we expanded our analysis of runway conditions beyond this subgroup of national system airports. However, we cannot use this same approach to make reliable projections about how much it is likely to cost to rehabilitate and maintain runways throughout the national airport system. The pavement management software used to project pavement costs requires detailed information, including specific distress data and other section data, provided by PCI ratings or some similarly detailed approach.

Table 3.1: Cost to Maintain and Rehabilitate 1,154 National System Airports—First Scenario

Dollars in millions

Airport type	Number of airports	Maintenance and rehabilitation costs
Small airports		
General aviation	1,005	$989
Other commercial service	19	14
Primary airports		
Large hub	14	66
Medium hub	17	86
Small hub	19	29
Nonhub	80	200
Total	**1,154**	**$1,384**

Note: We made several key assumptions for the first scenario. First, we assumed that the critical PCI that would serve as the trigger for conducting rehabilitation work would be 55 for small airports (general aviation and other commercial service) and 65 for primary airports (large, medium, small, and nonhub). Second, we assumed that the estimated costs would include maintenance projects (such as crack-sealing or joint resealing) done to help keep pavements from reaching their critical PCI for as long as possible. Third, we assumed that funding for all projects would be available when the PCI reached the critical point. This meant, for example, that almost $774 million of the total would be spent in the first year, because many runways are currently below their critical PCI—which makes them more expensive to repair than if they were at or above the critical PCI. Although this funding assumption may not reflect the reality of individual airports' actual funding constraints, it does provide the most accurate estimate of funding needs. Finally, we assumed that inflation would increase costs by 2.4 percent per year.

In this scenario, about 89 percent of the total funding is used for rehabilitation work, while the remaining 11 percent would be needed for maintenance, such as crack-sealing, seal coats, or thin overlays.

The needs of 1,154 airports with PCI data are not necessarily representative of all 3,331 airports in the national system, either in the total amount of money needed or in the distribution of this money between types of airports. Because the size of the group that could not be analyzed is so great, it is likely that the need for rehabilitation funds for all the airports in the system is considerably higher than the amount we could identify. Similarly, because general aviation airports constitute more than 84 percent of all airports in the national airport system, they would likely have a considerable portion of total funding needs.

At Current Funding Levels, Rehabilitation Projects at Some of the 1,154 Airports Would Go Unmet, and Costs Would Eventually Rise

Although the first scenario assumes that every runway will be maintained or rehabilitated at least cost—when it reaches its critical PCI—this assumption does not reflect recent funding experience. For the projects to be done at the least cost, more than half of the $1.38 billion needed under this scenario, $744 million, would need to be spent in the first year. However, if funding availability more closely matches spending in recent years, expenditures on runway rehabilitation would be only a fraction of that amount in that year. This means that some projects are likely to go unfunded by AIP, resulting in airports needing either to find alternative financing sources or to delay projects and increase their eventual cost.

While there is no reliable, complete information about how much airports currently spend on runways, an FAA headquarters official indicated that for most airports, AIP funds were the largest source of funding for runway rehabilitation projects. Since 1982, FAA has allocated over $2.2 billion through AIP for runway rehabilitation and eligible runway maintenance projects.

We conducted another analysis of our PCI database, this time using $162 million per year as the maximum funding available, to provide some indication of what was likely to occur at funding levels that were more likely to reflect current spending levels.[4] In this second estimate, airports in our database would spend a total of $1.62 billion over 10 years.[5] Primary airports would receive about 42 percent of the funding, while small airports would receive about 58 percent (see table 3.2).

[4]Since we could not predict how FAA would allocate future AIP funding, we elected to average the total amount of AIP allocated to rehabilitation and maintenance of runways over the past 16 years and apply the entire amount to the airports in our database. The $162 million represents the average AIP funds allocated to runway rehabilitation and maintenance projects and the "share" that airports would apply to the grant. Our total probably overstates the amount these airports collectively spend on runway rehabilitation, because the average represents funds expended at all of the 3,331 eligible airports. Nonetheless, in the absence of better data, doing so provides a reasonable point of comparison against our first estimate.

[5]Because inflation is built into both this cost estimate and the first scenario, the estimates of the amounts that would be spent are in nominal, rather than constant, dollars. That is, they allow the cost of rehabilitation to rise over time, not just because deterioration gets worse but also because of inflation.

Table 3.2: Cost to Maintain and Rehabilitate 1,154 National System Airports—Second Scenario

Dollars in millions

Airport type	Number of airports	Maintenance and rehabilitation costs
Small Airports		
General aviation	1,005	$928
Other commercial service	19	11
Primary airports		
Large hub	14	88
Medium hub	17	141
Small hub	19	104
Nonhub	80	345
Total	**1,154**	**$1,620**

Note: We made several key assumptions for the second scenario. First, each year's funding was divided among the various airport types according to the pattern of AIP allocations in recent years. For example, general aviation airports have typically received 26 percent of AIP funds, so we allocated 26 percent of the $162 million to these airports. If a particular type of airport did not need the entire allocation, we reallocated the remaining amounts to airport types that still had unmet needs. Second, the point at which a runway section would become eligible for rehabilitation funding would be the same as in the first scenario—when it reached the critical PCI of 65 for primary airports or 55 for small airports. We also assumed that inflation would increase costs by 2.4 percent per year. Projects were ranked by priority, and if a project was not ranked highly enough to qualify, less expensive maintenance procedures were applied and funding availability was reexamined in future years. However, if the pavement deteriorated to such a point that maintenance projects could no longer extend the life of the pavement, then no funds would be applied to the section until rehabilitation funds were available.

In the second scenario, the percentage of funding devoted to rehabilitation increases to 92 percent, while the percentage for maintenance decreases to 8 percent.

The $1.62 billion in future spending in the second estimate does not pay for the same number of projects as the $1.38 billion in the first estimate. Because of the dramatic cost increases that occur when rehabilitation is deferred past the critical PCI, the additional $233 million would not be enough to meet total need.[6] Two categories of airports—general aviation and nonhubs—would have unmet needs totaling $2.37 billion over the 10-year period.[7] Because this estimate is based on these 1,154 airports spending an amount that is likely to reflect what all airports in the national airport system are currently spending, it probably understates the unmet need.

[6]In addition, when rehabilitation is deferred, inflation adds to the nominal cost and reduces the amount of runway rehabilitation that can be done for a given nominal expenditure.

[7]For general aviation airports in our database, the unmet need would be $1.901 billion over the 10-year period; for nonhub airports, the unmet need would be $469 million over the same period.

The amount of rehabilitation that could be accomplished in the first estimate exceeds that of the second estimate even when each option is restated in present value terms.[8] Present value analysis reduces the difference between the two estimates because more of the second estimate's costs is incurred in later years and is more heavily discounted. Even so, the first estimate is still somewhat less expensive ($1.22 billion versus $1.29 billion, respectively). That is, the present value savings resulting from spending money later do not fully offset the cost increase resulting from greater deterioration. In addition, our present value analysis did not consider the $2.37 billion in projects left unfunded by the second scenario.

The potential lack of funding in the second estimate could have the greatest implications for small airports. Small airports have a more difficult time getting access to alternative financing resources and therefore may have little choice but to rely heavily on AIP grants. Primary airports, which have a greater availability to tap into other sources of funding, such as bonds or passenger facility charges, may have more flexibility in this regard.

This is not to say that airports will definitely face a funding shortfall for their rehabilitation and maintenance projects or that more pavement will fail than has historically been the case. However, the potential for airports to be somewhat at risk heightens the need for FAA to have a mechanism in place for determining how best to decide which airports should receive grants for runway rehabilitation and eligible maintenance. In chapter 4, we examine FAA's current approach for making such decisions.

[8]Present value analysis removes the influence of inflation and accounts for the time value of money by discounting the future cost of investment by a discount rate equal to the government cost of funds. We used a 5.9-percent discount rate for our analysis because that was the approximate interest rate for long-term government bonds in May 1998, when we did this analysis.

Revised Approach for Evaluating the Timing of Runway Projects Could Help Stretch Airport Aid

The substantial estimated funding need described in chapter 3 raises questions about what, if anything, FAA should do to ensure that AIP funding for runways is spent as wisely and effectively as possible. FAA's system for determining which projects should get funding first gives runway-related projects higher priority than most other types of projects, thus enhancing their likelihood of funding. However, this system does not formally consider the timing of maintenance and rehabilitation projects—factors that pavement experts say can maintain good pavement condition at the least cost. We developed several options that could be explored for doing so. They involve either improving the information that FAA inspectors collect as part of their annual visits to airports or obtaining independent PCI ratings from airports.

High Priority of Runway Rehabilitation Projects Helps Ensure AIP Funding

The National Priority System is FAA's primary method for determining which airport projects should receive discretionary AIP funding.[1] Historically, the demand for discretionary funds has exceeded the amount available for distribution. The system provides a way for FAA to evaluate, in a standardized manner, which projects should receive initial consideration for funding.

FAA officials said when projects are put in priority order using the National Priority System, the rankings of runway rehabilitation projects have historically been high enough to qualify them for funding. FAA headquarters officials also said that most runway rehabilitation projects contained in FAA's 5-year Capital Improvement Plan (CIP) receive funding. However, they added that local FAA officials screen projects for inclusion in the CIP and limit the list according to the funding levels anticipated for each year. While the local FAA screening process may include factors such as a review of a runway's PCI, there is no formal mechanism in place at the national level to determine (1) whether it is the most cost-effective time to rehabilitate the runway given the pavement's projected deterioration and (2) whether the runway in one FAA jurisdiction is more time-critical to rehabilitate than a runway in another jurisdiction. Therefore, while it may appear that all runway rehabilitation projects are funded each year, it is likely that there is some unmet need that is not captured in FAA's current process for setting priorities.

[1] In their initial screening of projects, most FAA field offices sometimes consider some additional factors in recommending which applications to send forward for headquarters approval. One of these factors, PCI ratings, is discussed later in this chapter.

FAA's Current Selection Approach Is Not Geared Toward Life-Cycle Pavement Management

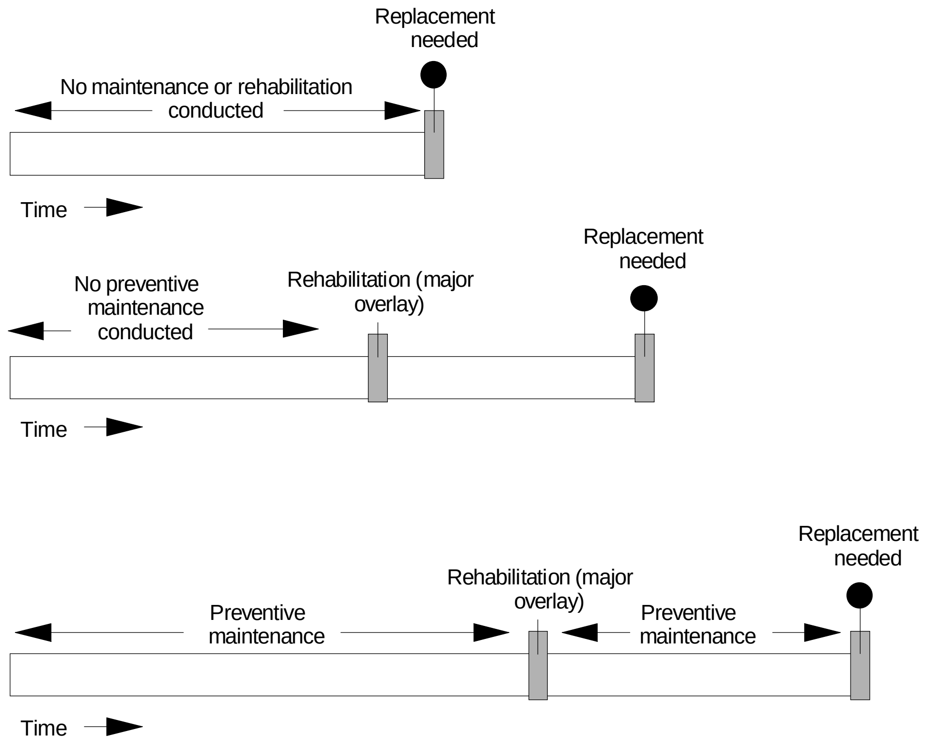
Because it appears that runway rehabilitation projects currently fare well in the competition for discretionary grants at the national level, FAA has not formally acknowledged the need to choose among them—that is, to decide which rehabilitation projects should be placed ahead of others. Should this need arise, FAA has no way to determine which projects should be funded. Ranking projects might be necessary if, for example, overall funding levels dropped, there was a heavy influx of applications for even higher-priority projects, or a delay in funding projects occurred that caused the potential funding gap identified in chapter 3 to materialize.

There is another more important reason for FAA to examine its process for evaluating runway projects: the current process does not provide FAA with a means of evaluating whether the proposed project contributes the maximum possible benefit toward extending the life of the runway pavement. As discussed in chapter 3, FAA and pavement management experts believe that the most cost-effective way to manage a pavement system is to maintain or rehabilitate it at a critical point, before relatively rapid deterioration sets in. (See fig. 3.1.)

A pavement management approach that selects maintenance and rehabilitation projects at critical times makes the maximum use of the total dollars invested to build the runway and keep it serviceable. For example, as figure 4.1 shows, an appropriate rehabilitation project (such as a major pavement overlay) before the pavement begins to deteriorate can significantly add years to its life. Adding an effective preventive maintenance program, such as sealing pavement cracks on a regular basis, is likely to lengthen the life even more.[2] The cost of doing such activities at the appropriate time is more than repaid by being able to wait longer to replace the runway.

[2]The Congress has recognized the importance of maintenance in lengthening pavement life and (since 1995) has required airports to have a management program for pavement maintenance in place as a condition of receiving AIP funds for pavement replacement or reconstruction. At present, however, there is no specific requirement other than that the airport owner assure FAA that a maintenance program is in place. The Congress also approved a pilot maintenance program, allowing airports to use AIP funds for pavement maintenance projects currently not eligible for AIP funds. (See ch. 5 for more information on the program.)

Figure 4.1: the Effect of Different Rehabilitation and Maintenance Scenarios on the Life-Cycle of an Asphalt Runway



Note: The examples shown here are hypothetical. Actual pavement life and the timing of rehabilitation projects also depend on other factors, such as climate and the amount of use.

Lack of Data Impairs FAA's Decision-Making

FAA's current process for evaluating runway rehabilitation proposals does not include an evaluation of information from the perspective of critical times for maintenance or rehabilitation at the national level, and airports are currently not required to have PCI data for their runways for such an assessment at the local level. As a result, FAA is not in a position to determine which projects are being proposed at the most economical point in time, as represented by the critical PCI range. Having such information would allow FAA and airports to know when to plan runway rehabilitation at the most cost-effective times. This, in turn, would help maximize the federal, state, and local investment in runways.

FAA has some information on runway surface conditions (collected as part of its Airport Safety Data Program) for each airport in the country. However, the data are based on pavement evaluations that are not rigorous or specific enough to be used as a pavement management tool. The collection of information on runway conditions represents a minor part of the overall inspection conducted under the Airport Safety Data Program—a quick rating of pavements as "good," "fair," or "poor." The inspectors who assign these ratings generally have limited training in this aspect of the inspection, and the rating criteria they use are vague and focus only on cracks, omitting other types of pavement distresses. FAA officials and state inspectors said that the pavement rating was not intended to provide the same information as the PCI and should not be used to assess the condition of individual runway pavements.

PCI ratings would provide far more specific information that would enable airports and FAA to take a more proactive approach toward pavement management. However, these ratings are currently available only for less than half of the airports in the national airport system, and even for these airports, some are unusable. Moreover, FAA currently does not systematically collect such data from airports. Furthermore, available PCI data would require considerable work before the information is fully comparable from airport to airport.

Options for Developing a Life-Cycle Approach

In consultation with our advisory panel, airport officials, and FAA, we identified three options that would help to improve the information available to FAA on the condition of runway pavement: (1) improving the existing database, (2) using PCI information on a limited basis to help evaluate airport master plans and individual projects, and (3) creating a PCI database that would allow FAA to become more proactive in managing runway grants. The actions that would have to taken under each of these options are discussed below.

Option 1: Strengthen the Pavement Portion of FAA Inspectors' Airport Reviews

To improve the information on airport runway conditions it collects during its inspections for the Airport Safety Data Program, FAA would have to take such actions as developing sufficient rating criteria and providing more updated guidance for inspectors. The current rating criteria are vague (i.e., good, fair, poor) and require substantial interpretation by inspectors. For example, state officials in 9 of the 10 states we visited told us they had developed their own interpretation of the criteria, as well as adding other evaluative factors on their own, such as the quality of the ride, color of the asphalt, presence of vegetation or foreign debris, and type of distress present in the pavement. There appears to be little consistency among the states. As a result, pavements in similar conditions in different states could be rated differently. For example, one state inspector said that he was trained so that he "should be able to determine what good and poor pavements are—fair is everything in between," while in another state, the inspector said that determining what is a fair pavement is the hardest task.

The variance in interpretation may be further exacerbated by the minimal training inspectors receive in evaluating runway pavement conditions. The analysis of pavement conditions receives little attention in the instruction provided through the safety inspection classes funded by FAA. At the same time, inspectors we interviewed said they are not expected to spend much time evaluating pavement during inspection because the inspection focuses on other safety aspects of the airport, such as measuring runway obstructions and noting physical changes to the airport. To the extent that these pavement evaluations would require additional time from inspectors, FAA would also need to determine how to make additional time available or what other portions of the inspection might be reduced to make up the difference.

Improving the existing rating approach would give FAA additional information for managing runway grants, but this approach would also carry some limitations. An improved rating system would give FAA a better tool for understanding the general condition of runways nationwide and for assessing the merits of individual runway projects. However, because the system would still lack the rigor of a more structured approach, such as the PCI, FAA probably would not be able to project runway conditions into the future or to estimate the likely costs involved in keeping runways in reasonable condition.

Option 2: Require Airports to Submit PCI Data With Airport Master Plans or Project Applications

Airports could be required to submit PCI data to FAA to better determine their needs for maintenance and rehabilitation funds for their runways. PCI ratings could be included as part of an airport's development planning process as well as be submitted to FAA as part of a package of information used in applications for runway grants. About 35 percent of all airports in the national airport system currently have PCI ratings usable for this purpose. Although federal law currently requires airports to have a maintenance management system as a condition of receiving AIP funding for pavement replacement or reconstruction, this requirement does not specify that the system include a PCI. General aviation airports, which account for the majority of airports in the national airport system by far, constitute 1,762 of the airports that are not in our database. The cost for most general aviation airports to have an engineer develop a PCI is likely to be about $2,500 to $3,500, according to a consultant who conducts such evaluations. Large commercial service airports, which generally have more complex runway systems and construction histories, will face a higher cost. This consultant indicated that to ensure reasonable accuracy, a PCI would generally need to be conducted about every 3 years. Several software packages are available for compiling the information and projecting future runway conditions and costs.

With this option, much of the effort to develop detailed information on the condition of runway pavement shifts to the airports. Instead of FAA's developing an improved rating system and administering a nationwide database, airports themselves would obtain a PCI analysis and make it available to FAA. If FAA were to ask airports to submit PCI information with their airport master plans or grant applications, it would have a sound basis to evaluate whether future proposed projects were appropriate for the situation and being proposed at the right time. We did find evidence that FAA field offices were already doing this kind of evaluation when such information was available. FAA officials at 22 of the 23 airport district and other field offices we surveyed said they use PCI data, when available, in considering which proposals should be submitted to FAA headquarters for formal review. Headquarters officials said they are aware of such applications of PCI data, but because the availability of PCI data is spotty, this kind of evaluation is now being done only on an ad hoc basis. Adopting this option would mean incorporating PCI data into the evaluation process as a standard way of doing business.

We found that more airports are interested in developing PCI information, perhaps using AIP grant money to do so. During our review, a number of states and airports obtained AIP grants to conduct a PCI analysis for their airports or expressed their intention to do so. Some states told us that FAA has offered AIP grants to obtain PCI ratings for the airports in the states' system plans.

Option 3: Obtain PCI Data From All Airports and Change the Grant Management Approach

Obtaining PCI data from all airports would offer FAA a unique opportunity to move dramatically from a reactive to a proactive role in managing grants for pavement maintenance or rehabilitation. Because PCI data can be used to forecast pavement conditions—and therefore to determine in advance when maintenance and rehabilitation can be done most cost-effectively—this option would give FAA information previously unavailable for ensuring that AIP dollars are spent as wisely as possible. Using PCI information, FAA would be able to develop a better sense of how much rehabilitation and maintenance expenditures were likely to cost several years in the future.[3] Even more important, the information would give FAA the opportunity to alert airports to upcoming opportunities for conducting runway rehabilitation and maintenance projects at times that promise the greatest payout for the dollars expended. Under the existing system, FAA must wait for airports to come to it with project proposals. With PCI information, FAA would be able to foresee needs rather than react to requests.

This option differs from the previous one in the degree to which FAA would be obtaining PCI information and creating a database from it. In option 2, airports would submit PCI data as part of their airport master plan or AIP grant applications. Under this third option, FAA would obtain PCI data from all airports, whether they were submitting pavement-related AIP grant applications or not. FAA would also be combining the information from individual airports into a systemwide database that would produce forecasts about future needs and costs.

FAA would face a considerable effort in ensuring that PCI information could become a useful database. As we found from our efforts to analyze PCI information, the presence of PCI data at one airport was no guarantee that this information could be combined with data at other airports. Airports use different software packages to catalog and analyze PCI data, and the software packages are not compatible. As discussed in chapter 2, we used one type of pavement management software; however, hundreds of airports have used one of several proprietary software packages that often do not provide an easily accessible computer link to other software packages. In developing our database of PCI information, for example, we had to exclude many airports that had PCIs because we could not use their computerized data.

To some extent, FAA itself has fostered the development of proprietary systems. Over the years, FAA has awarded many grants to states or airports for the development of planning systems. One outgrowth of these grants has been stand-alone information systems that differ enough from other systems to make comparisons difficult or impossible. Acknowledging a benefit in creating crosswalks between databases, one company is developing software to provide a feasible way to translate data from one

[3]FAA has some indication of these costs through its current system, in that airports are required to submit anticipated projects in advance of actually applying for AIP grants. FAA requires airports, through their planning process, to identify individual projects for funding consideration. The NPIAS database includes individual airport projects from approved airport master plans, system plans, and discussions with airport officials, and it shows this planned development for up to 10 years into the future.

software package in and out of its own proprietary software. The developers of one of the other software packages are developing similar techniques. It is unclear if other companies will follow suit.

Conclusion

While runway rehabilitation projects currently fare well in the competition for AIP funding, evaluating whether improvements are needed in the process for considering them is important for several reasons. First, if AIP funding levels should drop, or if the demand for even higher-priority projects should increase, FAA has no objective means to determine which applications for rehabilitation projects will do the most to extend pavement life for the dollars expended. Second, if AIP funds are not spent as effectively as possible on runway projects, less money is available to fund other important but lower-priority projects.

Timing is key in making the dollars spent on rehabilitation projects work the hardest, many experts agree. For example, two airports—one with moderately deteriorated runways, the other with runways in much worse condition—may both need rehabilitation projects, but the project at the airport with runways in better shape is likely to cost only a fraction of the cost of the other airport's project. Information about pavement conditions, in turn, is key to knowing the opportune times to conduct such work. FAA's current information is not adequate for making such judgments, nor does FAA require airports to develop such information in developing their airport master plans or project applications. While we have concentrated our work on runways, it should be noted that the situation is similar with regard to projects for taxiways and aprons. A better information system could affect all three types of pavement projects.

To develop better information, FAA could improve its existing information on runway condition or rely on airports to develop PCI data. Of these two approaches, using PCI information would give airports and FAA more flexibility in managing airport development. Because of the rigor of the PCI approach and the ability to project this information into the future, a PCI database would give FAA the opportunity to manage the grant program more proactively—to anticipate runway project needs and work with airports to ensure that projects were proposed and developed at the most opportune times.

Recommendation

To enable FAA to make the most cost-effective decisions when awarding Airport Improvement Program grants for runway rehabilitation projects, GAO recommends that the Secretary of Transportation direct the Administrator of FAA to evaluate options for improving the quality of information on airfield pavement conditions for national system airports. These options include, but are not limited to,

- improving the existing runway condition information contained in the Airport Safety Data Program by reviewing and revising rating criteria, and providing adequate training for inspectors;
- requiring airports to submit PCI information as part of their airport master plan or as support in applications for relevant discretionary AIP grants; or
- requiring all airports in the national airport system to submit PCI information on a regular basis and using this information to create a pavement condition database that could be used in evaluating the cost-effectiveness of project applications and forecasting anticipated pavement needs.

Agency Comments

FAA said that it would consider the options for developing a life-cycle approach to pavement management as outlined in our recommendation.

Participation in Pavement Maintenance Pilot Is Limited

The Congress, in 1996, authorized FAA to use AIP funds for up to 10 pilot projects for pavement maintenance at nonprimary airports, but interest in participating in this program has been limited. FAA awarded grants to three states and one airport owner in fiscal year 1997. We contacted every state to determine why so few had applied. Their responses ranged from not having enough time or staff to apply to having their own programs to pay for such work. At the same time, however, two states and one airport owner that received grants in fiscal year 1997 told us they could not have financed maintenance at general aviation airports without the grants. Given the experience with the pilot program to date, if the Congress wishes to let the states and airports apply for grants that cover stand-alone crack-sealing projects, the most efficient approach may now be to forgo the pilot program and add stand-alone crack-sealing to the list of eligible AIP projects.

Few States or Airport Owners Expressed Interest

Under current law and FAA rules, crack-sealing as a stand-alone project is not eligible for AIP funding.[1] The pilot program allowed for expanded eligibility, but only 14 states or airport owners had expressed interest in it as of October 1997. In May 1997, FAA selected five states and one airport owner as candidates for pilot projects. These candidates were expected to negotiate project costs with FAA and provide supporting information leading to a grant application. As of December 1997, FAA had awarded grants to three states and one airport owner.[2]

According to our September 1997 survey of the 50 state aviation departments, 10 states asked to be considered for stand-alone crack-sealing projects: Alabama, Alaska, Colorado, Louisiana, New Hampshire, New Jersey, Pennsylvania, Texas, Vermont, and Virginia. In May 1997, FAA announced the selection of Alabama, Louisiana, New

[1]For the purposes of the pilot program, FAA also included pavement patching and the cleaning of drainage systems as eligible maintenance projects and said it would consider the eligibility of other projects. According to an FAA attorney, the determination not to fund routine maintenance under the AIP program is a policy decision based on statute. In order to allow stand-alone crack-sealing projects (other than the pilot program) to be funded, FAA would have to modify its handbook and determine if legislation would also be necessary.

[2]All projects conducted under the pilot program are to be completed by Sept. 30, 1999.

Hampshire, Texas, and Vermont as candidates for pilot grants.[3] The selected airports met the program's criteria because they were nonprimary airports; and the three states, Alabama, New Hampshire, and Vermont, had no medium or large hubs, a requirement for at least some of the projects receiving funds. Of the candidate states, only Texas funds crack-sealing and other airfield maintenance at its general aviation airports. Among individual airport owners, four airport owners asked to be considered: the Port of Portland, Oregon; the state of New York for its Republic Airport in Niagara Falls, New York; and the city of Butte, Montana. The Port of Portland was subsequently selected as the only airport owner candidate.

As of December 1997, FAA had awarded four grants totaling $566,018—three to states (Alabama, New Hampshire, and Vermont) and one to the Port of Portland—for maintenance work at 24 airports. The four awardees all plan to conduct, or have conducted, projects that include certain other types of maintenance, such as seal coating, that were already eligible for AIP funding. Table 5.1 summarizes the grant amounts, number of airports covered, and types of maintenance planned and completed.

Table 5.1: Projects Planned by Fiscal Year 1997 Maintenance Pilot Grant Awardees

Awardee	Grant amount	Number of airports	Maintenance projects
Alabama	$282,977[a]	8	Crack sealing, seal coats, and patching
New Hampshire	$83,041[b]	5	Crack-sealing and seal coats
Port of Portland	$100,000	3	Crack-sealing and seal coats
Vermont	$100,000[c]	8	Crack-sealing and seal coats

[a]Alabama's grant amount is high because it could not do all the needed work with an allocation of just $25,000 per airport.

[b]New Hampshire has completed its projects and, as a result of cost overruns, plans to request $89,473.

[c]Vermont believes its final costs will be $70,000 to $80,000.

Sources: Awardees.

[3]For various reasons, Texas decided to forgo participating in the pilot. Five other states (Alaska, Colorado, New Jersey, Pennsylvania, and Virginia) did not participate for the following reasons: Alaska, because FAA determined that its needs were primarily in the area of development rather than routine pavement maintenance; Colorado, because it feared jeopardizing its state maintenance funding and did not want to use its AIP funds that had already been committed to projects; Virginia, because it did not wish to use its state funds; New Jersey, because it did not provide information to pursue the pilot maintenance program; and Pennsylvania, because its original application was submitted as part of a block grant proposal. (For most states, FAA awards separate grants to individual nonprimary airports, but block grant states receive a single grant and administer it at the state level.) FAA has asked Pennsylvania to resubmit its application separately from its block grant.

Grant Awardees Said Program Was Important for Meeting Maintenance Needs

Although few states or airport owners decided to participate in the pilot program, the four that received grants in fiscal year 1997 indicated that the program was very important for conducting maintenance at these small airports. Alabama, Vermont, and Portland officials we interviewed said they were pleased to be part of the pilot program because they believed they could not have financed maintenance at their general aviation airports in fiscal year 1997 without it. A New Hampshire official noted that the program is valuable in his state because the only other source of maintenance dollars is the local airport owner.

The pilot program will provide certain other benefits in addition to those cited by grant recipients. Pilot airports will have maintenance management programs in place, and many will have pavement performance data. Pavement life will be extended as a result of the pilot repair work and of the implementation of the maintenance programs, and the technical data on pavement condition will help the airports make better informed decisions about federal dollars needed for any future pavement work.

FAA planned to evaluate the success of the pilot program by collecting data on maintenance performance from the participants but has done little to ensure that it would receive such data from the airports. FAA promulgated guidelines noting that baseline surveys should be available to evaluate the effectiveness of maintenance practices and that airport owners would be required to inspect and report on the effects of these pilot projects. Most of the airports participating in the pilot conducted PCI inspections to serve as their baseline surveys. However, in recent discussions with 1997 grant recipients under the pilot program, we learned that most of them were not provided with specific guidance on completing either the baseline surveys or the maintenance project reports.

Pilot Program Participation Limited for Various Reasons

State officials responding to our September 1997 questionnaire cited many reasons for not expressing interest in the pilot program, and our recent discussions with FAA indicate that interest in the program continues to be low. We found no dominant reason for the lack of interest in the program among the 40 states that did not apply.[4] Several reasons were related to some aspect of the application procedure, such as the perception that the application period was limited or the lack of staff to prepare an application. Nonetheless, problems related to the application process account for only a portion of the reasons the program received few

[4]Given the large number of airport owners in the national airport system, we did not attempt to determine why owners did not apply. However, the FAA official administering the program speculated that owners might have little interest because so few of them own more than one airport.

applicants. Many states that did not indicate a problem with the application process also chose not to apply. Their reasons for not applying included, for example, the absence of additional money to fund the program, the existence of their own maintenance programs, and some states' statutory restrictions against applying.

One reason we expected might be a key factor in decisions about applying was whether a state's general aviation airports were eligible to receive state-provided maintenance funding. However, the presence or absence of a state-funded maintenance program did not predominate among the reasons cited by the states, and we found no dramatic differences in the percentage of applications by the states that had a state-funded program and those that did not.[5]

In recent discussions with FAA officials administering the pilot program for pavement maintenance, we learned that the expressed interest from the airport community continues to be low. Because of this continuing lack of interest and because it believes that other demonstration programs are more demanding on its resources and have higher visibility, FAA has decided to focus more of its resources on these other programs. On April 24, 1998, FAA announced that six states and airport owners had expressed interest in receiving pilot program grants in fiscal year 1998 and that it had selected six candidates. As of June 15, 1998, FAA had awarded fiscal year 1998 pilot program grants, once again, to three of the fiscal year 1997 grant awardees, the states of Alabama and New Hampshire and the Port of Portland, Oregon. FAA intends to count any projects approved this fiscal year toward the total of 10 projects that the Congress had authorized for the program and award any remaining projects in fiscal year 1999.

Conclusion

The limited response to the pilot program, while the result of many factors, suggests that in the future only a few states and airport owners may want to use AIP grants for crack-sealing and that more states and airport owners would prefer to use AIP grants for capital improvement projects. If the response remains limited, a separately administered pilot program may not be necessary to address the need for crack-sealing. FAA's evaluation efforts are unlikely to provide much additional information for deciding whether to continue the program because most participants were not told how to collect performance data for FAA's analysis. Because the pilot program in effect makes crack-sealing—currently ineligible under AIP

[5]Of the 34 states that have their own maintenance support program, 6 (17 percent) applied for the pilot program. Of the 16 states that do not have such a program, 4 applied (25 percent).

as a stand-alone project—temporarily eligible for AIP funds, it may be more efficient to simply add crack-sealing to the list of AIP-eligible stand-alone projects. Doing so would remove the need to administer a separate program, and those states and airport owners that might need AIP funds for maintenance assistance would have these funds available through the regular federal funding process.

Recommendation

Because of the limited interest expressed to date in the pilot program for pavement maintenance, we recommend that the Secretary of Transportation direct the Administrator of FAA to review the need for a separate pilot for airfield pavement maintenance. To accommodate applicants interested in using Airport Improvement Program funds for stand-alone crack-sealing projects, the Administrator should determine if it would be necessary to seek legislation before adding stand-alone crack-sealing projects to the regular list of eligible projects for the Airport Improvement Program.

Agency Comments

FAA said that it agrees with this recommendation and will explore the means to make crack-sealing eligible for funding under the Airport Improvement Program.

Methodology for Analyzing Runway Pavement Conditions and Associated Cost

To determine the current condition of the nation's airport runways and the funding levels needed to maintain and rehabilitate them over the next 10 years, we solicited data from the Federal Aviation Administration (FAA), individual airports, and state aviation departments in an attempt to develop a database to examine pavement condition. About 35 percent of the airports in FAA's national airport system had pavement condition index (PCI) information that could be assembled into a database. While PCI is the result of a visual, not physical survey of airfield pavements, it was the only pavement condition information broadly available in computerized format for the purposes of our analysis. Using available computer software for pavement management, we analyzed the current and future condition of runways at these airports and determined their future cost requirements for maintenance and rehabilitation. We were also able to develop a model to predict current runway conditions at 65 percent of the airports without pavement condition information. The following sections discuss the development of the database, the analysis of the database, and the process used to predict the current condition of runway pavements for the runways at airports not included in the database.

Developing Pavement Condition Index Database for Airport Runways

To develop the most comprehensive database possible, we sought information from airports with PCI ratings. To build the actual database, we used software called MicroPAVER 4.0.[1] Although other computer software exists for this purpose, we chose MicroPAVER 4.0 because more than half of the airports that provided PCI data provided it in the MicroPAVER format, the FAA funded portions of its development, and it is generally available to anyone at a minimal cost.

To build the database, we first solicited PCI data from commercial airports, state aviation departments, and consultants who conduct PCI inspections at airports. In all, 1,710 airports submitted some type of PCI information for inclusion in the database. The data arrived as (1) various versions of MicroPAVER software; (2) a format requiring software called AIRPAV, a similar proprietary software developed by Eckrose & Green, Inc.; (3) a format requiring software called Decision Support System (DSS) developed by ERES, Inc.; and (4) various other forms. To combine these data formats, we performed the following tasks:

[1]MicroPAVER 4.0 was developed by the U.S. Army Construction Engineering Research Laboratories to provide software for use when creating pavement inventories, projecting future pavement condition, and determining the future cost of pavement maintenance and rehabilitation.

- MicroPAVER data: 1,017 airports submitted data in one of three MicroPAVER formats or in hard copy to be entered into the software.[2] We performed a records review of each data set submitted by an airport and found that 835 airports had submitted complete data sets. We were not able to include data sets from 182 airports because their sets did not contain one of the following data elements: runway information or the latest inspection date. Complete data sets were all converted to MicroPAVER 4.0.
- AIRPAV data: 393 airports submitted data in AIRPAV format. After consultation with the developers of AIRPAV and MicroPAVER 4.0 software, we were able to extract the necessary data fields from the AIRPAV file, reformat the data, and import the data into MicroPAVER 4.0. We performed a records review of each airport's data and found that 141 airports had complete data sets usable in MicroPAVER 4.0. We were not able to include 252 airports' data because they did not contain one of the following data elements: runway information, latest inspection date, slab length/width, or the amount or type of distress.
- DSS data: 193 airports submitted data in DSS format. We contracted with a company to translate and deliver airports' airfield pavement databases from this structure into MicroPAVER 4.0. The company was able to successfully translate all data for analysis, but we dropped 15 airports from the database because their information did not contain one of the following data elements: runway information, latest inspection date, or slab length/width.
- PCI Data in other formats: 71 airports submitted PCI data in a variety of formats not outlined above; none were included in the database. Some of these airports used a pavement indexing system that varied significantly from the PCI guidance published by FAA.[3] Others submitted PCI data in hard copy, but we could not extrapolate enough data to manually enter the information into MicroPAVER 4.0.

While we did not assess the validity of individual airports' data, we did eliminate data that was incomplete (as discussed above) as we created the database. In total, we were able to use data from 1,154 airports, or about 35 percent of the 3,331 airports in FAA's national airport system, and therefore able to apply for funds through the Airport Improvement

[2]The majority of airports submitting hard copy data used a form of MicroPAVER as their pavement management software. However, one company, LAW Engineering and Environmental Services, Inc., provided us with hard copy data so that we could enter the data into MicroPAVER 4.0. LAW maintains data for its clients in its own pavement management software.

[3]Advisory Circular 150/5380-6 Guidelines and Procedures for Maintenance of Airport Pavements (Dec. 3, 1982).

Program (AIP). In all, these airports had 1,647 runways with 4,905 sections for purposes of a PCI analysis.

In addition to the PCI data, we used several FAA databases to ascertain other airport characteristics. These databases included data from FAA's AIP, Capital Improvement Plan (CIP), National Plan of Integrated Airport Systems, Airport Safety Data (5010), and aircraft operations. We did not audit the accuracy of these databases but did perform some limited cross-checking of information to assess their reasonableness. We developed a climate database derived from a climate map developed by Professor Samuel Carpenter, University of Illinois. The map contained data for the continental United States and thus confined our analysis to 3,000 airports. The climate data were traced to the source. We also used state maintenance information derived from our survey work in chapter 5.

Determining Current and Future Condition of Runway Pavements With PCI Data

To ascertain the condition of the runways within the MicroPAVER 4.0 database, we determined the rate at which runway pavement deteriorated over time and applied the deterioration curves to the sections in our database. To accomplish this task, we created a series of prediction "family" models within the MicroPAVER 4.0 software using an approach explained by pavement expert Dr. M.Y. Shahin.[4] This approach includes the following steps:

- Define the pavement families. According to Dr. Shahin, a pavement family is defined as "a group of pavement sections with similar deterioration characteristics." We created a series of models using combinations of the following characteristics:
- Pavement type. We analyzed four pavement types—asphalt, portland cement concrete, asphalt concrete overlay over portland cement concrete, and asphalt concrete overlay over asphalt concrete.
- Pavement use. Only runways were included in the analysis.
- Airport size. We analyzed pavement type by size of airport, using the definitions employed by FAA (general aviation/reliever, commercial service, large hub, medium hub, small hub, nonhub).
- Climate. We created a database that assigned a climate variable to each airport on the basis of a climate map developed by Professor Samuel Carpenter, University of Illinois.
- Filter the data. According to Dr. Shahin, MicroPAVER 4.0 "allows the user to filter out suspicious data points." We defined a set of broadly defined boundaries (using PCI and age of pavement) and excluded data points that

[4] Pavement Management for Airports, Roads, and Parking Lots (New York, NY: Chapman & Hall, 1994).

fell outside of the boundaries. Most data outside of the boundaries were considered errors and were eliminated from the database.

- Develop PCI models based on pavement characteristics. We used about 60 models in MicroPAVER 4.0 and assigned sections to models that best fit the characteristics of the model. If a model did not clearly demonstrate pavement deterioration over time, we assigned the affected sections to a default deterioration model provided by the software.
- Predict the pavement section condition. According to Dr. Shahin, "the PCI prediction at the section level uses the (rate of deterioration established in the) pavement family prediction model. The prediction function for a pavement family represents the average behavior of all sections of that family. The prediction for each section is done by defining (individual sections') position relative to the (rate of deterioration of other sections with similar characteristics)."

Using modeling tools in MicroPAVER 4.0, we analyzed the 4,905 runway sections in our database and predicted each section's PCI for the years 1998 and 2007. We used the section-by-section PCI information to create weighted average PCI ratings for entire runways at airports that had PCI data, weighing by section area. We aggregated the results of the condition analysis by airport type and reported the condition information in chapter 2 of this report.

Future Cost of Maintaining and Rehabilitating Runways With PCI Data

To determine the future cost of maintaining and rehabilitating the runways at the 1,154 airports in our database, we (1) developed budget scenarios for the amount of money airports might have available to spend, (2) determined the unit cost of maintenance and rehabilitation treatments, and (3) specified the relationship between the condition and the unit cost of maintenance and rehabilitation. Each of these steps is described below.

Budget Scenarios

We created two budget scenarios—one with an unlimited amount of funds available (the first budget scenario) and the other imposing more funding limitations, largely on the basis of historical AIP allocations of runway rehabilitation and maintenance funds (the second budget scenario).

The second budget scenario may actually overstate the level of AIP funding traditionally received by these airports, however, because we applied an historical allocation of all AIP runway rehabilitation and maintenance funds to just this 35 percent of the airports eligible to receive such funds. We decided on this course of action because (1) we could not readily determine what percentage of AIP funding these airports could expect in the future and (2) we were unable to analyze other sources of funding that airports might use. Because of the approximate nature of the second budget scenario, we did not attempt to present the dollars in any other format than their nonadjusted, nominal state.

Unit Cost of Maintenance and Rehabilitation

Using data provided by our advisory panel (see app. IV), we developed a set of unit cost data to use in determining the cost of maintenance and rehabilitation, as detailed in tables I.1 through I.4.

The first category of cost is localized preventive maintenance and repair, which is defined as distress maintenance activities performed with the primary objective of slowing the rate of deterioration. These activities include crack-sealing, joint resealing, and patching and are typically applied every few years (for our purposes, we used only the maintenance treatments listed in table I.1). Treatments are applied to pavements above the critical PCI.[5]

Table I.1: Cost Factors for Localized Preventive Maintenance

Treatment	Cost
Crack-sealing	$2.00/linear foot
Joint (or crack) resealing	$2.00/linear foot

Source: GAO’s analysis of data provided by pavement advisors.

The second category of costs is global preventive maintenance, which is defined as activities applied to entire pavement sections with the primary objective of slowing the rate of deterioration. These activities include surface treatments for asphalt-surfaced pavements only. Treatments are applied to pavements above the critical PCI. (See table I.2.)

Table I.2: Cost Factors for Global Preventive Maintenance

Distress	Treatment	Interval	Cost
Minimal	Fog seal	5 years	$0.05/square foot
Climate-related	Slurry seal	5 years	$0.25/square foot
Skid-causing	Thin overlay (less than 2”)	10 years	$0.70/square foot

Source: GAO’s analysis of data provided by pavement advisors.

[5]These types of maintenance are generally not eligible for AIP funding.

The third category of costs is major maintenance and rehabilitation, which is defined as activities applied to the entire pavement section to correct or improve existing structural or functional requirements. Major maintenance and rehabilitation is also used to upgrade pavements that are below the critical PCI.[6] The activities include reconstruction and structural overlays. (See table I.3.)

Table I.3: Cost Factors for Major Maintenance and Rehabilitation—Asphalt

Airport type	PCI range	Treatment	Cost
Large hub	0-40	Reconstruct	$55/square yard
	50-70	Overlay	$20/square yard
Medium hub	0-40	Reconstruct	$45.30/square yard
	50-70	Overlay	$19.3/square yard
Small/nonhub	0-40	Reconstruct	$41.60/square yard
	50-70	Overlay	$15/square yard
General aviation	0-40	Reconstruct	$26.34/square yard
	50-70	Overlay	$10.15/square yard

Note: These cost figures assume only the cost of the runway project (remove existing materials, purchase replacement materials, lay materials).

Source: GAO's analysis of data provided by pavement advisors.

Table I.4: Cost Factors for Major Maintenance and Rehabilitation—Concrete

Airport type	PCI Range	Treatment	Cost
Large hub	0-40	Reconstruct	$71/square yard
	50-70	Overlay	$23.3/square yard
Medium hub	0-40	Reconstruct	$64.30/square yard
	50-70	Overlay	$20/square yard
Small/nonhub	0-40	Reconstruct	$61.60/square yard
	50-70	Overlay	$20/square yard
General aviation	0-40	Reconstruct	$49/square yard
	50-70	Overlay	$12.67/square yard

Note: These cost figures assume only the cost of the runway project (remove existing materials, purchase replacement materials, lay materials).

Source: GAO's analysis of data provided by pavement advisors.

[6]Sections with a PCI higher than the stated PCI range in the overlay category were regarded as "do nothing" for major maintenance and rehabilitation.

Relationship Between Condition and Unit Cost

MicroPAVER 4.0's budget management program examines the condition of a particular section and assigns the appropriate maintenance or rehabilitation treatment (and its associated cost). Establishing the point at which a section would be rehabilitated versus maintained—the critical PCI—is key to obtaining the most cost-effective system. The critical PCI procedure, according to FAA, Dr. Shahin, and others is based on the concept that it is more economical to maintain pavements above rather than below the critical PCI because as deteroriation increases the unit cost of repair also increases. After consultation with our advisory panel and other pavement consultants and airports, we established a critical PCI for primary airports (65) and one for nonprimary airports (55).

In MicroPAVER 4.0's maintenance and rehabilitation program, costs were determined in the following manner:

- Sections at or below critical PCI . The program determined the type of reconstruction required (depending on the PCI rating and the distress types/amounts associated with the section). Then the program checked to determine if funds were available to accomplish the project. If the project could be funded, the PCI was reset to 100. If funds were not available, the program would check funding availability in future years.

  The program also assigned priority among various projects. For example, if three runways had PCI's of 60, 55, and 40 respectively (and all other variables were equal), the program assigned funds first to the runway with the PCI of 60 to maximize its limited funds. Runways with poor, very poor, and failed PCI ratings were assigned the lowest priority for funding because once pavements deterioriate to that point it would be expensive to rehabiliate them at any time.

- Sections above critical PCI with no structural distress. The program determined whether the section required localized preventive maintenance or global preventive maintenance (after determining that the specified interval between applications and the total number of applications had not been exceeded).
- Sections above critical PCI with structural distress. The program determined the cost of reconstruction or structural overlay for the section and checked to ascertain whether funds were available. The project would then either receive funding or be postponed and revisited in future years.

This analysis was conducted for both the first and second budget scenarios. The costs were analyzed by airport and pavement type and then aggregated by airport type and reported in chapter 3.

Predicting Current Condition of Runways Located at Airports Not Included in the Micropaver 4.0 Database

To determine the runway conditions at airports not in the MicroPAVER 4.0 database, we conducted a regression analysis on the MicroPAVER 4.0 runways to identify a group of characteristics that tended to be significantly associated with runway conditions. A regression model is a type of statistical model that investigates the relationships among variables. For this study, we used regression analysis to explore which factors, called independent variables, are associated with the pavement conditions, called the dependent variable, for runways at airports having PCI data. Unlike PCI data, information on these independent variables was available for most airports. We then used the resulting regression equations to estimate runway pavement conditions at the other airports.

Using the section-by-section PCI information available in the MicroPAVER 4.0 database, we first created PCI ratings for entire runways. This was necessary because the independent variables in our model are all either runway or airport characteristics obtained from other databases that did not have the same level of specificity as the MicroPAVER 4.0 data. Our measure of pavement condition at the runway level was calculated as the weighted average of the PCI ratings across all sections at a runway, weighted by the area of the section. Similarly, we calculated a runway's age as the weighted average age across all sections at the runway, weighted by the section area.

In addition to runway age, we used several other runway or airport characteristics as independent variables in our model. These were obtained from either FAA's Airport Safety Program Database (also called the 5010 database), AIP project data for 1982-97, the CIP data for 1997, operations data obtained from FAA, or our survey of the states on airfield maintenance programs. We did not audit the accuracy of these databases but did perform some limited cross-checking of information to assess their reasonableness. In addition, we developed a climate database derived from climate information developed by Professor Samuel Carpenter, University of Illinois. He divided the continental United States into climatic zones. We assigned each airport a climatic zone; however, this confined our analysis to 3,000 airports because we disregarded airports outside the continental United States. The climate data were traced to the source. Together with the runway-level MicroPAVER 4.0 data, we used these sources to create a data set that included the characteristics of runways and their associated airports. The data set contained a record for each of 1,647 runways, located at 1,154 airports having PCI data.

To examine which factors are associated with pavement condition at these 1,647 runways, we used ordinary least-squares regression models. We developed several different models, looking at the contribution each independent variable made to the predictive ability of the model, and the overall explanatory power of the model as measured by the R-squared. R-squared is a measure of the proportion of the total variation in the dependent variable that can be explained by the independent variables in that particular model.

We modeled asphalt, cement concrete, and mixed-surface runways separately. For this analysis, asphalt included the surface types of asphalt; asphalt concrete overlay over portland cement concrete; and asphalt concrete overlay over asphalt concrete; cement concrete runways were those made entirely of portland cement concrete; and mixed-surface runways were those with a combination of at least one of the asphalt types and cement concrete. However, because the asphalt model and the cement concrete model were similar, we combined that data, resulting in just two groups of runways being modeled separately. Our data included 1,576 runways that were either asphalt or cement concrete and 71 runways that were of mixed-surface type.

The dependent variable in all models was the weighted average runway PCI rating. The independent variables included in the final model for the 1,576 asphalt or cement concrete runways are the following:

- the weighted average age for the runway;
- an indicator variable whose value was 1 if the runway was constructed of cement concrete and whose value was 0 if the runway was constructed of asphalt;
- a set of eight indicator variables to categorize runways as being located in one of nine climate zones (wet/freeze, wet/freeze-thaw, wet/no freeze, intermediate/freeze, intermediate/freeze-thaw, intermediate/no freeze, dry/freeze, dry/freeze-thaw, and dry/no freeze);
- a set of two indicator variables to categorize runways as being located at one of three airport types (general aviation, reliever, or other airports);

- an indicator variable whose value was 1 if the airport received some AIP funding for runway construction or improvement since 1982 at any of its runways, and whose value was 0 otherwise;
- an indicator variable whose value was 1 if the airport indicated any planned future spending for runway construction or improvements at any of its runways (in the CIP database), and whose value was 0 otherwise;
- the amount of planned future spending at the airport for runway construction or improvements at any of its runways (in the CIP database);
- the number of operations at the airport, using actual amounts from air traffic control towers when available and otherwise using operation estimates from FAA's 5010 database; and
- an indicator variable whose value was 1 if the airport was located in a state with an airfield maintenance program and whose value was 0 otherwise.

This model appeared to fit the data as well as any of the other models we fit, as measured by the R-squared value. Diagnostic tests revealed no evidence that the inherent assumptions in the regression model were violated, so this became our final regression model for the asphalt and cement concrete runways. The R-squared value is .28 for this model. Table I.5 shows the statistically significant effects.

Table I.5: Airport and Pavement Characteristics Identified as Predictive of Runway Conditions at Airports With PCI Data

Characteristic	Nature of relationship with pavement condition
Age of pavement	With all other factors being equal, for an increase in age there is a corresponding decrease in pavement condition
Type of pavement	With all other factors being equal, concrete pavements have better pavement conditions, on average, than asphalt pavements
Type of airport	With all other factors being equal, general aviation airports tend to have worse pavement condition than other airports
Climate	With all other factors being equal, there are significant differences among the average pavement conditions found in different climates
AIP funding for runway improvement projects	With all other factors being equal, airports that tend to receive AIP funds have better pavement conditions, on average, than those airports that do not tend to receive AIP funds
Airport plans for future runway improvement or construction projects	With all other factors being equal, airports that plan to spend capital in the future have worse pavement conditions, on average, than those airports not planning to spend funds on runway projects.

To assess the predictive power of the model, we used double cross-validation analysis. We randomly split the data set into two equal size sets of 788 runways each. We then developed regression models for each half, using the set of independent variables discussed above. Using the independent variables' values from one half of the data, we then used the estimated regression equation coefficients developed with the other half of the data to predict PCI ratings. These predicted PCI ratings were compared to the actual weighted average runway PCI ratings for that half of the data. The squared correlation coefficient between the predicted and actual runway PCI ratings was calculated. This is called the cross-validated R-squared, and it is a measure of the predictive ability of the model. We repeated this analysis for both halves of the original data set, resulting in two cross-validated R-squared measurements. The values were .23 and .29, both similar to the original R-squared of the total data set (.28).

We separately modeled the mixed-surface runways, again using the weighted average runway PCI ratings as the dependent variable. The independent variables included in the final model for the 71 mixed surface runways are the following:

- the weighted average age for the runway,
- an indicator variable whose value was 1 if the airport was general aviation or reliever, and whose value was 0 otherwise, and
- an indicator variable whose value was 1 if the airport received some AIP funding for runway construction or improvement since 1982 at any of its runways, and whose value was 0 otherwise.

This model appeared to fit the data as well as any of the other models we fit, as measured by the R-squared value. Diagnostic tests revealed no evidence that the inherent assumptions in the regression model were violated, so this became our final regression model for the mixed-surface runways. The R-squared value is .35 for this model. The runway age is the only statistically significant effect. Because of the relatively small size of this group of runways, we were unable to perform a cross-validation as we did with the asphalt or cement concrete runways.

We estimated these regression equation coefficients to predict PCI ratings for those runways not included in the MicroPAVER 4.0 data set. We needed to create a data set containing one record for each of these runways, including data for each of the independent variables used in our models. There were 2,177 national system airports without detailed pavement condition data excluded from our MicroPAVER 4.0 database. 299 of these airports were excluded because they either were not located in the continental United States or did not currently exist (planned or closed), leaving 1,878 airports. An additional 103 of these airports were not included in the FAA 5010 database and so were dropped from our analyses. The resulting 1,775 airports, together with the 1,154 airports in our MicroPAVER 4.0 database, made up our universe for analysis of 2,929 airports, having a total of 4,794 runways listed in FAA's 5010 database. Of these runways, 1,647 runways had PCI information in our MicroPAVER 4.0 database, leaving 3,147 without PCI information. However, because the runway identifiers in the MicroPAVER 4.0 file were unreconcilable with those in FAA's 5010 data set, we were unable to determine exactly which of the 4,794 runways had PCI data. Therefore, we matched the two files at the airport level, selecting only those airports having no runways at all in the MicroPAVER 4.0 database. This method will exclude some runways because at some airports only a subset of the runways have PCI information. Rather than attempting to predict PCI information for 3,147 runways, we were able to conclusively identify 2,812 runways in FAA's data sets that were not a part of our MicroPAVER 4.0 database. This methodology allowed us to identify approximately 90 percent of the runways without PCI ratings in our universe of analysis. Out of this set of 2,812 runways, there were 365 runways whose surface type, as contained in FAA's 5010 database, was something other than asphalt, cement concrete, or a mix of the two. These surfaces were those for which a PCI rating does not make sense—for example, turf or water surfaces, and were therefore excluded from our analyses. This left us with 2,447 runways for which we attempted to predict PCI ratings.

For these runways, we created a data set containing information for each of the independent variables. However, there was no source of information for runway age, which was seen to be an important predictor of pavement condition in our regression models. To estimate runway age, we used dates relating to runway construction or improvement projects contained in the AIP data set. If a runway had no information for such projects in the AIP database, we considered that runway to be at least as old as our data for AIP projects. An FAA official told us that this was a reasonable approach, and that he would assign an accuracy rate of approximately 90 percent to this methodology. To assign an estimated age to those runways with no AIP projects, we used the age distribution of the older runways from the MicroPAVER 4.0 data set.

We compared the distributions of the independent variables for both the runways without PCI data and those with PCI data contained in our MicroPAVER 4.0 database. The initial comparisons of these characteristics showed that both groups were fairly similar in terms of these distributions. Therefore, we would expect that the pavement conditions at the airports without PCI data would be unlikely to be highly dissimilar to the conditions at those airports with PCI data.

For the runways at airports without PCI data, we then evaluated the estimated regression equations, using each runway's values for the independent variables, to calculate an estimated PCI rating for each runway. We used either the asphalt/cement concrete or the mixed-surfaces equation as appropriate for a runway's surface type. We had sufficient data to predict a PCI rating for 2,433 runways located at 1,705 airports. As we expected, the distribution of estimated PCI scores for these runways was not highly dissimilar to the distribution of the actual weighted average PCI scores for those runways having information in our MicroPAVER 4.0 database.

Although our estimated PCI ratings were not precise enough to allow us to project future conditions and expenses, our work was sufficient to lead us to conclude that the general nature of what we found among airports with PCI data was not likely to be highly dissimilar to what would be found if the rest of the national system airports had PCI data.

Airports GAO Visited

This appendix provides a list of the airports GAO visited during this review. The airports are listed by state and within the state, by city, airport name, and location identifier.

Alabama

Alabaster, Shelby County Airport (EET)
Bessemer, Bessemer Airport (EKY)
Birmingham, Birmingham International Airport (BHM)
Centreville, Bibb County Airport (0A8)
Clanton, Gragg-Wade Field (02A)
Fort Deposit, Fort Deposit-Lowndes County Airport (67A)
Montgomery, Dannelly Field (MGM)
Prattville, Autauga County Airport (1A9)
Selma, Craig Field (SEM)
Wetumpka, Wetumpka Municipal Airport (08A)

Arkansas

Blytheville, Blytheville Municipal Airport (HKA)
Fayetteville, Drake Field (FYV)
North Little Rock, North Little Rock Municipal Airport (1M1)
Osceola, Osceola Municipal Airport (7M4)
Rogers, Rogers Municipal-Carter Field (ROG)
Springdale, Springdale Municipal Airport (ASG)
West Memphis, West Memphis Municipal Airport (AWM)

California

Auburn, Auburn Municipal Airport (AUN)
Fallbrook, Fallbrook Community Airpark (L18)
Hemet, Hemet-Ryan Airport (HMT)
Palm Springs, Thermal Airport (TRM)
Riverside, Riverside Municipal Airport (RAL)
Sacramento, Sacramento International Airport (SMF)
San Diego, Brown Field Municipal Airport (SDM)
San Bernadino, San Bernadino International Airport (SBD)
South Lake Tahoe, Lake Tahoe Airport (TVL)
Truckee, Truckee-Tahoe Airport (TRK)

Florida

Bartow, Bartow Municipal Airport (BOW)
Clearwater, Clearwater Air Park (CLW)
St. Petersburg/Clearwater, St. Petersburg/Clearwater International Airport (PIE)

Orlando, Kissimmee Municipal Airport (ISM)
Orlando, Executive Airport (ORL)
Plant City, Plant City Municipal Airport (PCM)
St. Petersburg, Albert Whitted Airport (SPG)
Winter Haven, Winter Haven's Gilbert Airport (GIF)
Zephyrhills, Zephyrhills Municipal Airport (ZPH)

Maine

Auburn, Auburn/Lewiston Municipal Airport (LEW)
Bethel, Colonel Dyke Field (0B1)
Oxford, Oxford County Regional Airport (81B)
Pittsfield, Pittsfield Municipal Airport (2B7)
Portland, Portland International Jetport (PWM)
Waterville, Waterville Robert LaFluer Airport (WVL)

Minnesota

Aitkin, Aitkin Municipal Airport (AIT)
Brainerd, Brainerd-Crow Wing County Regional Airport (BRD)
Cambridge, Cambridge Municipal Airport (CBG)
Detroit Lakes, Detroit Lakes Airport (DTL)
Hawley, Hawley Municipal Airport (04Y)
South St. Paul, South St. Paul Municipal-Richard E. Fleming Field (D97)
St. Cloud, St. Cloud Regional Airport (STC)

New Hampshire

Concord, Concord Municipal Airport (CON)
Laconia, Laconia Municipal Airport (LCI)
Lebanon, Lebanon Municipal Airport (LEB)
Newport, Parlin Field (2B3)
Portsmouth, Pease International Tradeport (PSM)
Whitefield, Mt. Washington Regional Airport (HIE)

North Dakota

Bottineau, Bottineau Municipal Airport (D09)
Casselton, Casselton Regional Airport (5N8)
Cooperstown, Cooperstown Airport (S32)
Dickinson, Dickinson Municipal Airport (DIK)
Harvey, Harvey Municipal Airport (ND17)
Hettinger, Hettinger Municipal Airport (HEI)
Jamestown, Jamestown Municipal Airport (JMS)
Mohall, Mohall Municipal Airport (HBC)

Tennessee

Dyersburg, Dyersburg Municipal Airport (DYR)
Jackson, McKellar-Sipes Regional Airport (MKL)
Knoxville, Knoxville Downtown Island Airport (DKX)
Lexington, Franklin Wilkins Airport (M52)
Morristown, Moore-Murrell Airport (MOR)
Columbia/Mt. Pleasant, Maury County Airport (MRC)
Murfreesboro, Murfreesboro Municipal Airport (MBT)
Parsons, Scott Field (0M1)
Rockwood, Rockwood Municipal Airport (RKW)
Smyrna, Smyrna Airport (MQY)
Trenton, Gibson County Airport (TGC)

Vermont

Lyndonville, Caledonia County Airport (6B8)
Middlebury, Middlebury State Airport (6B0)
Barre/Montpelier, Edward F. Knapp State Airport (MPV)
Rutland, Rutland State Airport (RUT)
Burlington, Burlington International Airport (BTV)
Springfield, Hartness State Airport (VSF)

Survey of State Airfield Maintenance Programs

United States General Accounting Office

GAO Resources, Community, and Economic Development Division

Survey of State Airfield Maintenance Programs

**U.S. General Accounting Office
Survey of State Aviation Officials
Regarding Airfield Maintenance Practices**

Introduction

At the request of the Senate Committee on Commerce, Science, and Transportation, the U.S. General Accounting Office is conducting a review of the nation's airfields pavement condition and examining the types of maintenance performed on those airfield pavements. The Congress intends to use this information in early spring when it deliberates the 1998 reauthorization of the Airport Improvement Program (AIP).

As part of this review, we are surveying all 50 states to assess whether states participate in the maintenance and repair of general aviation and commercial service airport airfield pavements. We are requesting that you complete this questionnaire. Specifically, the questionnaire asks for information about your state's maintenance program, the types of airports assisted through the program, and your opinion about using federal funds to conduct airfield pavement maintenance.

Instructions

Please answer the following questions and return your completed questionnaire in the enclosed business reply envelope within 10 working days of receipt.

We recognize that there are great demands on your time; however, your cooperation is critical to our ability to provide comprehensive information to the Congress in time for these reauthorization hearings during the early spring 1998.

If you should lose or misplace the envelope, please return the completed questionnaire to:

Dana Greenberg
U.S. General Accounting Office
701 5th Avenue, Suite 2700
Seattle, Washington 98104

Or, you may fax a copy of your completed questionnaire marked "Attention: Dana Greenberg" at 206-287-4872. If you have any questions, please call Dana Greenberg at (206) 287-4836 or Sarah Brandt at (206) 287-4783.

Thank you for you help.

General Definition of Airfield Pavement Maintenance

For the purposes of this questionnaire, the term airfield pavement maintenance includes such maintenance items as crack or joint sealing, patching, applying seal coats, replacing concrete slabs, or cleaning of drainage systems.

Other activities related to airfield pavement maintenance, such as sweeping, mowing, or pavement marking, are not included in this survey.

State Involvement in Airfield Pavement Maintenance

1. Does your state have a state-funded (i.e., non-AIP) airfield pavement maintenance program?

   1. [34] Yes (CONTINUE)

   2. [16] No (GO TO QUESTION 6)

2. Does this state-funded (non-AIP) maintenance program fund airfield pavement maintenance through project grants or other mechanisms, such as sending out state maintenance crews to airports to seal cracks or joints or awarding state contracts with maintenance crews to provide slab replacements or seal coats to several airports? (CHECK ALL THAT APPLY)

   1. [30] Yes, through project grants (PLEASE ALSO ANSWER 2A)

   2. [6] Yes, by sending state maintenance crews to airports to crack or joint seal or perform other airfield pavement maintenance

   3. [11] Yes, by contracting with maintenance crews to provide crack or joint sealing, patching, replacing slabs or providing seal coats to several airports

   4. [1] Yes, other (please explain on back of page)

2A If your state awards project grants for airfield pavement maintenance, what types of projects are funded through this program? (CHECK ALL THAT APPLY)

   1. [29] Crack/joint sealing

   2. [23] Patching

   3. [20] Slab replacement

   4. [26] Seal coats

   5. [21] Thin overlays (less than 2 inches)

   6. [11] Other (please explain below)

3. What types of airports are eligible to participate in your state-funded (non-AIP) maintenance program? (CHECK ALL THAT APPLY)

1. [34] General Aviation Airports

2. [27] Reliever Airports (public)

2A. [9] Reliever Airports (private)

3. [30] Small Commercial Service Airports (2,500-10,000 enplanements annually)

4. [25] Primary - Nonhub Airports (10,001-264,459 enplanements annually)

5. [17] Primary - Small Hub Airports (264,460-1,322,300 enplanements annually)

6. [14] Primary - Medium Hub Airports (1,322,301-5,289,204 enplanements annually)

7. [15] Primary - Large Hub Airports (5,289,205 or more enplanements annually)

4. What types of airports actually received funding from your state-funded (non-AIP) airfield pavement maintenance program during the past 12 months? (CHECK ALL THAT APPLY)

   1. [34] General Aviation Airports

   2. [24] Reliever Airports (public)

   2A. [6] Reliever Airports (private)

   3. [24] Small Commercial Service Airports (2,500-10,000 enplanements annually)

   4. [16] Primary - Nonhub Airports (10,001-264,459 enplanements annually)

   5. [6] Primary - Small Hub Airports (264,460-1,322,300 enplanements annually)

   6. [7] Primary - Medium Hub Airports (1,322,301-5,289,204 enplanements annually)

   7. [4] Primary - Large Hub Airports (5,289,205 or more enplanements annually)

5. How does your state determine which airports receive state-funded (non-AIP) airfield pavement maintenance assistance? (CHECK ALL THAT

APPLY) (NOTE: IF YOU HAVE SOME FORMAL CRITERIA, PLEASE ATTACH IT TO THIS SURVEY)

1. [15] Pavement Condition Index (PCI) ratings
2. [27] Visual pavement surveys (other than PCI)
3. [6] Number of annual aircraft operations
4. [10] Size of airport
5. [15] Other (PLEASE EXPLAIN BELOW)

6. Does your state consider whether the airport owner has either an airfield maintenance program or an airfield maintenance management system in the following cases? (CHECK ONE)

1. [20] State considers existence of a maintenance program when awarding both state projects and matching grants for AIP projects
2. [4] State considers existence of a maintenance program only when awarding state projects
3. [4] State considers existence of a maintenance program only when awarding matching grants for AIP projects
4. [15] State does not consider existence of a maintenance program when awarding any projects
5. [7] State does not award any projects

7. Please describe any innovative airfield pavement maintenance activities occurring in your state. (IF YOU HAVE RESEARCH PAPERS OR ARTICLES DESCRIBING YOUR ACTIVITIES PLEASE ENCLOSE WITH THIS SURVEY)

5010 Inspection Program

8. Does your state use the "good," "fair," or "poor" runway pavement rating to describe the pavement condition or the safeness of the runway? (CHECK ALL THAT APPLY)

   1. [43] The rating describes the runway pavement condition
   2. [18] The rating describes the safeness of the runway
   3. [8] Other (Please explain below)

9. How does your state determine whether a runway is "good," "fair," or "poor" during a 5010 inspection? (CHECK ALL THAT APPLY)

1. [36] Use criteria provided by the Center for Aviation Research & Education's Data Elements Manual

2. [14] Use PCI or other pavement rating system already used by the state

3. [22] Use other criteria focusing on safety factors such as smoothness of ride or amount of FOD on runway

4. [7] Use other criteria (Please explain below - if you have printed criteria please attach)

Federal Involvement in Airfield Pavement Maintenance

10. Do you believe that AIP funds should be used for airfield pavement maintenance projects (e.g., crack/joint sealing, patching, seal coats, slab replacement)? (CHECK ONE AND THEN EXPLAIN BELOW)

1. [33] Definitely yes

2. [11] Probably yes

3. [1] No opinion

4. [4] Probably no

5. [1] Definitely no

11. Do you believe that you can currently use AIP funds for the following airfield maintenance projects?

	Yes	No
1. Crack sealing	[14]	[36]
2. Seal coats	[19]	[31]
3. Patching	[11]	[39]
4. Joint sealing	[18]	[32]
5. Slab replacement	[22]	[28]
6. Other (please explain)	[15]	[35]

12. Did your state apply for the AIP pilot maintenance program?

1. [10] Yes (CONTINUE)

2. [40] No (SKIP TO QUESTION 14)

13. If your state was accepted into the pilot program, what types of projects did you plan to include in the program? (PLEASE EXPLAIN BELOW OR ATTACH PROPOSAL, THEN SKIP TO QUESTION 15)

14. What were the reasons that your state did not apply for the AIP pilot maintenance program? (PLEASE EXPLAIN BELOW)

Comments

15. Please provide below, or on the back of this sheet of paper, any comments you might have about the AIP, airfield pavement maintenance, or the questions in this questionnaire.

Please provide the following information concerning the person responsible for completing this questionnaire, so that we may call to clarify information, if necessary.

Name: ____________________________

Title: ____________________________

Agency:____________________________

Telephone No:______________________

REMINDER: If available (and applicable), please send

1. A copy of the method of determining which airports receive state-funded (non-AIP) airfield pavement maintenance assistance.

2. Any research papers or articles describing your state's innovative maintenance activities.

3. A copy the criteria used to assign a rating to the runway pavement as part of the 5010 inspection

4. A copy of your state's proposal for the AIP maintenance pilot program

THANK YOU!

DEG
SERO/9-8-97
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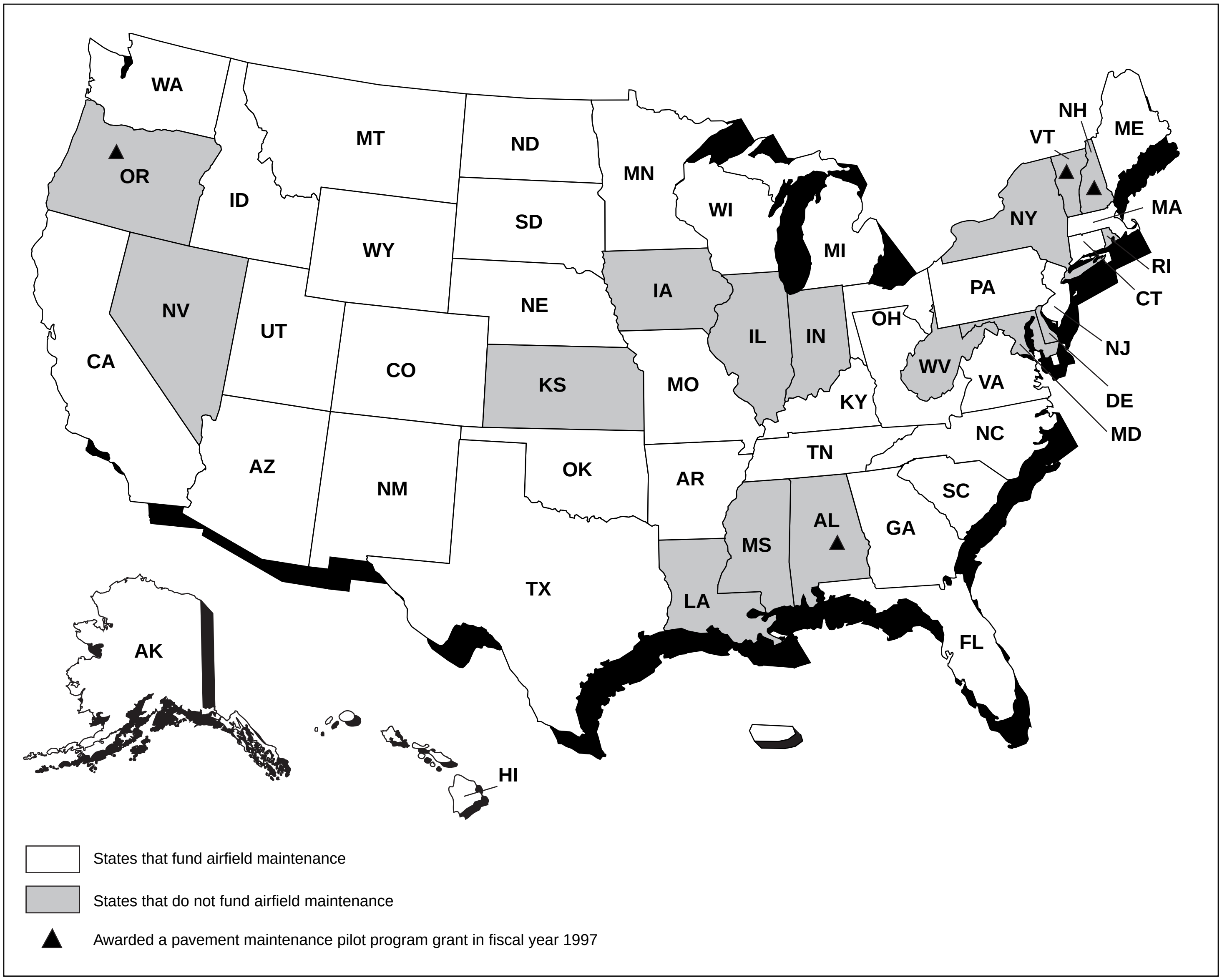
States With Airfield Maintenance Programs, as of September 1997



Pavement Advisory Panel Members

Robert Boyer, P.E.
District Engineer
Asphalt Institute

Margaret R. Broten, P.E.
Project Manager/Principal
Applied Pavement Technology, Inc.

Adil Godiwalla, P.E.
Chief, Airport Pavements
City of Houston
Department of Aviation

Stanley Herrin, P.E.
Manager, Airports
Crawford, Murphy & Tilly, Inc.

Jo Lary
President
Pavement Consultants, Inc.

Steven McNeeley
Chief Airport Engineer
Senior Airport Services Division
Virginia Department of Aviation

John E. Naughton III, P.E.
Director, Airports and Training
American Concrete Pavement Associations

Ed Oshinski, P.E.
Airport Engineer
Aviation Division
Texas Department of Transportation

George Schwandt, P.E. (Retired)
Chief Airport Engineer
City of Chicago, Department of Aviation

Mohamed Shahin
Principal Investigator
U.S. Army Construction Engineering Research Laboratories

Major Contributors to This Report

Robert Aiken
Sarah Brandt
Dana Greenberg
Barbara Johnson
Julia Rachiele
Sara Ann Moessbauer
Luann Moy
Stanley Stenerson
Mindi Weisenbloom
Pamela Williams
Randy Williamson

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