# Integrated Approach to Statewide Airport Management in the Commonwealth of Virginia

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To maintain a safe and efficient air transportation system, Virginia has implemented several management programs to enable the Department of Aviation to monitor and correct existing deficiencies and maximize the benefits received from limited budgets. The three systems discussed in this paper are (a) runway approach identification, (b) airport information management, and (c) pavement management. The runway approach identification system is used to identify obstructions to the approach surfaces for all hard surfaced public-use runways in Virginia. By using the photographs produced through this procedure obstructions are easily identified. The airport information management system is used to store information on an airport's property holdings, approach slope analysis, FAA Form 5010-1, runway and apron pavement data, grant tracking for planning and construction projects, and other valuable data used in airport management and planning. The pavement management system (PMS) is used to store and analyze pavement condition data. PMS provides a coordinated, budgeted, and systematic approach to programming maintenance and rehabilitation work.

All three systems have been of enormous assistance to the Department of Aviation by identifying, quantifying, and storing a large amount of information for quick and easy update and retrieval. The systems have been computerized to allow for ease and speed of the system. The integration of these management systems permits the Department of Aviation to consider all pertinent factors (pavement condition, runway obstructions, and property ownership within runway protection zones) when making decisions pertaining to Virginia's air transportation system.

Since 1928, the Commonwealth of Virginia has taken an active role in the development of an efficient air transportation system. When Virginia enacted its first law in 1928, the Commonwealth had 1 licensed aircraft, 8 airports, and 37 licensed pilots. In the following 64 years, aviation became an important part of Virginia's economic strength.

Virginia's air transportation system consists of 75 public-use airports and 1 heliport, shown in Figure 1. These airports link Virginia with commercial markets, serve as gateways for tourism, generate $1.3 billion in wages, and contribute $6.4 billion to the economic activity of Virginia (*1*).

Before implementing the three management systems, the Department of Aviation relied heavily on the sponsor's knowledge of aviation laws and regulations and their project justification when funding was requested. In most cases, the sponsors consist of some form of a commission or authority in which the members have been appointed by their respective governing bodies. These members may or may not be aviation oriented or familiar with aviation law, regulations, or the real needs of their facility. This lack of experience created problems. In some cases, projects that could have been delayed were funded. In other situations, sponsors should have requested funding for projects but were unaware of the conditions at their airport requiring correction. Safety violations were unrecognized and uncorrected. Paving projects were constructed too soon or too late. Questions of property ownership were raised. Was sufficient land owned for the project being requested? The Department of Aviation and the sponsors had no easy way to review pertinent documents when evaluating safety and capital improvement projects. The Department of Aviation did not have easy access to the necessary information without going through file after file of previous project documents.

As a result of a commitment and responsibility to maintain a safe and efficient system of air transportation, Virginia has implemented several management systems to enable the Department of Aviation to efficiently monitor and correct its deficiencies and take advantage of limited budgets. The three systems discussed in this paper are (a) runway approach identification, (b) airport information management, and (c) pavement management. All three systems have been of enormous assistance to the Department of Aviation by identifying, quantifying, and storing a large amount of information for quick and easy update and retrieval. All have been computerized to allow ease and speed of the system.

The runway approach identification system (*2*) is used to identify obstructions to the approach surfaces for all hard surfaced public-use runways in Virginia. By using the photographs produced through this procedure an airport authority can easily identify and remove obstructions. The airport information management system (AIMS) (*2*) is used to store information on an airport's property holdings, approach slope analysis, FAA Form 5010-1, runway and apron pavement data, grant tracking for both planning and construction projects, and other valuable data used in airport management and planning. The pavement management system (PMS) (*3*) is used to store and analyze pavement condition data. The program facilitates the development of annual maintenance plans and long-term (5 to 10 year) capital improvement programs.

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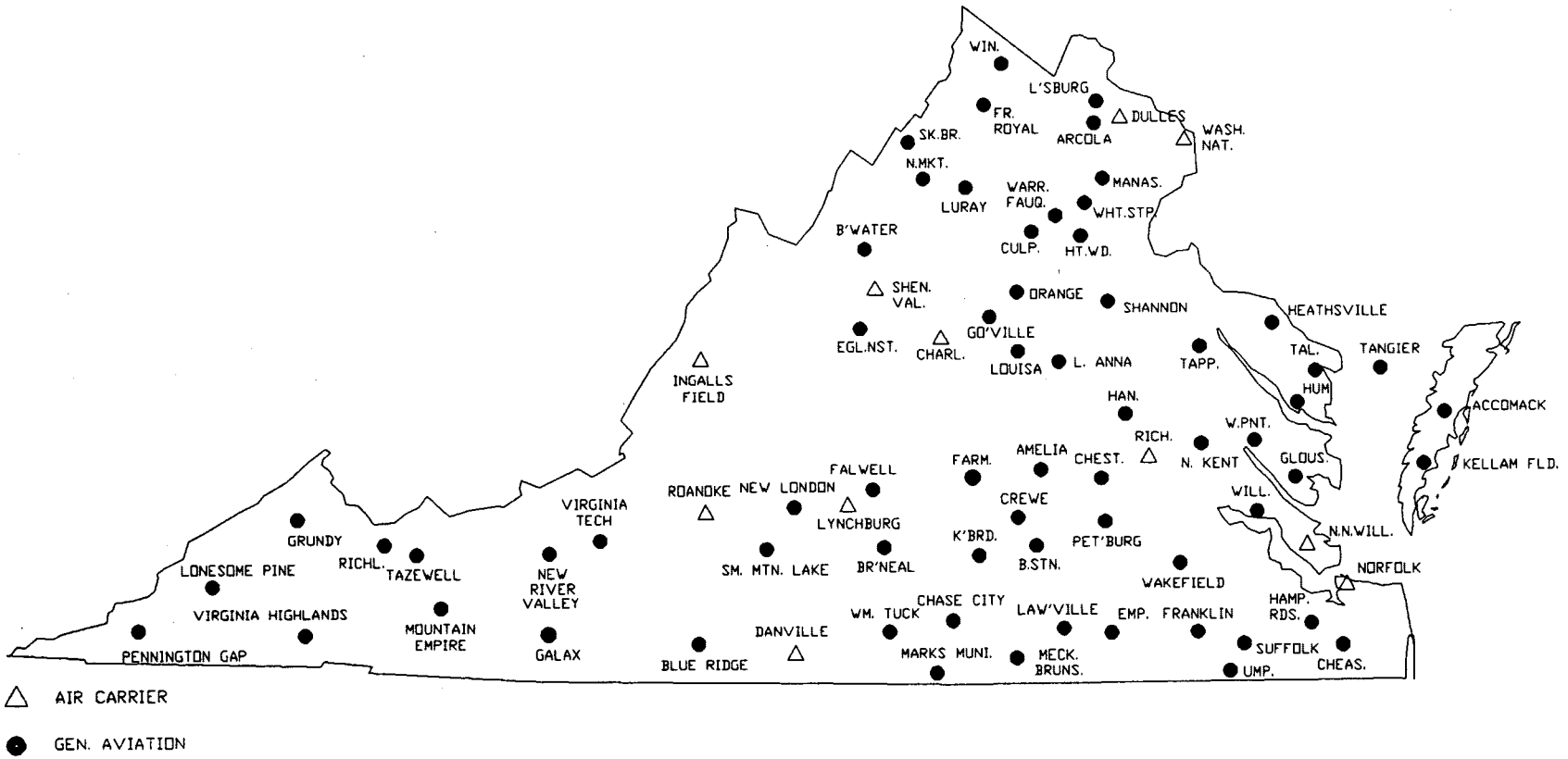


**FIGURE 1 Virginia air transportation system.**

## VIRGINIA RUNWAY APPROACH IDENTIFICATION SYSTEM

In 1986 the Virginia Department of Aviation determined that there was an urgent need to identify obstructions to the approach surfaces for all hard-surfaced public-use runways in Virginia. FAA is concerned about the presence of obstructions in runway approach surfaces, as stated in Federal Law (Section 18 of the Airport and Airway Development Act of 1970) (*4*) and FAA Advisory Circular 150/5300-13 (9/29/89) (*5*). Figure 2 draws an obstruction within the approach surface of a runway.

### Demonstration Project

In 1986 the Department of Aviation initiated a demonstration project at the Emporia Municipal Airport to investigate the usefulness of a process known as Photoslope in identifying obstructions. Photoslope, developed by G.C.R. & Associates, Inc., is a terrestrial photographic surveying process used to document the condition of a runway end approach surface in accordance with FAR Part 77 and FAA Form 5010 reporting procedures. The method uses a series of photographs to identify visually and mathematically any obstructions to the approach surface.

Photoslope takes traditional obstruction identification surveying methods one step further by attaching a camera to a precision theodolite. The result is a series of ground-level photographs that establish the plane and outside limits of the approach and transitional slopes. These "lines" can then be superimposed on the photos with a high degree of accuracy. The major advantage of Photoslope over traditional surveys is that it provides actual photographs—in correct perspective—as an end product.

Each runway end is evaluated to locate the most severe obstruction, and the approach slope required to clear that obstruction is calculated. The critical obstruction is located (identifying its distance from the runway end or primary surface, its distance left or right of the centerline, and its height and required slope to clear the obstruction) by digitizing the photographs and using triangulation procedures. Figure 3 shows the Photoslope procedure.

During the evaluation period of the sample project, several comparisons were made between traditional obstruction identification surveying methods and the Photoslope method.

- Unless an airport sponsor has a surveying or engineering background, it is often difficult for that person to understand the conventional method of plotted obstructions on a plan and profile view (as used in master plans). Photoslope makes it easy to show and describe the problem to the airport sponsor. If the sponsor then has to approach an adjacent property owner for obstruction removal, it is much easier to show the owner the extent of the removal required.
- By using Photoslope, whether the entire approach surface area was covered during the survey can be ascertained quickly simply by matching the photographs. Under the conventional method, the information is recorded in a field survey book by a surveyor who may have missed an obstruction, and there is no easy way to check the collected information.
- A cost analysis revealed that the difference between Photoslope and the conventional aerial photography was quite substantial (*6*). Photoslope costs approximately $1,700 per runway end; aerial photography costs $2,400 per runway end. The cost of updating the photographs is approximately $100 per runway end.

### Statewide Implementation of Photoslope

The results of the demonstration project confirmed that Photoslope provided an excellent way to detect the presence of obstructions within a runway approach surface. Because of the success of the sample project and the favorable comments of the airport authority of the Emporia Municipal Airport, the Department of Aviation decided to continue implementing the Photoslope process at the remaining public-use air-

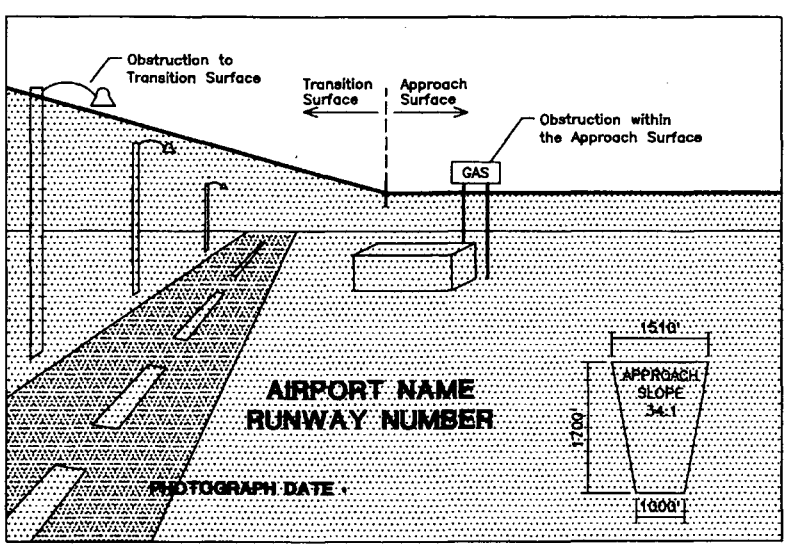


**FIGURE 2 Approach surface to a runway with an obstruction.**

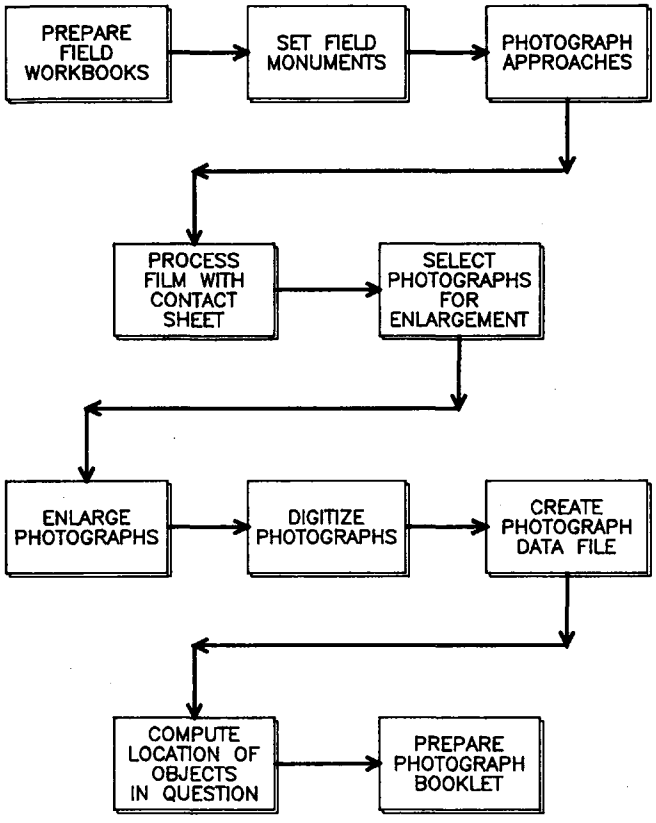


**FIGURE 3 Photoslope procedure.**

ports in Virginia. The first phase of the project consisted of 28 airports with 78 runway ends. The second and final phase consisted of 36 airports with 80 runway ends.

The steps in the Virginia runway approach identification system are as follows:

1. Verify the runway approach slope and width with FAA and the Virginia Department of Aviation.
2. Survey and establish at least three permanent monuments at each runway end for the airports identified for use of the Photoslope process.
3. Photograph approach surfaces using Photoslope.
4. Organize necessary vertical and horizontal data control to locate and size any violations or penetrations of the approach slopes observed in the photographs.
5. Specifically locate and size the most severe obstructions at each runway and calculate the approach slope required to clear them.
6. Prepare a field-work information sheet for each runway end, describing the exact location of permanent monuments and procedures required to photograph the approach surfaces for the runway end.
7. Prepare three copies of a Photoslope booklet that contains photographs depicting the status of the approach for each runway at the airports identified.

The Photoslope booklets and information sheets for each airport were presented in numbered, coded hanging files ready for placement in a 12-in.-wide drawer filing cabinet. Three sets of the Photoslope filing system were provided. One set for the FAA, one for the airport sponsor, and one for the Virginia Department of Aviation.

### Equipment and Training Needs

For future updating of data, the Department of Aviation purchased the following equipment and training.

- One T-16 Wild theodolite with tripod and one P-32 Wild Terrestrial Camera,
- Eight hr of classroom instruction in runway approach and transition surfaces with an introduction to how Photoslope identifies these surfaces,
- Eight hr of classroom and field training in the use of the T-16 theodolite and P-32 Terrestrial Camera, and
- Field training at selected airports.

### Summary

The Department of Aviation, with partial funding from FAA, contracted for 158 runway ends at 64 airports. This covered all the public-use hard-surfaced runways. The final product provided the Department of Aviation with LORAN coordinates as well as rectangular coordinates on each runway end and airport reference point. The total contract was more than $330,000 and the department purchased the equipment to update the photographs itself.

Within 1 year of the completion of the Photoslope Systems Plan in Virginia, which showed only two airports in the state to have clear approaches to all runway ends, more than 40 airports were clear of obstructions. This monumental task was accomplished because Virginia adopted and enforced regulations excluding an airport from receiving federal or state funds if there were obstructions to the runway approach surfaces. The program administered by Virginia allows airports to ask for and receive funding for airport improvements if the project contains "obstruction removal" as an item in the grant request.

Photoslope has enabled the Department of Aviation to evaluate, quantify, and correct the conditions of the runway approaches in Virginia. The Department, along with the airport sponsor, has begun clearing or mitigating obstructions to the approach surfaces. The photographs have made the decision of which objects need to be removed much easier for the sponsor. All comments from the sponsors have been favorable. Safety has been improved and will continue to be improved as a result of the Virginia runway approach identification system.

## VIRGINIA AIRPORT INFORMATION MANAGEMENT SYSTEM

In 1987 the Virginia Department of Aviation began a comprehensive inventory and assessment of public-use airports in the state to document approach surfaces and property ownership. This effort was initiated as a statewide aviation systems plan, and the results were intended to comply with FAA safety

standards. The Photoslope process was used to document runway approaches and the AIMS program was instituted to establish and verify land ownership.

In 1988 the Virginia Department of Aviation with FAA completed the initial phase of a systems plan program to identify obstructions to runway approaches using Photoslope. While establishing the status of the runway approaches at the subject facilities, it became evident that individual airports and, therefore, the Department of Aviation, lacked sufficient information on the properties owned, leased, or under easement rights. In addition, it was determined that a significant number of the runway approach obstruction problems are caused by insufficient control of the property surrounding the runway.

The AIMS program, developed by G.C.R. & Associates, Inc., was implemented to facilitate the retrieval of property information. It is a completely automated system that provides instant access to airport information. The system is specifically designed to meet the daily needs of individual airport sponsors and the Department of Aviation. The program includes information on an airport's property holdings, approach slope analysis, FAA Form 5010-1, runway and apron pavement data, grant tracking for planning and construction projects, and other valuable data used in airport management and planning. Through use of menu-driven screens, such information is immediately available and suitable for use on demand.

## AIMS Components

The purpose of the AIMS program is to provide documentation for the land currently owned by each airport and to compare this with the property interest that should be held to meet the operational requirements of the runways and their designated classifications. The program also establishes a consolidated file of all documents confirming the ownership or control of airport properties in conformance with FAA recommendations. In addition to the hard copy file folder, AIMS includes software that provides access to a data base containing information about the property owned or under the control of the airport and other general and technical information about the airport. AIMS components are as follows:

- Photoslope booklet,
- AIMS summary document,
- Property deeds folder, and
- AIMS software and computer data file.

### *Photoslope Booklet*

The Photoslope booklet is the result of the complete Photoslope process and contains all information necessary to duplicate the process and identify the controlling obstruction to the runway approach surface, and it contains the actual photographs for each runway end at the airport. The copy of the Photoslope booklet retained by the Virginia Department of Aviation has been restructured and is now an exhibit in the AIMS summary document prepared for each airport as a part of this current project. As part of the AIMS computer program, the Photoslope analysis and actual photographs for each runway end are also retained as a computer data file and are accessible for viewing on a VGA color monitor.

### *AIMS Summary Document*

The AIMS summary document is a three-ring binder prepared for each airport. It contains a synopsis of illustrations, summary information on the status of the runway approaches, and real estate files of the airport. An important product provided in the summary document is the property illustration map. This illustration identifies the total land area of the airport and each parcel acquired by the airport to establish the total area.

In addition to the various maps and illustrations of the airport, the Summary Document includes a copy of the Photoslope booklet and a summary of the property deeds folder. The maps and illustrations in this document are intended to assist the reader in visualizing the layout of the airport and provide access to the basic reference maps and drawings depicting the airport. Such information and maps are often used on a daily basis by airport managers, FAA, and Department of Aviation staff.

### *Property Deeds Folder*

The property deeds folder contains copies of the actual source documents confirming the airport's ownership of the land depicted on the property illustration map, which is established as a component of this study. It provides an illustration and a copy of the source documents (if found through the search of the files at the FAA, the Virginia Department of Aviation, or direct communications with the airport management) for individual parcels of land. The folder uses a cross-reference number system to match the source document to the parcel on the property illustration map. A property deeds folder was prepared for each airport and organized to provide an immediate, comprehensive filing system for the Virginia Department of Aviation to help maintain the real estate files. This organization is in accordance with FAA recommendations.

### *AIMS Software and Computer Data Files*

A major component of this project is the AIMS software and data files for each of the airports. The AIMS software is a user friendly menu-driven system that provides the user with access to a wealth of information about each airport in the system. The primary benefit of the AIMS software is that it converts data into information. Through the appropriate organization of data on airport facilities and operations, AIMS provides the user with a convenient and accurate means of obtaining managerial information for routine daily activity. The program software contains the following data.

- General airport information and layout illustration,
- Photoslope analysis and actual photographs,
- Property layout map and real estate files,

- U.S.G.S. quadrangle map,
- Aeronautical chart illustrating each airport,
- FAA Form 5010-1 information, and
- Construction and planning grant information.

In addition to providing access to the information for each airport, the AIMS program summarizes the information for queries at the state level to help the Department of Aviation view statewide statistics.

### AIMS Implementation

During the course of this study, a survey was mailed to each airport in the system plan. Although each airport was contacted directly by the consultant and the Department of Aviation, only 35 airports provided source documents or actual deeds confirming ownership of the airport properties. Most real estate information was obtained from FAA or Virginia Department of Aviation files. Through the efforts described it was realized that many airport sponsors did not have the proper documentation to confirm property ownership. As a continuation of this process, the Department of Aviation will strive to acquire all land documents available.

## VIRGINIA PAVEMENT MANAGEMENT SYSTEM

In September 1990, the Virginia Department of Aviation approved a contract with ERES Consultants, Inc., assisted by Pavement Consultants, Inc., for the implementation of a comprehensive PMS for airfield pavement evaluation and management. Sixty-one commercial, reliever, and general aviation airports were included in this study. The PMS implemented by the team members initially accessed the computer program Micro PAVER (*7*), developed by the Corps of Engineers, Construction Engineering Research Laboratory, and used supplemental budgeting and prioritization software created by ERES Consultants, Inc. The use of the Micro PAVER system was temporary, however, and was replaced by ERES' PMS software in the final delivery.

The work to meet the project objectives included gathering information pertaining to pavement history, defining the pavement network, conducting visual condition surveys, performing nondestructive deflection testing (NDT) on selected runway pavements, and establishing a PMS data base. Maintenance and repair (M&R) cost estimates and prioritization schemes were integrated into the PMS software, and computerized maps showing network layouts and condition ranges were developed. Individual airport reports were prepared and distributed to airport sponsors, the Department of Aviation, and FAA.

### PMS Overview

The four primary activities performed during pavement management are network inventory compilation, data base development, network data analysis, and project-level analysis. A network inventory includes information pertaining to the pavements under an agency's jurisdiction. Once the sectioning has been completed, a data base can be developed as a means of establishing an efficient filing system. Pavement management provides information for decision making at two distinct levels: (a) network level management and (b) project level management. Network level management involves the evaluation of all pavements under the Department of Aviation's jurisdiction to determine M&R needs into the future for the preparation of multiyear budget plans. When a section has been identified as a candidate for repair, it is evaluated at the project level. This analysis level requires detailed inspection sampling rates, often 100 percent. Other testing, such as NDT or coring, provides additional insight into pavement condition and distress mechanisms, which in turn is useful in selecting the proper corrective treatment.

Three pavement management philosophies are often applied today. The most commonly used and least sophisticated management approach involves selecting and applying repair alternatives that are familiar and have worked satisfactorily in the past. Unfortunately, this approach often precludes the consideration of many alternatives that may have, under further analysis, provided the most cost-effective solutions to a pavement problem.

An improvement on the first approach involves the evaluation of existing pavement distresses before the selection of feasible M&R alternatives. This approach allows consideration of all repair techniques that may correct the existing deficiencies and delay their recurrence. However, no consideration is given to the life-cycle cost. This approach may thus eliminate consideration of an alternative with high initial costs but low maintenance costs over its design life.

The preferred approach to pavement management, which the Virginia Department of Aviation selected, uses the results of the in-depth pavement evaluation and the development of representative deterioration models to predict future condition throughout a pavement's life. This pavement condition prediction in turn permits the comparison of various repair alternatives on a life-cycle cost basis over the design life of each alternative, resulting in better decisions on the basis of cost effectiveness.

For the preferred pavement management approach to work, an accurate projection of future pavement condition is required. The objective and repeatable indicator used to identify current condition is the pavement condition index (PCI). This index has been adopted by the FAA as an indicator of existing pavement condition (*8*). By projecting the rate at which the condition will change over time, a meaningful life-cycle cost analysis can be performed to compare the initial costs of various M&R alternatives and identify the future maintenance costs associated with each alternative under consideration. In addition to identifying the most economical repair alternative by condition-prediction modeling, the optimal time for applying treatments can be identified. Typically, the optimal repair time is the point at which a gradual rate of deterioration begins to increase at a much faster rate. It is critical to identify this important point to avoid higher M&R costs caused by excess deterioration.

### PMS Implementation

Although the Micro PAVER system is useful in storing and retrieving inventory and condition information, it did not pro-

vide the budgeting and planning capabilities the Department of Aviation required. Because of these limited capabilities, the department implemented the ERES' PMS system, which assists in the generation of customized annual and long-range plans.

On the basis of data stored in the data base, interviews with the Department of Aviation engineers, and engineering experience, the team identified the M&R alternatives being used by the airports and the unit costs associated with each of them. Customized deterioration curves were established for similar types of pavements on the basis of results of the PCI field surveys. Following this task, decision trees were constructed to determine the feasibility of each alternative on each type of pavement. Finally, a prioritization scheme was developed with the department to identify the highest priority pavements for the allocation of available funding.

### *Customized Deterioration Curves for Performance Prediction*

One of the first steps was to divide the network into groups of pavements that perform similarly. These groups are termed "families" and were developed to establish deterioration curves reflecting the actual performance of these pavement types (*9*). The families distinguished among asphalt runways, taxiways, aprons, and concrete pavements. The curves were further subdivided by airport type, grouping general aviation and reliever airports together and commercial airports as separate items. Because of a lack of data, all concrete pavements were grouped together to develop one curve. Expert points were added to three family curves to improve their prediction calculation at the point where pavements were 40 years or older.

The data were divided into two geographical regions to determine the impact of climate on deterioration patterns. It was found that the curves were not different enough to warrant separate modeling equations, particularly between pavements 0 to 30 years old. However, as additional performance data are collected, those curves will be examined again.

### *Repair Alternatives Module*

The next step in customizing the software involved determining rehabilitation alternatives to be considered to repair specific distresses. The applicability of applying these rehabilitation types in different situations and repairing different types of pavements was discussed, as were the impacts on the condition and typical costs. The unit costs for each alternative were broken down into two components. The first was initial cost of the repair per square foot and the second was the annual cost following the repair. These costs are used in the life-cycle analysis to determine the life cost of each alternative considered. This step in the customization process ensures that there is a direct applicability of the recommended treatments to the existing techniques used by the department.

### *Prioritization Module*

A prioritization scheme was then developed to assist in ranking pavement rehabilitation alternatives according to the practices used by the Department of Aviation. This technique enables M&R strategies to be performed on pavements in a more critical situation. By using these inputs, the software analyzes each section in the data base to determine whether it is eligible for repair. If so, each decision tree is evaluated to determine which alternatives are feasible for the particular conditions of the section being evaluated.

### *Budgeting and Planning Software*

A benefit/cost ratio is determined for each alternative, and the highest ranking ratio is selected as the recommended treatment for that particular section. Benefit is determined as the area between the section's deterioration curve, assuming no repair is done, and the new deterioration curve for the section, following the repair. Costs are determined on a life-cycle cost basis so that alternatives with differing useful lives can be evaluated on an equal basis. On the basis of the user input budget estimates and the department's prioritization scheme, the ratios are ranked for each year in the budget analysis.

A five-year capital improvement plan can be prepared using the Budget Optimization Program. For each individual airport, or the system as a whole, the budget report identifies feasible rehabilitation alternatives from the list of alternatives entered into the decision trees. The feasible alternatives for each section are evaluated on an automatic life-cycle benefit/cost analysis and then ranked in order from the most beneficial to the least beneficial on the basis of the pavement section's priority among other pavement sections and actual dollars available.

The software budgeting capabilities were customized to make the system useful to the department. The software was adjusted to make it possible to input the different type of airport (general aviation, reliever, or air carrier) so that separate reports could be run for different funding sources.

### *Maintenance Program*

An individual maintenance and repair policy was developed for the Virginia statewide airport data base from direct interviews with the Department of Aviation. Each data base contains the distresses, severity level for each distress, code for the maintenance and repair, and description of the maintenance and repair. The data base also contains the maintenance and repair policies for asphalt concrete and portland cement concrete pavements.

### *Computer-Aided Drafting Link to Data Base*

The final software delivery permitted generated reports to be linked with computer-aided drafting drawings of each airport, allowing all software outputs to be displayed graphically. This capability is unique in its flexibility and ease of use. The generated maps can be displayed on the screen or sent to a plotter or printer for use in presentations and reports. This feature is a powerful management tool, presenting information in a clear, concise, and easily understood format. These reports can be generated in a matter of seconds and provide

the type of information needed to justify budget expenditures and M&R alternative selections.

### Future Requirements

The usefulness of the information obtained from the PMS depends on the quality of the data being used. To maintain the integrity of the data base, it is the Department of Aviation's responsibility to ensure that the system continues to represent the environment under which it operates. To do this, several modules of the program should be reviewed periodically to keep the data in the system current. The items to be addressed are as follows:

- When pavement deterioration trends have been established, the condition of the pavements should be measured every 3 years;
- The treatment matrices should be reviewed each year to reevaluate treatment types and costs;
- Deterioration curves should be updated whenever new performance data become available;
- Maintenance policies should be reviewed annually to determine whether the maintenance activities and costs are still representative of conditions within Virginia;
- If rehabilitation projects alter the pavement management sections or new sections are added to the network, the system should be modified; and
- Any major M&R performed should be stored in the data base.

### PMS Summary

With the completion of this study, the Virginia Department of Aviation has a state-of-the-art PMS in house and operational. It contains an up-to-date data base and is easily operated by the staff. Through this program, the department is able to select specific rehabilitation methods based on engineering and economic considerations. In addition, the program will help the state and FAA prioritize pavement rehabilitation work. Because the system establishes a time frame for rehabilitation work, it will enable the sponsor, state, and FAA to better budget and allocate funds. In addition, it will enable the Department of Aviation to better use its existing maintenance program, which provides funds for extending the life of pavements through routine maintenance. The PMS will provide a coordinated, budgeted, and systematic approach to programming maintenance and rehabilitation work.

## INTEGRATION OF THREE AVIATION MANAGEMENT SYSTEMS

The three management systems are used in conjunction to help the Department of Aviation evaluate capital improvement projects for funding. These systems enable the Virginia Department of Aviation, with limited financial resources, to make sound decisions when funding projects while maximizing the use of tax dollars. The computerized systems also allow the department to easily and readily access enormous amounts of valuable information on the 75 public-use airports in Virginia. This quick access of information contributes to the speed at which the staff can respond to a sponsor's need for assistance, which enhances the working relationship.

## CONCLUSION

The Virginia Department of Aviation has determined that the three systems discussed in this paper, Photoslope for runway obstruction identification, the AIMS program for property ownership identification, and the ERES PMS software for pavement maintenance and rehabilitation programming, have all proved to be powerful management and planning tools. The integration of these systems allows the Department of Aviation to rapidly consider all pertinent factors (pavement condition, runway obstructions, and property ownership within runway protection zones) when making decisions pertaining to Virginia's air transportation system. The facilitation of the decision-making process is important because the condition of the aviation system directly affects the economy of Virginia.

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