Unit 1
What is a Pavement Management System?
What is a Pavement Management Program?

• Defined in FAA Advisory Circular 150/5380-7B
  – Specifies the procedures to be followed to assure that proper preventative and remedial pavement maintenance is performed

• Public Law 103-305, section 107, amended Title 49, Section 47105 of the United States Code
  – To be eligible for federal funding, an airport agency must implement an effective pavement maintenance management program
Pavement Management Programs Must Include:

• Pavement Inventory
  – Location, type of pavement, dimensions, construction date

• Inspection Schedule
  – Detailed inspection must be performed at least once a year (3 years if PCI is used)
  – Less detailed inspection periodically (daily, weekly, monthly)

• Record Keeping
  – Inspection date, location, distress types, maintenance scheduled or performed

• Information Retrieval

• Program Funding
What is an Airport Pavement Management System?

- Discussed in FAA Advisory Circular 150/5380-7B
  - A system which identifies optimum strategies to maintain pavements at an adequate level of serviceability
  - Includes systematic procedures for scheduling maintenance and rehabilitation activities
  - Optimizes benefits while minimizing cost
## Benefits of an Airport Pavement Management System

<table>
<thead>
<tr>
<th>Provides</th>
<th>Identifies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective and consistent evaluation of pavement conditions</td>
<td>Budget requirements necessary to maintain pavements at various levels of serviceability</td>
</tr>
<tr>
<td>Systematic and documentable engineering basis for determining maintenance and rehabilitation needs</td>
<td>Impact on the pavement network as a result of performing no major repairs</td>
</tr>
<tr>
<td>Documentation on the present and future condition of the pavements in a network</td>
<td>Life-cycle costs for various maintenance and rehabilitation alternatives</td>
</tr>
</tbody>
</table>
• First several years of life: low deterioration
• At a certain point in time: deterioration accelerates
• Preventive maintenance early in pavement life is more cost effective than major maintenance later in life
• Determine the optimum time to effectively apply funds
In 1968, CERL begins development of a mainframe PMS for the DOD. The first version is completed in 1972.

By 2004, 84% of state aviation agencies in the US use an APMS.

In 1985, the FAA funds CERL to develop a microcomputer version of PAVER, named MicroPAVER. The first version is released in 1987.

February 2011, FAA releases a beta of FAA PAVEAIR, a public web-based APMS.

May 2016, FAA releases FAA PAVEAIR 2.6.

June 2012, FAA releases FAA PAVEAIR 2.0.

*CERL (U.S. Army Construction Engineering Research Laboratory)*
New for 2016

• Improved prediction modeling
• LCCA on server, not Excel
• Family curves integrated into M&R and Condition Analysis
• Change to comply with FAA web template
• Updated default costs
• Stored PCI values
Unit 2
FAA PAVEAIR Basics
About FAA PAVEAIR

- Airport Pavement Management System
  - Publicly available and free to use (source code available)
    - Branch website
    - [http://www.airporttech.tc.faa.gov](http://www.airporttech.tc.faa.gov)
  - Data can be made “public” or “private”
  - Includes similar functionality found in MicroPAVER version 5.3
- Web-based
  - Access though the Internet, company Intranet, or a stand-alone PC
- Regional Settings
  - English / Metric
Primary Functions

- **Inventory**
  - Manage Pavement Inventories
- **Work**
  - Record Pavement Work Histories
- **PCI / Update Inspections**
  - Calculate PCI / SCI / FOD
  - Record Condition Surveys
- **Prediction Modeling**
  - Predict future pavement conditions
  - Plot PCI vs. Age
- **Condition Analysis**
  - Provides projections about the viability of pavements
- **Maintenance and Repair Planning**
- **Reports / Maps**
  - Generate reports
  - Mapping support with shapefiles
- **Compatibility**
  - Import data from MicroPAVER (e60, e65)
  - Export data to XML
Versions

• Three supported configurations
  – FAA Hosted version (http://faapaveair.faa.gov)
  – Intranet Version
  – Locally Installed version

• National Airport Pavement Test Facility
  – http://www.airporttech.tc.faa.gov
  – Additional information
  – Setup files
  – Source code
User Accounts / Databases

• Registered Users
  – Create Database
    • Multiple databases supported
    • New database or import from MicroPAVER
    • Choose to make data “Public” or “Private”
  – Manage Database
    • Delete database
    • Change between “Public” and “Private”
    • Assign permissions to other registered users
Pavement Hierarchy

- **Pavement Network**
  - High-level grouping of an organization’s pavements for the purposes of maintenance and repair planning
  - Examples: Ohio State University Airport, JFK Airport

- **Pavement Branch**
  - Identifiable area of a pavement network having a distinct function
  - Examples: Runway 9L, Taxiway D, Apron

- **Pavement Section**
  - Subdivision of a branch with uniform construction, maintenance, usage, condition, traffic volume, and load intensity conditions
  - Example: Section A (Runway 32 end to 3,013’ west)
Create a User Account and Pavement Database

• Purpose
  – Create a user account
  – Create a new blank database
  – Set English / Metric unit preferences
Create a User Account and Pavement Database

1. From the “Home” page, click on the “Register” link in the “Login” box.

![Login form]

1. Fill out the “User Information” form and click “Next”.

![User Information form]

2. Fill out the “User Name and Password” form. Here is where you will choose the username and password you will use to access the system. The “security question” and “security answer” are used in case you need to recover your password. Once completed, click the “Create User” button.

![User Name and Password form]
Create a User Account and Pavement Database

1. Create a new blank database

2. Open FAA PAVEAIR and log in to your account.

3. Select “Member Area” from the Navigation Bar.

4. Click on the “Create Database” link.

5. Choose a name and description for your database and enter it in the form. In order to easily identify your database from the other participants’, it is recommended you use your last name and first initial followed by “_UserDB1” as your database name. For this lab, choose “Public” and select “No. I will enter data manually”, then press the “Create Database” button.
Importing MicroPAVER Data

• Importing MicroPAVER Data
  – Create an e65 file in MicroPAVER
    • Paver Database Tools
  – Create a new FAA PAVEAIR database
    • Choose to import database from a MicroPAVER e65 file
Importing MicroPAVER Data

Go to “Member Area” and Click on “Create Database” again.

User Profile and Data Management Page

- Update Profile
- Change Password
- Create Database
- Manage Database
- Inventory Update
- Work Update
- Update Inspection
- Upload Shapefiles
- Map Assignment Tool
- LCCA
- Roughness Profile Data

Importing MicroPAVER Data

- Create Database
- Database name: Lastf_User03
- Database Description: Seminar database
- Public
- Private
- Database Options
  - Would you like to import data from a MicroPAVER e55e60 file?
  - No. I will enter data manually
  - Yes. Import a MicroPAVER e55e60 file
- MICROPAVER data upload
  - Choose a MicroPAVER e55e60 file
  - Browse
  - No file selected
- Create Database
Importing MicroPAVER Data

When complete, you will see the message “The database is created successfully.” Click FAA PAVEAIR Home to select your database.
Unit 3
Assessing Pavement Condition
Pavement Condition Surveys
Inspection Process

• ASTM D 5340-12 and ASTM D 6433-10
  – Provides step-by-step process for identifying distresses, filling out survey forms, and calculating section PCI

• Create Sample Units
  – Divide pavement sections into Sample Units for Inspection

• Determine the Number of Sample Units
  – Calculate the minimum number of sample units that must be inspected

• Record Distresses
  – Condition Survey Forms

• Enter Inspection Data
  – Enter inspection data into FAA PAVEAIR’s Update Inspection module
Updated ASTM Standards

ASTM D5340-12 and ASTM D6433-10 identify new distresses and their deduct curves. FAA PAVEAIR has been updated to reflect these changes.

### ASTM D6433-09 - Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys

<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Old Distress</th>
<th>New Distress</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>20. Weathering</td>
</tr>
</tbody>
</table>

### ASTM D5340-10 - Standard Test Method for Airport Pavement Condition Index Surveys

<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Old Distress</th>
<th>New Distress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt</td>
<td>12. Weathering / Raveling</td>
<td>12. Raveling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17. Weathering</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Old Distress</th>
<th>New Distress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>10. Scaling / Map Crack / Crazing</td>
<td>10. Scaling / Map Crack / Crazing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16. Alkali Silica Reaction (ASR)</td>
</tr>
</tbody>
</table>
# Types of Distresses

## Distress Codes (AC)

1. Alligator Cracking
2. Bleeding
3. Block Cracking
4. Corrugation
5. Depression
6. Jet Blast
7. Joint Reflection (PCC)
8. Long & Trans. Cracking
9. Oil Spillage
10. Patching
11. Polished Aggregate
12. Raveling
13. Rutting
14. Shoving from PCC
15. Slippage Cracking
16. Swell
17. Weathering

## Distress Codes (PCC)

1. Blow up
2. Corner Break
3. Long / Trans / Diagonal Crack
4. Durability “D” Crack
5. Joint Seal Damage
6. Patching (Small)
7. Patching (Large) and Utility Cut
8. Popouts
9. Pumping
10. Scaling / Map Crack / Crazing
11. Settlement / Fault
12. Shattered Slab
13. Shrinkage Crack
14. Spalling-Joints
15. Spalling-Corner
16. Alkali Silica Reaction (ASR)
Distress Guide

- Part of the “Help” system
- High resolution color pictures
- Shows distresses at high, medium, and low
- Explains how to properly measure each distress
Distress Deduct Curves

- View deduct curves for each distress
- Deduct value details
- Spine interpolation equation
Create Sample Units

• Divide pavement sections into sample units for inspection
  – Asphalt
    • Subdivide into sample units consisting of 464.5 m² (5,000 ft²) of contiguous area (± 186 m²)
  – Concrete
    • Subdivide into sample units consisting of 20 contiguous slabs (± 8 slabs)
Determine Number of Sample Units

• Total Sampling
  – Total sampling is desirable for project analysis
  – May not be feasible for routing management due to manpower, funds, and time required

• Partial Sampling
  – Calculate the minimum number of random sample units $n$ that must be surveyed to obtain a 95% confidence level

$$n = \frac{Ns^2}{\left(\left(\frac{e^2}{4}\right)(N - 1) + s^2\right)}$$

- $e$ = acceptable error in estimating the section PCI; ± 5 PCI points
- $s$ = standard deviation of the PCI from one sample unit to another; assumed to be 10 for AC pavements and 15 for PCC pavements
- $N$ = total number of sample units in the section
Record Distresses

- Record distresses using the procedures documented in ASTM D5340-10 and ASTM D 6433-09
  - Divide pavements into sample units
  - Perform condition survey of sample units
  - Record distresses, severity, and quantity on survey data sheets

- Print survey data sheets from FAA PAVEAIR’s Update Inspections Module
  - Distresses for Asphalt Pavements
  - Distresses for Concrete Pavements
Enter Inspection Data
Update Inspection

- Input / update inspection data from Condition Surveys
- PCI button
  - Calculates section condition (PCI)
  - Displays distress, deduct, and PCI details
Pavement Condition Index (PCI)

- FAA PAVEAIR uses the procedures documented in ASTM D5340 to calculate PCI
- Developed by the US Army Corps of Engineers
- Quantify Airport Pavement Condition
- Numerical rating of the pavement condition

<table>
<thead>
<tr>
<th>PCI</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>Good</td>
</tr>
<tr>
<td>85</td>
<td>Satisfactory</td>
</tr>
<tr>
<td>70</td>
<td>Fair</td>
</tr>
<tr>
<td>55</td>
<td>Poor</td>
</tr>
<tr>
<td>40</td>
<td>Very Poor</td>
</tr>
<tr>
<td>25</td>
<td>Serious</td>
</tr>
<tr>
<td>10</td>
<td>Failed</td>
</tr>
</tbody>
</table>
Unit 4
Predicting Pavement Performance
Prediction Modeling

• Collect Model Data
  – Group pavement sections of similar construction and with similar traffic patterns
• Review Model Data
• Use Boundary / Outlier
  – Filter out erroneous data points
• Options
• Prediction Curve
  – Plot predicted PCI vs. Age
Definitions from Research

• **Serviceability:** Comparison of pavement’s actual behavior and performance to an expectation
  - Does this pavement do what we want?
  - Not an inherent property since it is a comparison

• **Distress:** A condition or property that reduces serviceability

• **Performance:** Change in serviceability with time

• **Failed:** No longer meets expectations

• **Condition:** A quantification of serviceability to enable repeatable assessment and comparison of pavement
Condition Analysis

• Provides projections about the viability of pavements
• Analysis based upon:
  – Prior inspection data
  – Comparison of values between previous inspections
  – Projected conditions
• Graph PCI vs. Age
Unit 5
Maintenance and Repair Planning
Maintenance and Repair Planning

- **Scope**
- **Timing**
- **Plan Mode**
  - Critical PCI Method
  - Minimum Condition
  - Consequence of Local Repair
- **Policies**
  - Apply Inflation Rate
  - Apply Policy in First Year
  - Global
- **M&R Data**
  - Applied Policy Consequence
  - Applied Policy Details
  - Inventory Info
Customizable M&R Settings

• Localized M&R
  – Policy
  – Work Type / Cost
  – Work Consequence
• Global M&R
  – Policy
• Major M&R
  – Minimum Condition
  – Branch Use Priority
  – Section Rank Priority
  – Major M&R Priority
• Cost by Condition
  – Cost by Condition
  – Budget
Critical PCI Method

• Critical PCI
  – PCI value after which a pavement rapidly deteriorates
  – Usually between a PCI number of 70 and 55

• More economical to maintain pavements above rather than below the Critical PCI
  – The cost of applying localized preventive maintenance increases significantly
Minimum Condition

- Minimum Condition
  - Only concerned with the Major M&R required to maintain a minimum PCI
    - Major M&R: Any overlay or other major work that results in a PCI of 100
  - Select the lowest pavement condition that is allowed for each pavement rank
  - Prioritize the Maintenance and Repair plan to reflect the choice of “Minimum Condition” as the variable for decision making in regard to future work
• Consequence of Local Repair
  – Calculates the cost and resulting condition from the immediate implementation of local maintenance and repair.
  – M&R actions are based on current distresses and their severity.
  – Consider this plan mode for pavements above Critical PCI.
Mapping

- Add a shape file to the current database
  - Use the “Upload Shapefiles to Current DB” tool

- Import a shape file from MicroPAVER
  - Shapefiles are imported with MicroPAVER data

- Shape file assignment tool
  - Allows the assignment of pavement sections to shape file objects
  - Non-concurrent sections are supported
Reporting

• Available Reports
  – Branch Listing Report
  – Work History Report
  – Branch Condition Report
  – Section Condition Report
  – Re-Inspection Report
• View, print, or export in Adobe PDF or Microsoft Excel format
• Condition Reports support additional mapping features
Life Cycle Cost Analysis

- Shares data with the AAPTP AirCost LCCA application
- Economic Analysis
  - Evaluate the long-term economic efficiency between different pavement design strategies
- Procedures
  - Establish alternative pavement design strategies
  - Determine the performance period and activity timing
  - Estimate costs
  - Compute Net Present Value (NPV)
  - Analyze results
  - Re-evaluate pavement design strategies
Life Cycle Cost Analysis

• Purpose
  – To demonstrate how to work with LCCA plans
  – Show how FAA PAVEAIR links with the AirCost application
1. Select “Member Area” from the Navigation Bar.

2. From the Member Area, click the LCCA link.

3. The “Add New” and “Delete” buttons are used to create and delete your LCCA projects. For this demonstration we will use the “Springfield Regional Airport” sample LCCA plan included with FAA PAVEAIR. From the Select Airport/ Project dropdown box, select “Springfield Regional Airport”.
4. The “Airport Information” tab displays general information about your airport. The “Edit” link is used to update this information.

5. The “Project Detail” tab is used to record the details regarding the category of work to be performed. The “Edit”, “New”, and “Delete” links are used to manage your Project Details.
6. The LCCA Parameters tab is used to modify the LCCA input parameters used for the simulation. Use the “Select project feature/facility ID” dropdown list to select our “Runway 5/23” project.

<table>
<thead>
<tr>
<th>Analysis Base Year</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Construction Year</td>
<td>2018</td>
</tr>
<tr>
<td>Analysis Period</td>
<td>50</td>
</tr>
<tr>
<td>Salvage Value</td>
<td>Prorated Life</td>
</tr>
<tr>
<td>Administrative Cost</td>
<td>5.00%</td>
</tr>
<tr>
<td>Engineering Cost</td>
<td>5.00%</td>
</tr>
<tr>
<td>Maint. of traffic Cost</td>
<td>5.00%</td>
</tr>
</tbody>
</table>

7. The “Analysis Variables tab is used to select the type of Discount Rate (Deterministic, Normal Probabilistic, Uniform Probabilistic, or Triangular Probabilistic), Service Life, and Pay Item Unit Costs.

<table>
<thead>
<tr>
<th>Select project feature/facility ID</th>
<th>Runway 5-23</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCCA Parameters</td>
<td>Analysis Variables</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Discount Rate</th>
<th>Deterministic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.75%</td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>0.00%</td>
</tr>
<tr>
<td>Service Life</td>
<td>Normal Probabilistic</td>
</tr>
<tr>
<td>Pay Item Unit Costs</td>
<td>Deterministic</td>
</tr>
</tbody>
</table>

**Analysis Variables**

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Discount Rate</strong></td>
</tr>
<tr>
<td><strong>Service Life</strong></td>
</tr>
<tr>
<td><strong>Pay Item Unit Costs</strong></td>
</tr>
</tbody>
</table>
The "Iteration Control" tab is used to control the accuracy and running time of the analysis, as well as which results to report.

<table>
<thead>
<tr>
<th>Indirect/User Costs</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Iterations</strong></td>
<td>Maximum number of repetitions in the simulation</td>
</tr>
<tr>
<td><strong>ConvTol</strong></td>
<td>How precise must the results be? Lower numbers indicate higher precision and require longer run times</td>
</tr>
<tr>
<td><strong>Percentile1</strong></td>
<td>Percentile of first reported result. The cost for which Percentile1 percent of the simulations were lower.</td>
</tr>
<tr>
<td><strong>Percentile2</strong></td>
<td>Percentile of first reported result. The cost for which Percentile2 percent of the simulations were less expensive.</td>
</tr>
<tr>
<td><strong>Percentile3</strong></td>
<td>Percentile of first reported result. The cost for which Percentile3 percent of the simulations were less expensive.</td>
</tr>
<tr>
<td><strong>Percentile4</strong></td>
<td>Percentile of first reported result. The cost for which Percentile4 percent of the simulations were less expensive.</td>
</tr>
</tbody>
</table>
10. The “Pay Item Cost” tab is used to manage the material library for inclusion in events and alternatives.

11. The “Create Alternatives” tab allows you to create up to four different scenarios for analysis.
Life Cycle Cost Analysis

11. The “Create Alternatives” tab allows you to create up to four different scenarios for analysis.

12. Click on “Alternative 1”. From the dropdown box select the Life-Cycle Event: “Initial construction”. We now view and edit the specifics for the plan. For this demonstration, the “Initial construction” and “Rehab 1” events have been pre-defined. Click the “Back to LCCA” button.
13. A queueing system is used to manage analysis runs. This allows users to set up multiple analyses and have them run in the background. Analyses are listed in the analysis grid. The status of each analysis is shown. “Not Submitted” indicates that the analysis has not been finalized and submitted to the analysis module. “Queued” indicates the analysis has been finalized and submitted, but results have not been calculated. “In Progress” indicates the results of that analysis are currently being calculated. “Complete” indicates the results are ready for viewing. To queue an analysis, select it from the “Select project feature/facility ID” drop down and press “Add New Row”. A new row is added to the analysis grid.
14. Click the “Submit” button to submit the parameters to the analysis engine. Any changes made in the analysis parameters made after clicking “submit” will not be reflected in the results.
15. Click the “Run Analyses” to start the analysis engine. Results will be calculated for all analyses with the status of “Queued”.
16. Click “Results” to see the results of the analysis.

<table>
<thead>
<tr>
<th>Project</th>
<th>Status</th>
<th>Report Date</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC2</td>
<td>Completed</td>
<td>5/8/2016 7:47:35 PM</td>
<td>Delete Results</td>
</tr>
<tr>
<td>Runway</td>
<td>Completed</td>
<td>5/8/2016 7:47:35 PM</td>
<td>Delete Results</td>
</tr>
<tr>
<td>Springfield Regional Airport</td>
<td>Queued</td>
<td>5/12/2016 11:11:34 AM</td>
<td>Delete</td>
</tr>
</tbody>
</table>
17. Data can also be exported to the AAPTP AirCost spreadsheet and run locally using the “Generate AirCost” button, but the LCCA routine built into PAVEAIR runs in approximately 10% of the time of the spreadsheet version.
Roughness Profile Data

- Store Airport Pavement Roughness Profile Data
  - Store computed BandPass, Boeing Bump, IRI, and Profile Index
  - Store RAW data in database (\texttt{.pro, .csv, .txt})
- Download stored RAW data
Sharing Data

- Importing Data
  - MicroPAVER e65 files
  - Existing shapefiles will be imported

- Exporting Data
  - Tools: Database Export
  - Export to XML
Road Map

Road Map: 2016 - 2018
- PCI Performance Enhancements
- Prediction Modeling Library
- Non-PCI Models
- FAA Pavement Software Conversions
  - WPF versions of COMFAA, BAKFAA, FAARFIELD, FEAFAA, ProFAA, and ProGroove

Road Map: 2018 +
- Improved LCCA Model
- Traffic Module
- Climatic Module
- Integration of FAA applications
  - BAKFAA (Strength Evaluation)
  - COMFAA (PCN Load Rating)
  - FAARFIELD (Thickness Design)
  - ProFAA (Roughness Condition Evaluation)