Airport Pavement 10-Year R&D Program

A $129M Investment in Airport Pavement

AIRPORT PAVEMENT 10-YEAR R&D PROGRAM MILESTONE												
Fiscal Year	12	13	14	15	16	17	18	19	20	21	22	Total Cost ($M)
Airport Pavement Design ($35M)												
Project No. 1: Extending Design Life to 40 Years for Airport Pavements												4.5
Project No. 2: Semi-Accelerated Full-Scale (SAFS) Rigid Pavement Test												5.0
Project No. 3: Validated Reflection Cracking Model for HMA Overlay Design												6.0
Project No. 4: Failure Criteria for Top-Down Cracking in Rigid Airport Pavements												3.0
Project No. 5: FAARFIELD-Based ACN/PCN Methodology												4.5
Project No. 6: New LCCA Integrated Design Procedures												12.0
Airport Pavement Materials ($42M)												
Project No. 1: Advanced Characterization of Paving Materials												22.0
Project No. 2: Use of Additives and Nanoparticles to Improve Performance of Airport Pavement Materials												5.0
Project No. 3: Use of Data and Results From Airport Pavement Instrumentation and Field Testing Studies												15.0
Airport Pavement Evaluation ($52M)												
Project No. 1: Improvements to FAA Airport Pavement Software Programs												14.5
Project No. 2: Development of New Roughness Standards for In-Service Airport Pavement												3.0
Project No. 3: Pavement Surface Profile Data Collection, Processing, and Analysis												11.0
Project No. 4: Nondestructive Pavement Testing												23.5

Airport Pavement 10-Year R&D Program

- Airport Pavement Design
  - David Brill/Yuanguo Chen
    - Six (6) R&D projects
- Airport Pavement Materials
  - Navneet Garg/Harkanwal Brar
    - Three (3) R&D Projects
- Airport Pavement Evaluation
  - Al Larkin/Injun Song
    - Four (4) R&D Projects

FAA Airport Pavement R&D Ten-Year Program

Airport Pavement Design

Federal Aviation Administration

Presented to: Airport Pavement Working Group Meeting

By: David R. Brill, P.E., Ph.D., FAA (ANG-E262) & Yuanguo Chen, Ph.D., SRA International

Date: April 17, 2013

Summary – Airport Pavement Design

Fiscal Year	12	13	14	15	16	17	18	19	20	21	22	Total Cost ($M)
Airport Pavement Design ($35M)												
Project No. 1: Extending Design Life to 40 Years for Airport Pavements												4.5
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Project No. 6: New LCCA Integrated Design Procedures												12.0

Extending Design Life to 40 Years for Airport Pavements

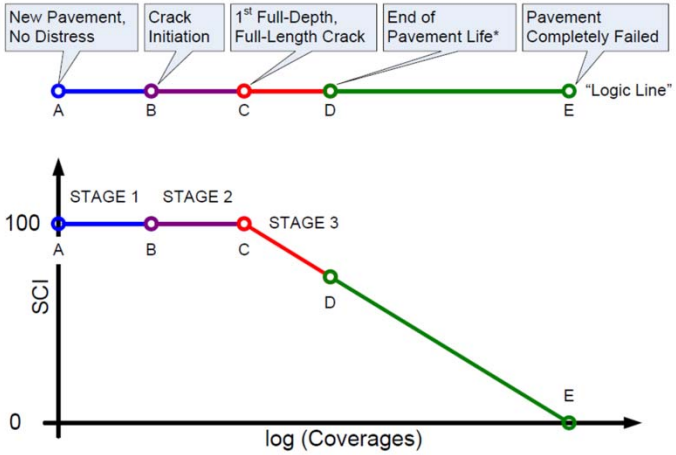
- **AAS has requested new methodologies extending life of runway pavements at large hub airports from 20 to 40 years.**
- **Current designs cannot reasonably be extended beyond 20 years.**
- **Expanded pavement life definition will incorporate functional as well as structural indexes.**
- **Expected life cycle cost savings to the AIP.**

Extending Design Life to 40 Years for Airport Pavements

- **Methodology for 40-year pavement design will combine:**
  - New pavement performance models;
  - Improved material properties and mix designs;
  - Innovative maintenance strategies;
  - Life cycle cost analysis (LCCA).
- **Long-term study of performance data from large- and medium-hub runway pavements in service (currently in progress).**
- **Expected Completion: FY 2016**

Semi-Accelerated Full-Scale (SAFS) Rigid Pavement Test

- **Previous rigid full-scale tests were characterized by relatively short trafficked periods (1 year or less).**
- **SAFS test is planned for 5 years (trafficking part of each year).**
  - Allows thicker PCC slabs (15 – 16 inches) with more realistic joint spacing.
  - Produces reliable rigid failure data in the 100,000 coverage range (more representative of 40-year life).
  - Provides missing data on fatigue damage during the first phase of service life.

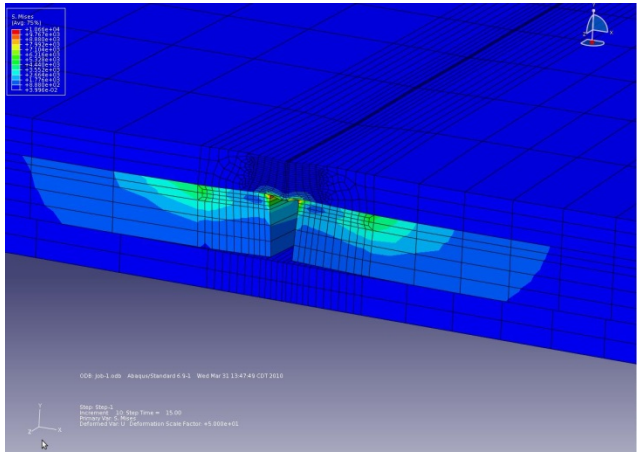


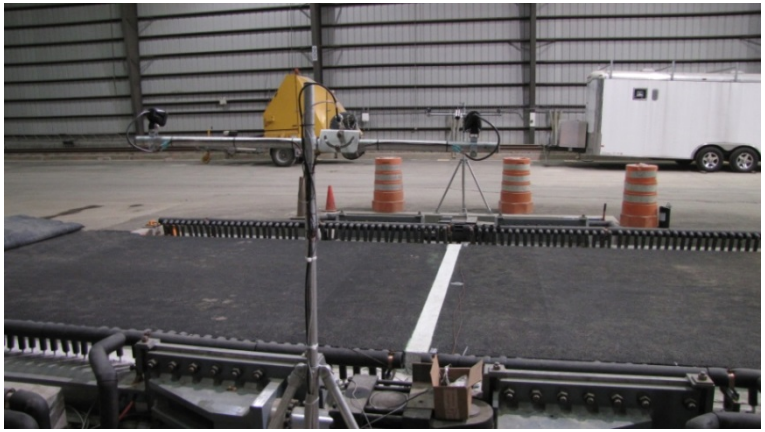
Semi-Accelerated Full-Scale (SAFS) Rigid Pavement Test

- **Major output will be a rigid pavement failure model uniting three phases of pavement deterioration:**
  - Phase 1 - from new construction to micro fatigue damage initiation;
  - Phase 2 - from fatigue damage initiation to the first visible cracks;
  - Phase 3 - from first visible crack to the end of the structural life (full failure).
- **Expected completion: FY 2020 (follow-on to CC8).**

Validated Reflection Cracking Model for HMA Overlay Design

- **Goal is to produce a reliable life prediction model for overlays based on reflection crack growth.**
- **FAARFIELD currently lacks such a model.**
- **Output will be a new overlay failure model that can be directly implemented in the overlay design procedure in all future versions of FAARFIELD.**





Validated Reflection Cracking Model for HMA Overlay Design

- **Three-pronged R&D approach:**
  - Testing using the indoor NAPTF reflection cracking rig;
  - Generalized finite element model (GFEM) previously developed by CEAT at the University of Illinois Urbana-Champaign;
  - Outdoor tests on asphalt-on-rigid overlay structures using the new FAA heavy vehicle simulator for airport pavements (HVS-A).
- **Expected completion: FY 2018.**

Failure Criteria for Top-Down Cracking in Rigid Airport Pavements

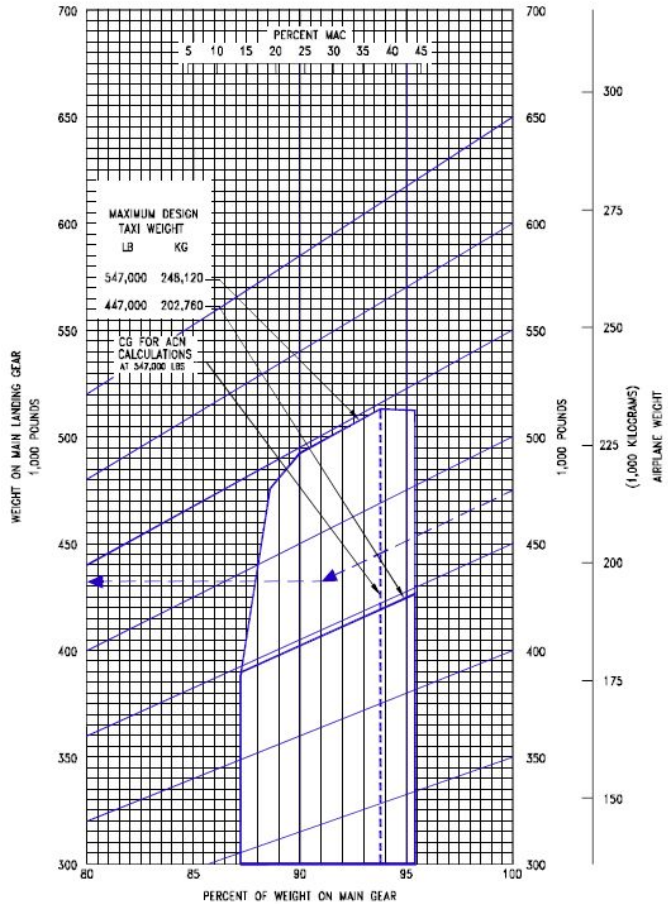
- **Develop rational criteria for including top-down cracking failure modes in rigid pavement design.**
  - Top-down cracks can lead to early failures of individual slabs or entire pavements.
  - FAARFIELD does not consider these modes in thickness design.
  - As the FAA considers higher PCC strength limits in pavement design, we need to answer how the resulting thinner slabs may affect top-down cracking risk.

Failure Criteria for Top-Down Cracking in Rigid Airport Pavements

- **R&D effort will result in a two part design criterion:**
  - **Whether or not** the top-down failure mode needs to be considered.
  - **How** to apply mathematical failure models where top-down cracking must be considered.
- **R&D approach combines analysis of**
  - Field data from the 40-year life study.
  - Numerical modeling using FEAFAA.
- **Expected completion: FY 2018**

FAARFIELD-Based ACN/PCN Methodology

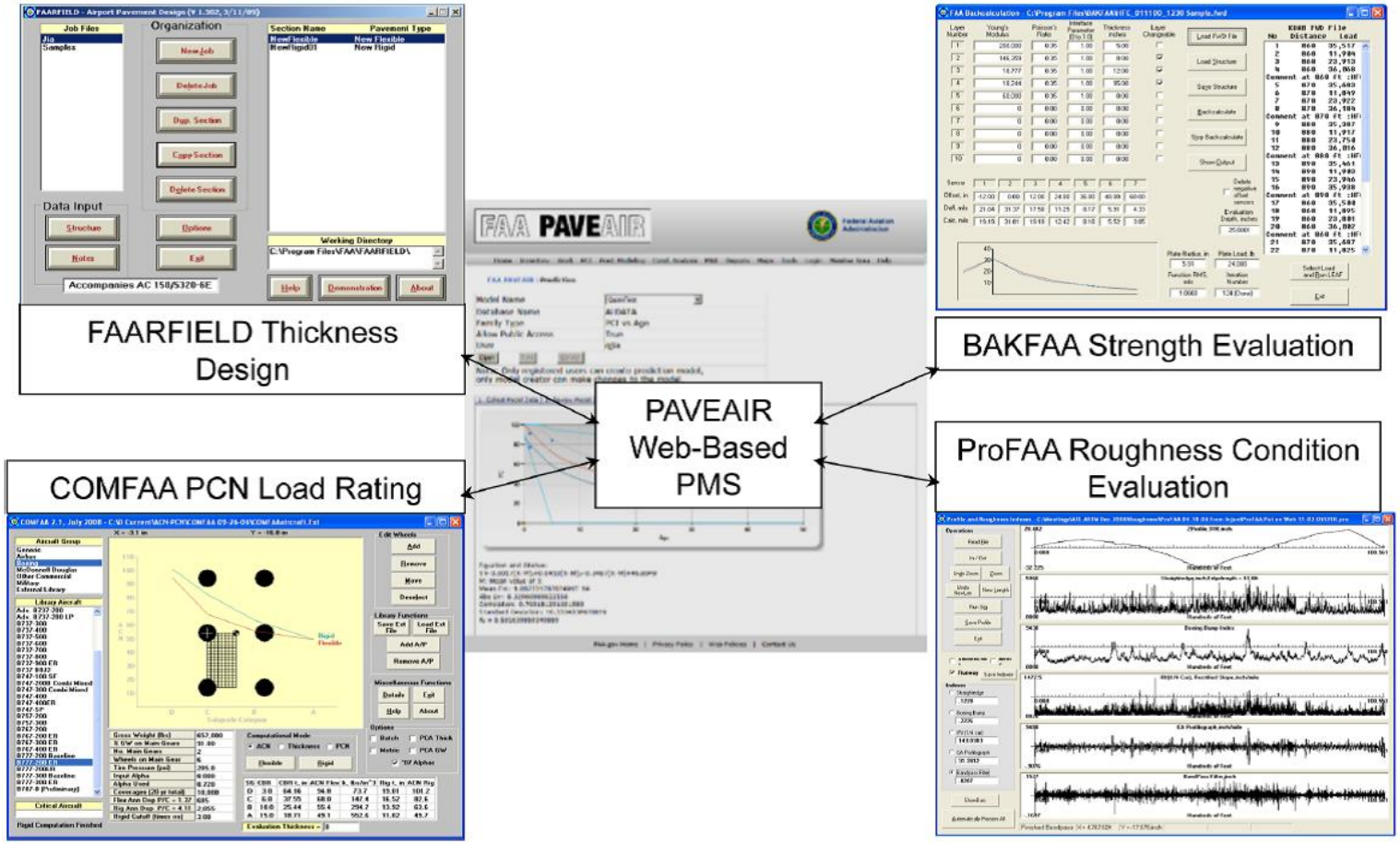
- **Develop an alternative method for calculating PCN using the FAARFIELD software.**
- **Advantages over existing procedure:**
  - Eliminate incompatibilities between pavement thickness design (FAARFIELD) and pavement strength reporting (COMFAA) requirements.
  - Reduce dependence on the choice of critical aircraft.
  - Facilitate integration of strength reporting function into FAA PAVEAIR.



FAARFIELD-Based ACN/PCN Methodology

- Output will be an automated PCN computation module within FAARFIELD, by FY 2017.
- Later stages will evaluate alternative ACN procedures based on FAARFIELD and develop rational overload procedures.
- Collaboration at all stages with PCN Working Group.
- Expected completion: FY 2021.

New LCCA Integrated Design Procedures

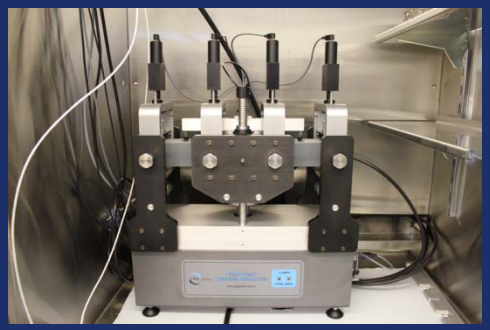


New LCCA Integrated Design Procedures

- **Update standard airport pavement design procedures to support integration with a life cycle cost-based approach.**
  - Goal of LCCA is to facilitate a rational selection of the optimal design from among several competing options.
  - Current design procedures disregard LCCA, or treat it as an afterthought.
- **Output will be a user-friendly design procedure generating 20- or 40-year airport pavement designs.**
  - Seamless integration with web-based FAA PAVEAIR environment.
  - New LCCA procedures to be developed under Airport Pavement Evaluation.
  - Access to stored cost data, performance models, etc.
- **A key milestone is modified HMA-on-flexible overlay design procedures based on CC7 and 40-year life study (FY 2017).**
- **Expected Completion: FY 2022.**

PAVEMENT MATERIALS 10 Year R&D Plan

Federal Aviation Administration



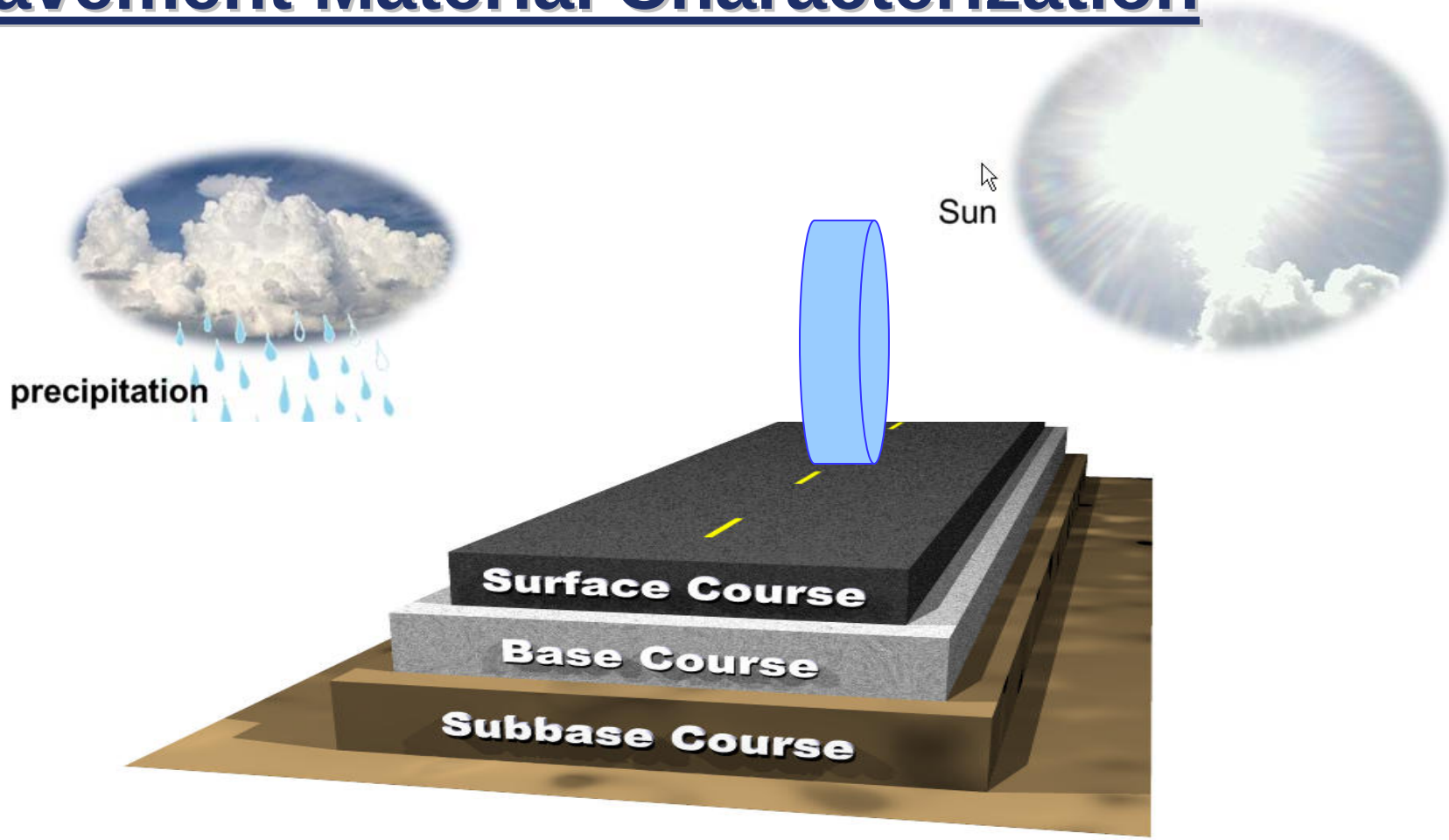
Presented to:

By: Navneet Garg, Ph.D., FAA ANG-E262

Harkanwal Brar, SRA Intl. Inc.

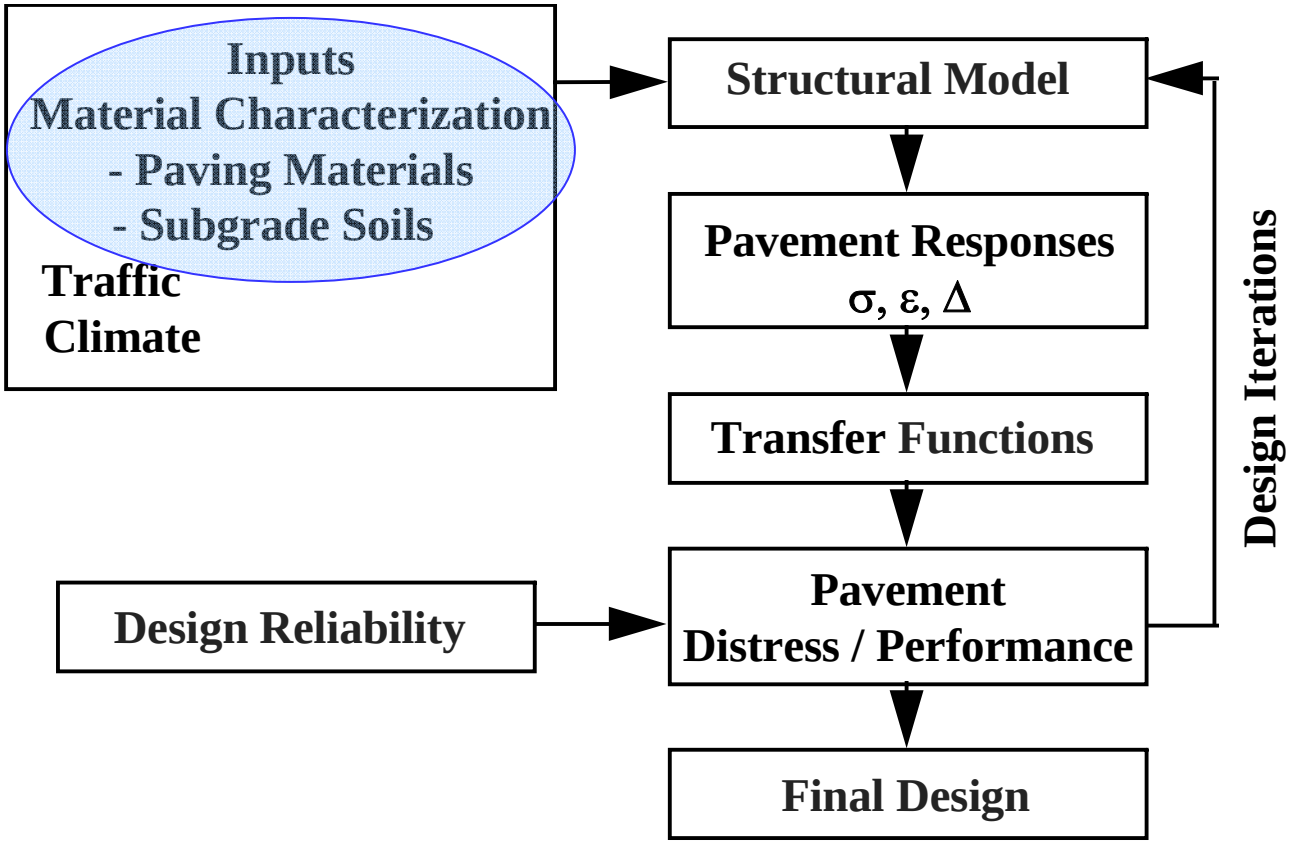
Date: April 17, 2013

Pavement Material Characterization



Ground Water Table, Freeze-Thaw

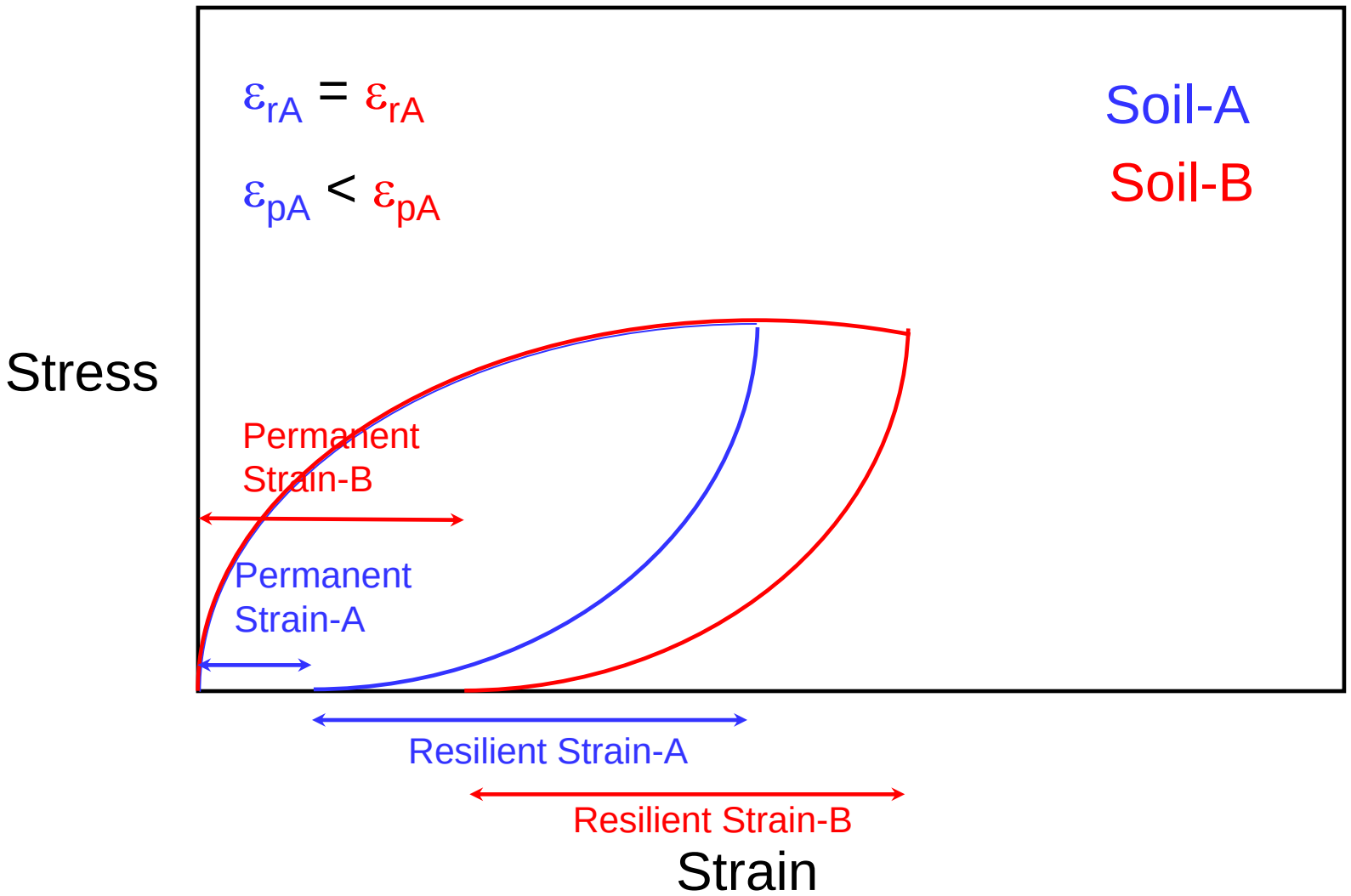
Pavement Materials - 10-Year R&D Plan



Pavement Material Characterization

- **Current Material Requirements**
  - Gradations
  - Compaction (Moisture/Density)
  - Volumetrics, stability, flow
  - CBR (for Subgrades)

- **Inputs for Design Procedure (current state)**
  - Only CBR (for subgrades)
  - Subgrade modulus computed as E = 1500*CBR
  - *No other mechanical property of unbound materials is used.*
  - Modulus is calculated internally as a function of layer thickness and subgrade CBR.


$\varepsilon_{rA} = \varepsilon_{rA}$
$\varepsilon_{pA} < \varepsilon_{pA}$
Soil-A
Soil-B
Stress
Permanent Strain-B
Permanent Strain-A
Resilient Strain-A
Resilient Strain-B
Strain

Pavement Material Characterization

- FAA advisory circulars lack guidance on the use of sustainable, environmentally friendly, recycled, and newer materials such as SMA, WMA, RAS, etc.

- Limited knowledge is available on the effect of high tire pressures and heavy gear loads on pavement material performance under full-scale loading.

Pavement Material Characterization

- The cost of using better quality material to improve pavement performance (life) cannot be justified using current guidance.

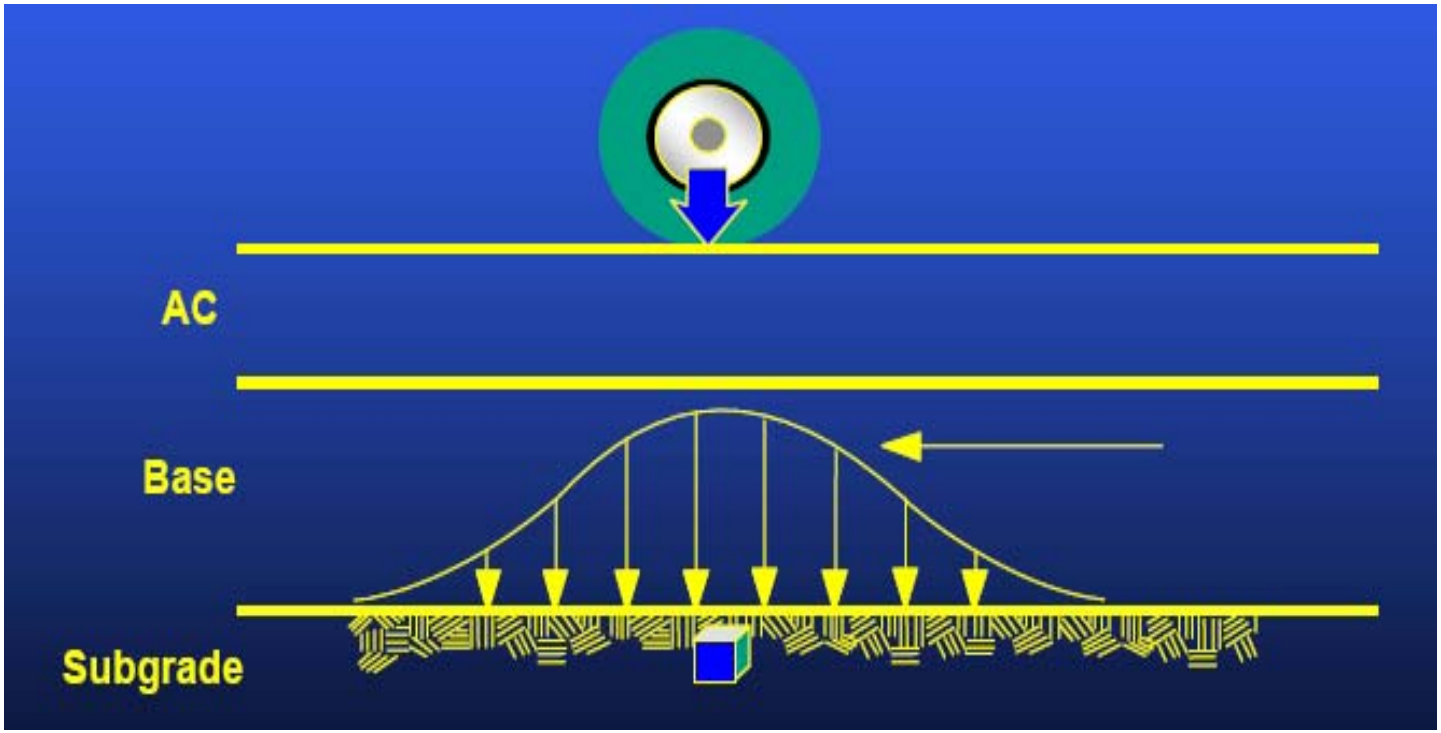
- Advances in pavement material testing techniques and knowledge gained in material behavior and characterization over the years is not used in the FAA pavement thickness design procedure.

Pavement Material Characterization

- Need to Consider Realistic Material Behavior

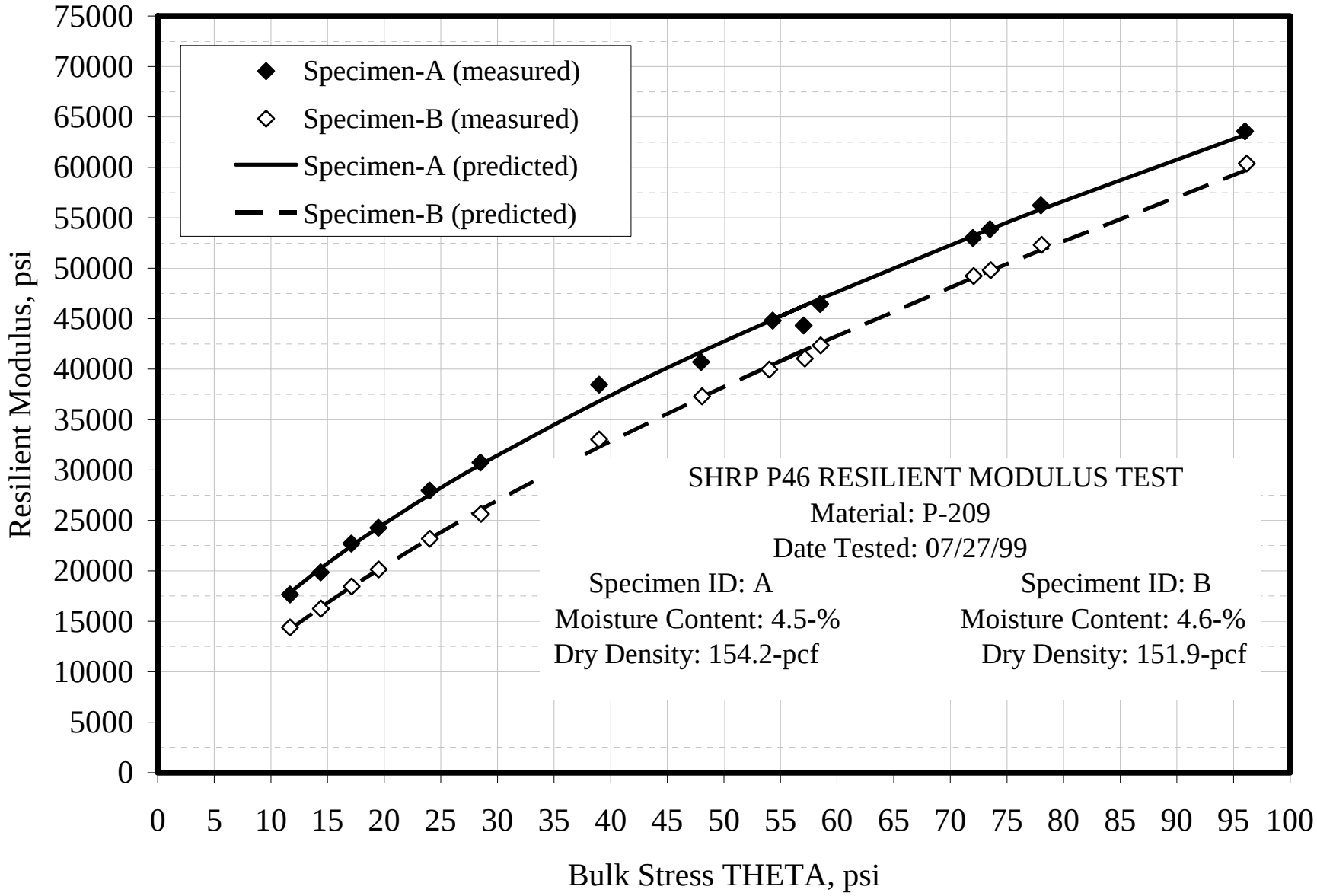
- Develop inputs for design procedure based on mechanical properties of materials (such as resilient modulus, shear strength, etc.)

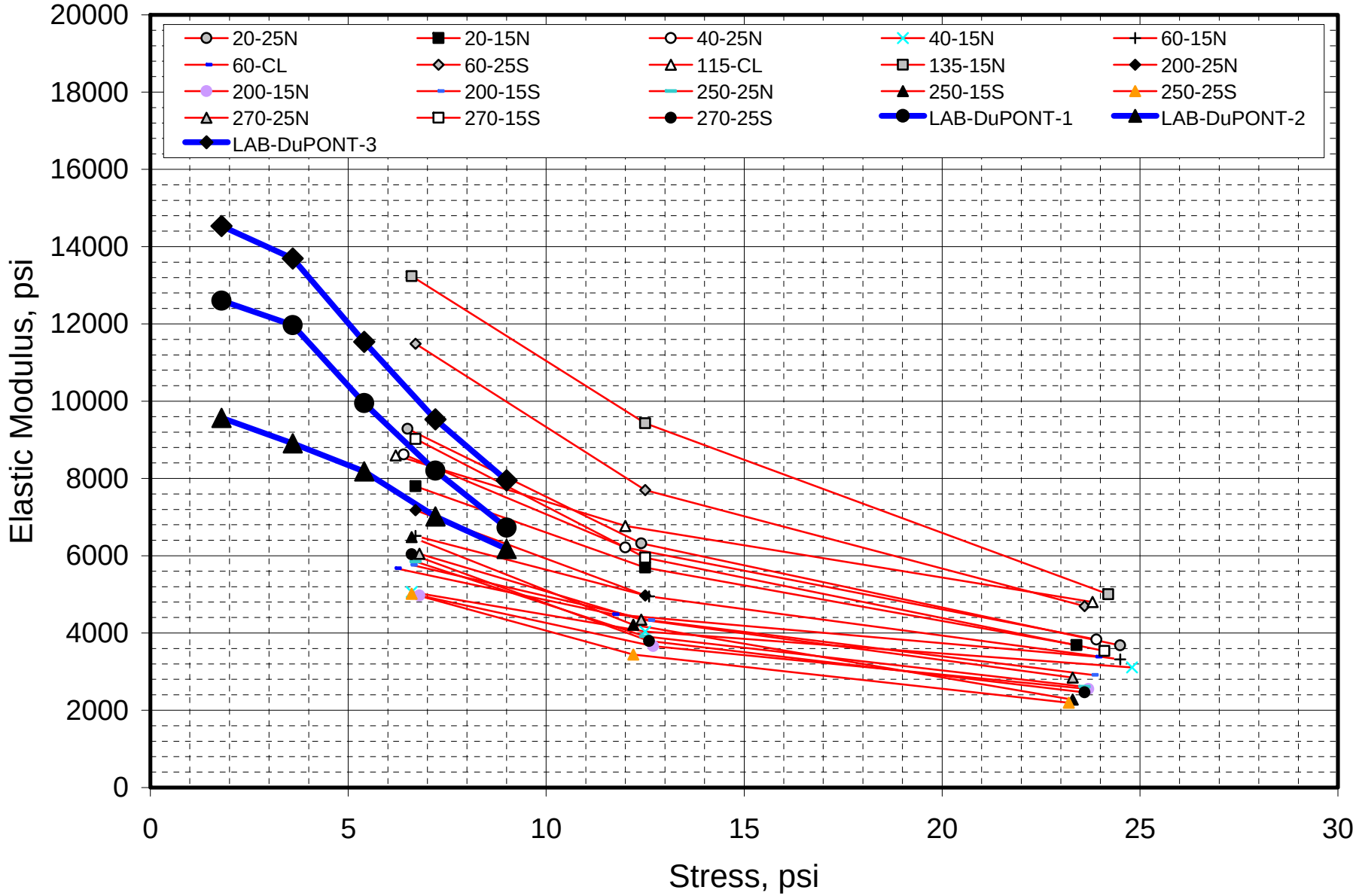
Pavement Material Characterization



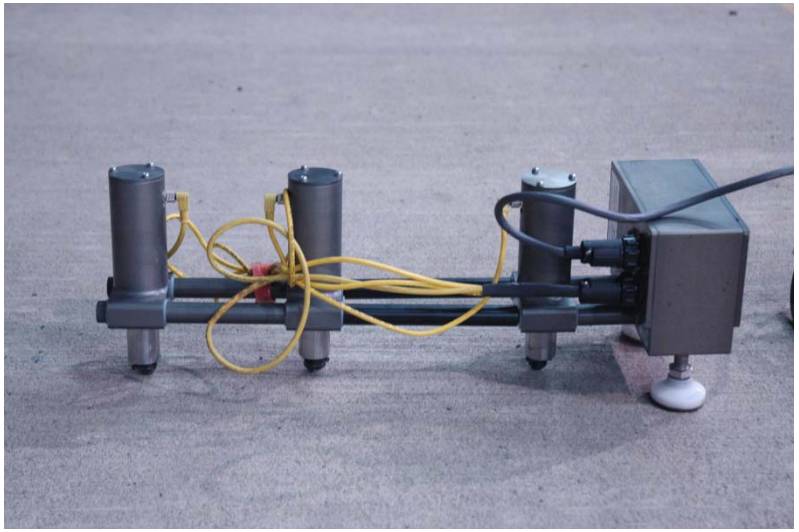
Pavement Material Characterization

Resilient Modulus Test


Specimen-A (measured)
Specimen-B (measured)
Specimen-A (predicted)
Specimen-B (predicted)
SHRP P46 RESILIENT MODULUS TEST
Material: P-209
Date Tested: 07/27/99
Specimen ID: A
Moisture Content: 4.5-%
Dry Density: 154.2-pcf
Speciment ID: B
Moisture Content: 4.6-%
Dry Density: 151.9-pcf
Resilient Modulus, psi
Bulk Stress THETA, psi
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000
55000
60000
65000
70000
75000
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100


20-25N
20-15N
40-25N
40-15N
60-15N
60-CL
60-25S
115-CL
135-15N
200-25N
200-15N
200-15S
250-25N
250-15S
250-25S
270-25N
270-15S
270-25S
LAB-DuPONT-1
LAB-DuPONT-2
LAB-DuPONT-3
Elastic Modulus, psi
Stress, psi
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
0
5
10
15
20
25
30

Pavement Material Characterization



Pavement Material Characterization

PROJECTS

Materials Project No. 1:

Advanced Characterization of Paving Materials

•Advanced Characterization of Pavement Materials in Laboratory, Field, HTPTF & NAPTF

•Develop Material Properties Input for use in Design Procedure

•Develop/Modify Pavement Material Standards/Specifications

PROJECTS

Materials Project No. 2:

Use of Additives and Nanoparticles to Improve Performance of Airport Pavement Materials

•Evaluate the use of Additives and Nanoparticles for Improved Performance of Airport Pavement Materials

•Develop Standards/Specifications and Guidelines for Pavement Materials that have been modified with Nanoparticles and other Additives.

PROJECTS

Materials Project No. 3:

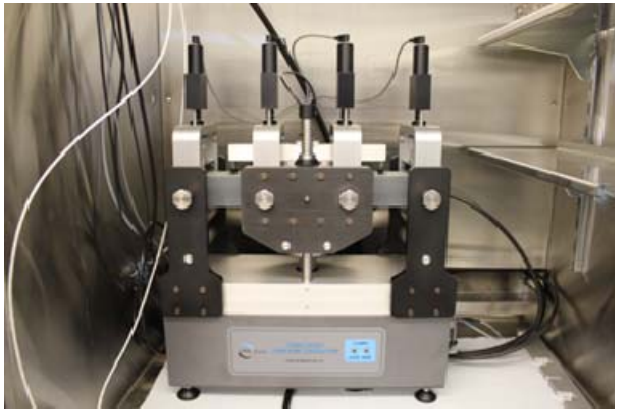
Use of Data and Results From Airport Pavement Instrumentation and Field Testing Studies

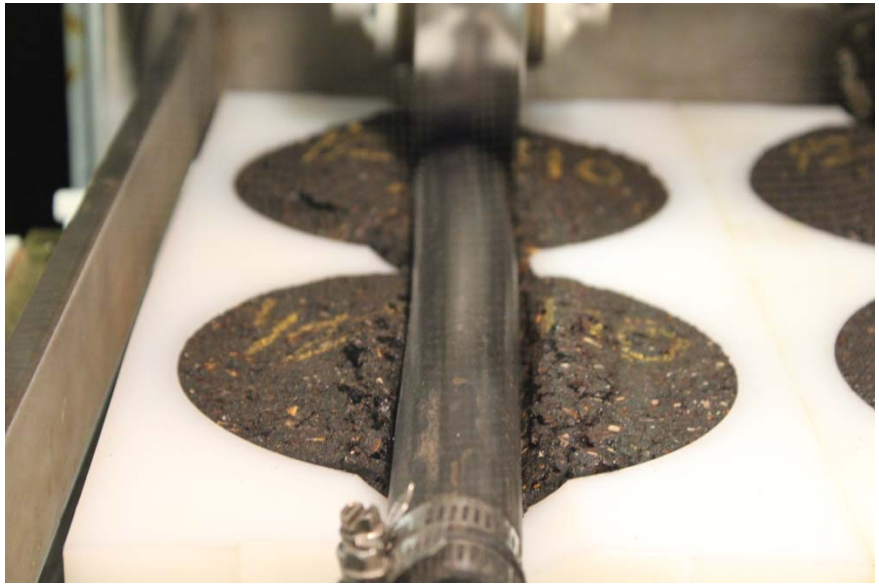
- Develop New Test Procedures and Techniques to Characterize In-Situ Pavement Materials and Layers
- Develop Guidelines for Material Input Properties for Thickness Design
- Evaluate In-use Pavement Load and Environmental Response Characteristics
- Develop Material Properties Database for use in PAVEAIR and LCCA

Pavement Material Characterization

AIRPORT PAVEMENT 10-YEAR R&D PROGRAM MILESTONE												
Fiscal Year	12	13	14	15	16	17	18	19	20	21	22	Total Cost ($M)
Airport Pavement Materials ($42M)												
Project No. 1: Advanced Characterization of Paving Materials												22.0
Project No. 2: Use of Additives and Nanoparticles to Improve Performance of Airport Pavement Materials												5.0
Project No. 3: Use of Data and Results From Airport Pavement Instrumentation and Field Testing Studies												15.0

Work in Progress





Work in Progress

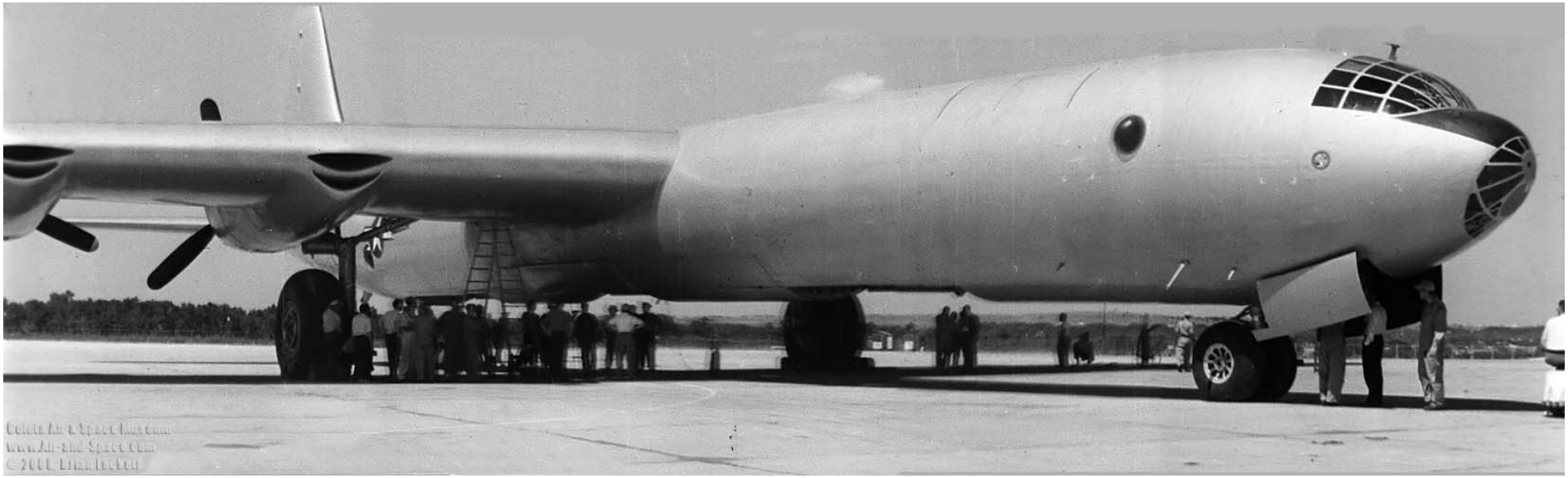
DCP Field Testing

DPSPA Field Testing

Shelby Tubes for Lab Tests

P-209 Sample Collection for Lab Tests

THANK YOU



FAA Airport Pavement R & D Ten Year Program

Airport Pavement Evaluation

Presented to: Airport Pavement Working Group Meeting

By: Al Larkin, FAA Technology R & D Branch & Injun Song, P.E., Ph.D., SRA International

Date: April 17, 2013

Airport Pavement Evaluation

- **Comprised of four projects:**

  1. Improvements to FAA Airport Pavement Software Programs,

  2. Development of New Roughness Standards for In-Service Airport Pavements,

  3. Pavement Surface Profile Data Collection, Processing, and Analysis,

  4.Nondestructive Airport Pavement Testing

Summary – Pavement Evaluation

Airport Pavement Evaluation R & D Projects Milestones											
Cost by Fiscal Year ($M)	13	14	15	16	17	18	19	20	21	22	TOTAL
Summary by Cost & Fiscal Year											
1. Improvements to FAA Airport Pavement Software Programs Cost Summary											14,500
2. Development of New Roughness Standards for In-Service Airport Pavement Cost Summary											11,000
3. Development of New Roughness Standards for In-Service Airport Pavement Cost Summary											3,000
4. Nondestructive Pavement Testing Cost Summary											23,500

Improvements to FAA Airport Pavement Software Programs

- **Access airport pavement data for use as a guide for pavement design and maintenance requirements.**
- **Double the expected life of large-hub runway construction from 20 to 40 years.**

Improvements to FAA Airport Pavement Software Programs

• Data Warehouse Example

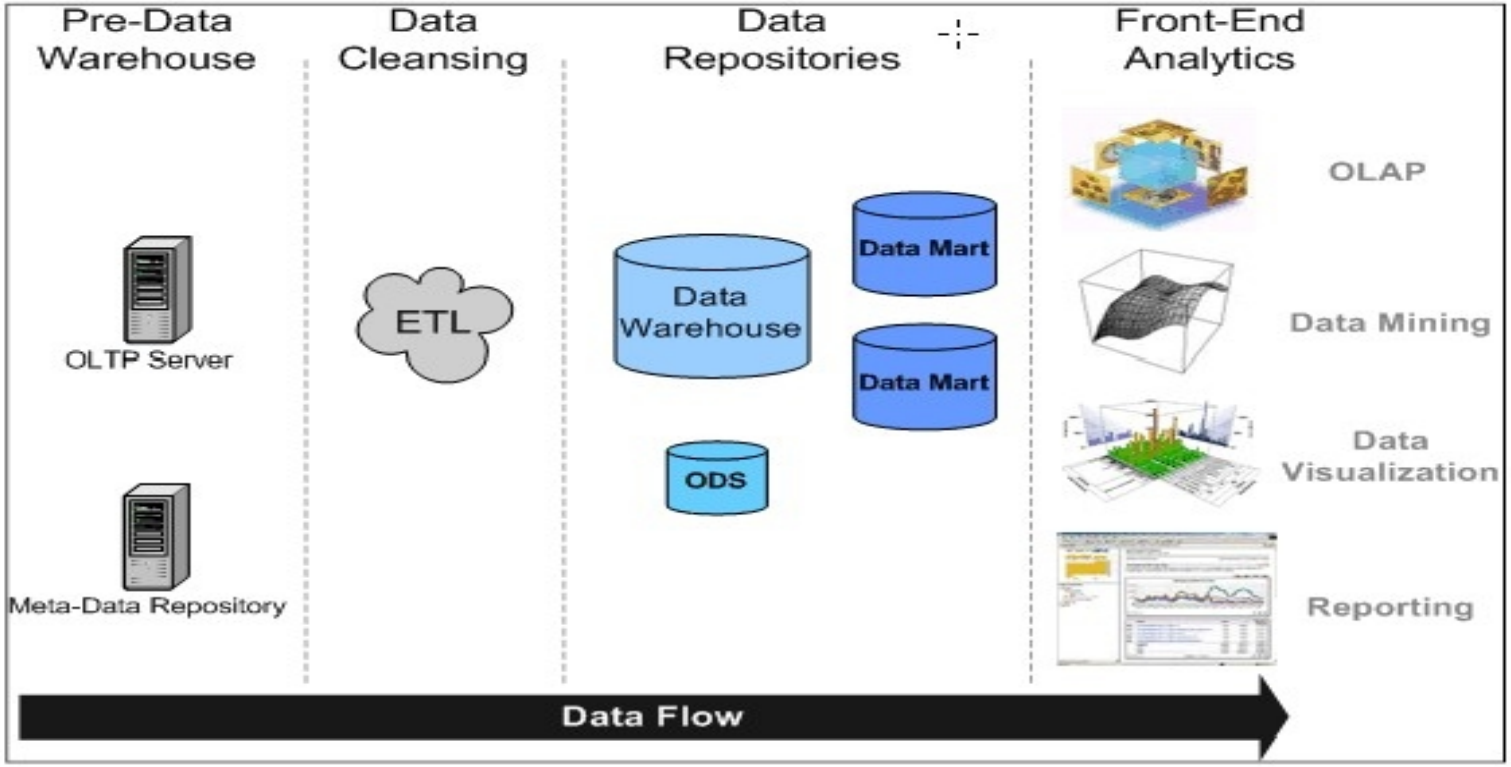


Figure 1. Data flow for the proposed data warehouse.

Improvements to FAA Airport Pavement Software Programs

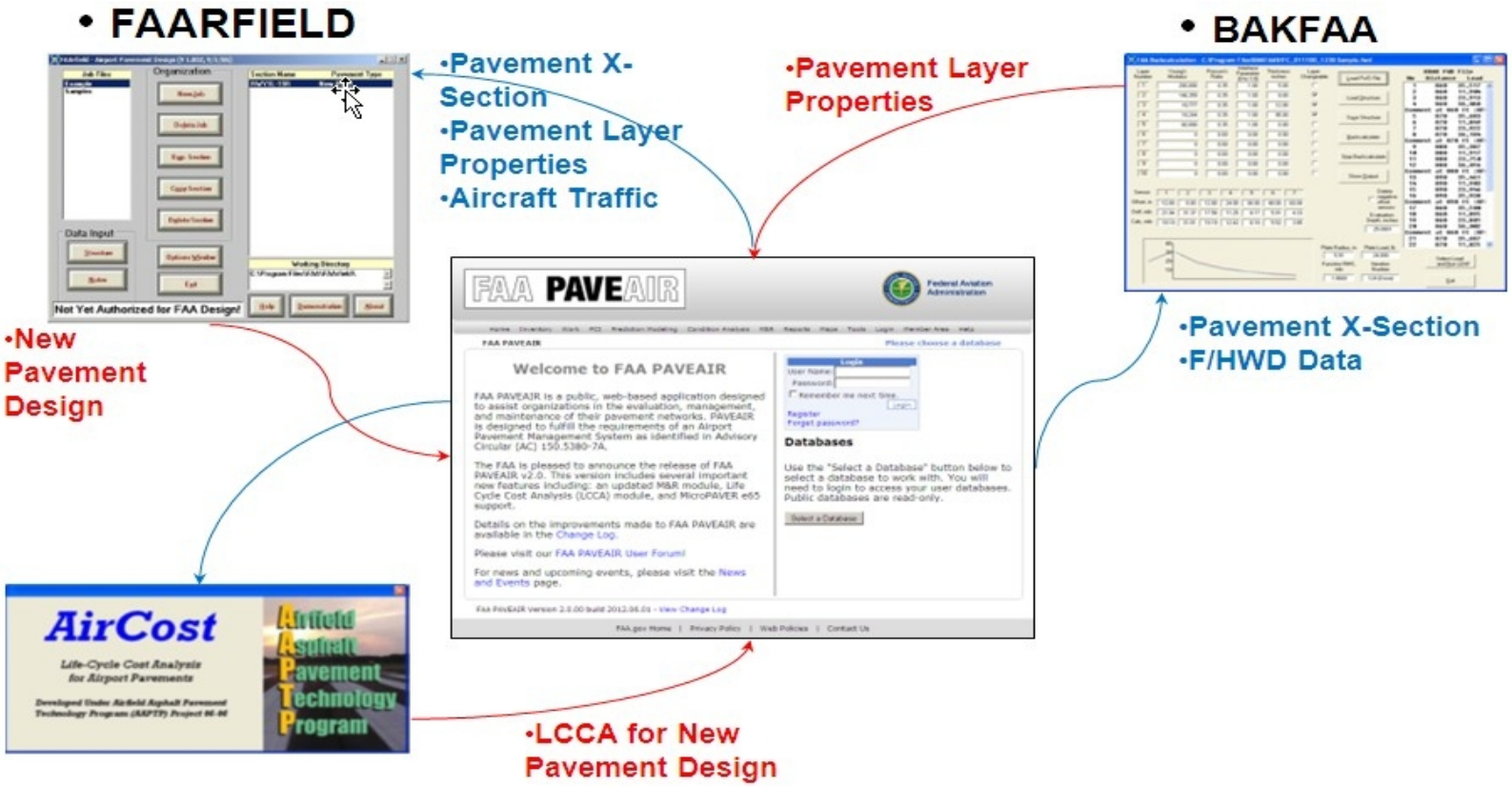
- Incorporate Artificial Intelligence into FAA Programs
- Incorporate Global Positioning System Capabilities into FAA Programs
- Integration of FAA Airport Pavement Software

Improvements to FAA Airport Pavement Software Programs

• Airport Database Locations

Improvements to FAA Airport Pavement Software Programs

• Software Integration Data Exchange



Development of New Roughness Standards for In-Service Airport Pavements

- **Create a roughness standard for in-service airport pavement to determine maintenance requirements.**
- **Roughness standard in a PMS is critical because it will effect pavement serviceability and budget decisions.**
- **Comparison of Full-Scale Aircraft Response and Ride Quality Criteria in Simulator Studies – Expand to Airbus Simulator and Instrument the FAA's Boeing 727**

Development of New Roughness Standards for In-Service Airport Pavements

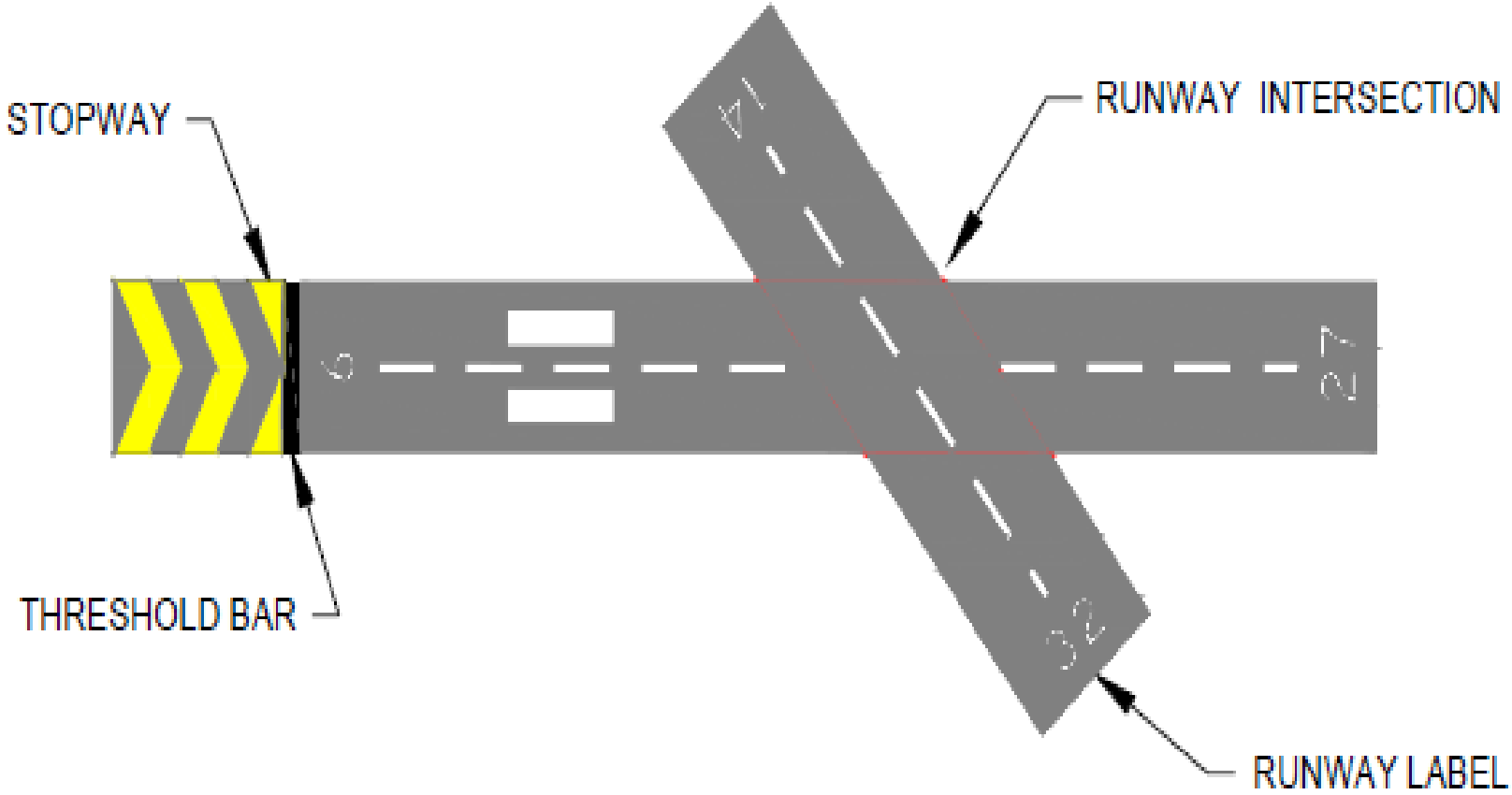
Pavement Surface Profile Data Collection, Processing, and Analysis

- **Runway Intersection Grading Criteria**

- **Safety needs to be evaluated at runway intersections for positive drainage and ride quality for all design and rehabilitation activities.**

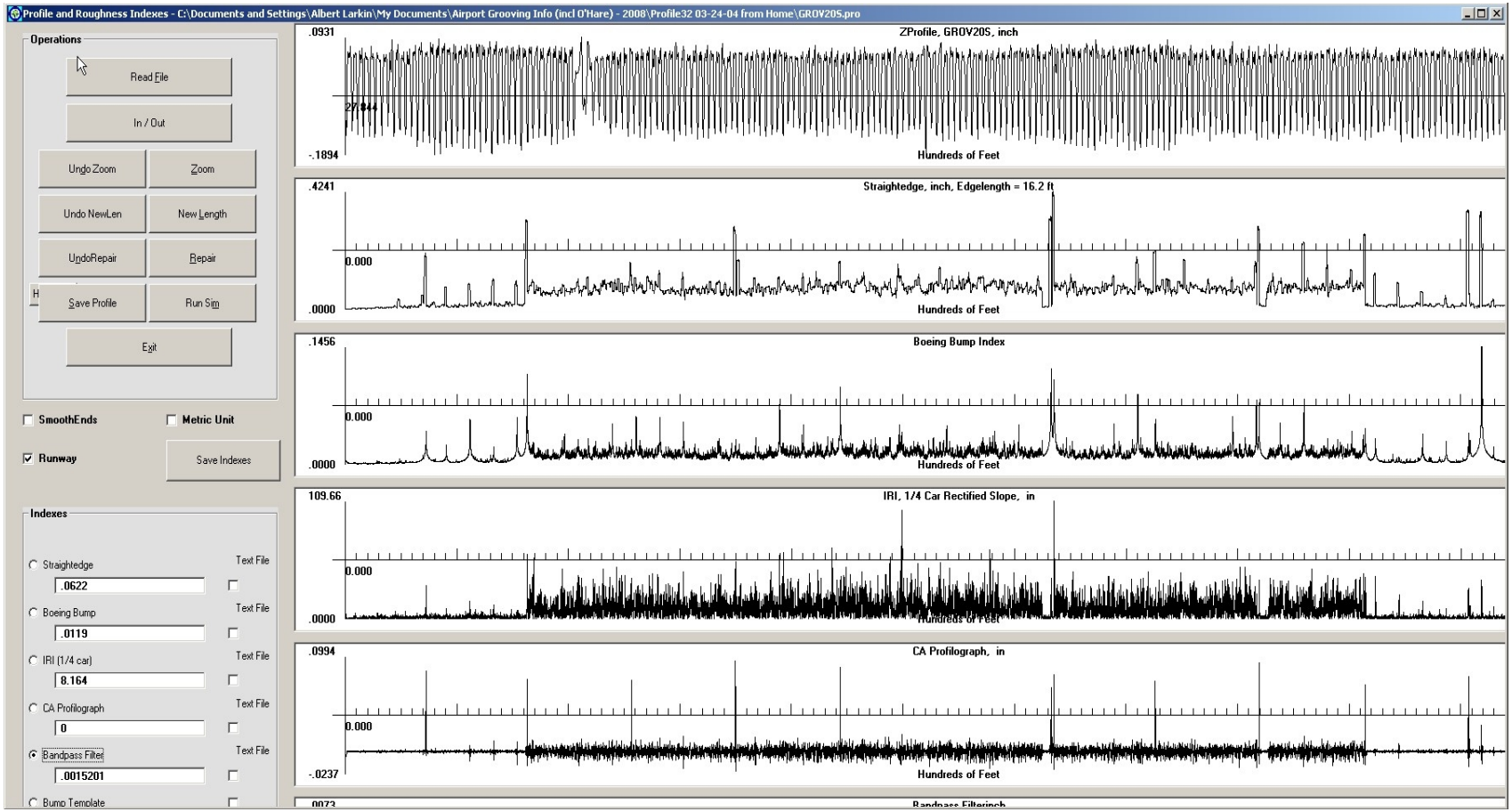
Pavement Surface Profile Data Collection, Processing, and Analysis

- **Runway Intersection Research**



Pavement Surface Profile Data Collection, Processing, and Analysis

• FAA ProGroove



Nondestructive Airport Pavement Testing

- **Nondestructive airport pavement testing is the hub of airport pavement evaluation.**
- **The FAA forecast predicts that the industry will grow from 731 million passengers in 2011 to 1.2 billion in 2032.**
- **NDT is anticipated to have an increasing role in construction quality control and quantity acceptance for construction or repair of pavement projects.**

Nondestructive Airport Pavement Testing

- **Pavement Deflection with Moving Load**

Nondestructive Airport Pavement Testing

• FAA NDT Vehicle