

RPA P-5 Airport Pavement Design

FAARFIELD Update

Presented to: REDAC Briefing to Sub-committee
on Airports

By: David R. Brill, P.E., Ph.D.

Date: September 9, 2021



Federal Aviation
Administration

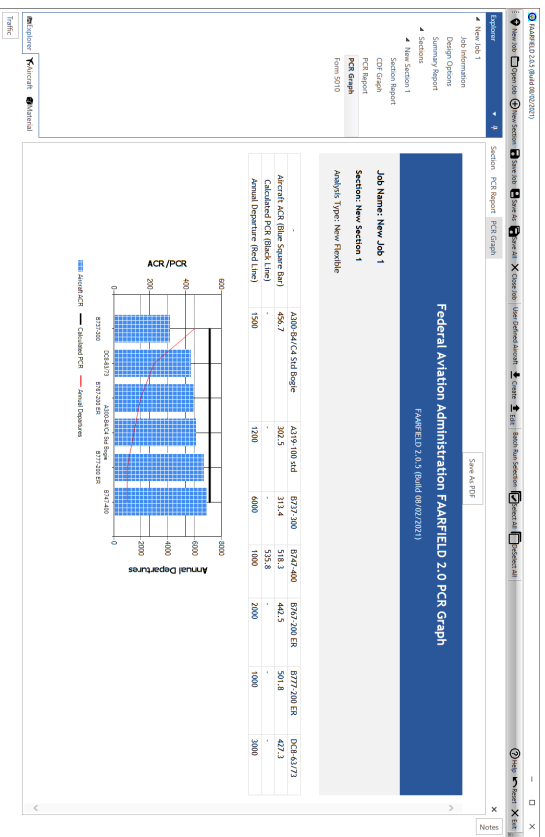
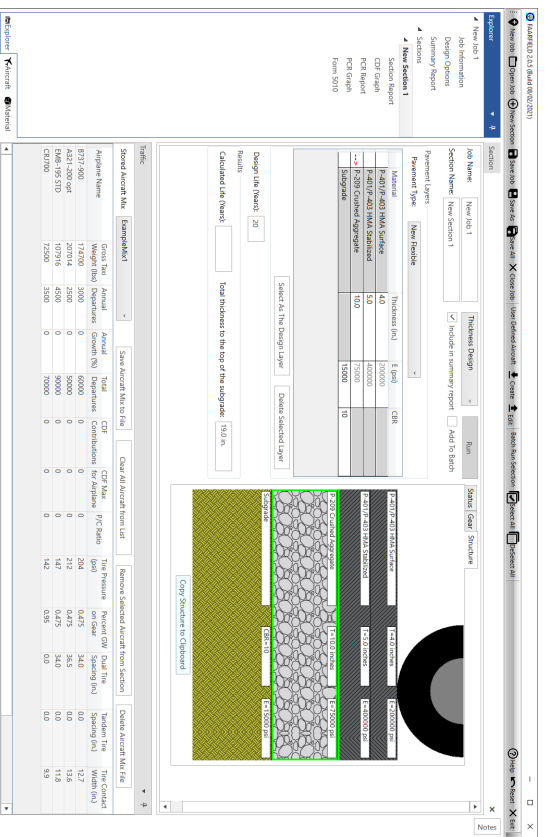


Advisory Circular Status

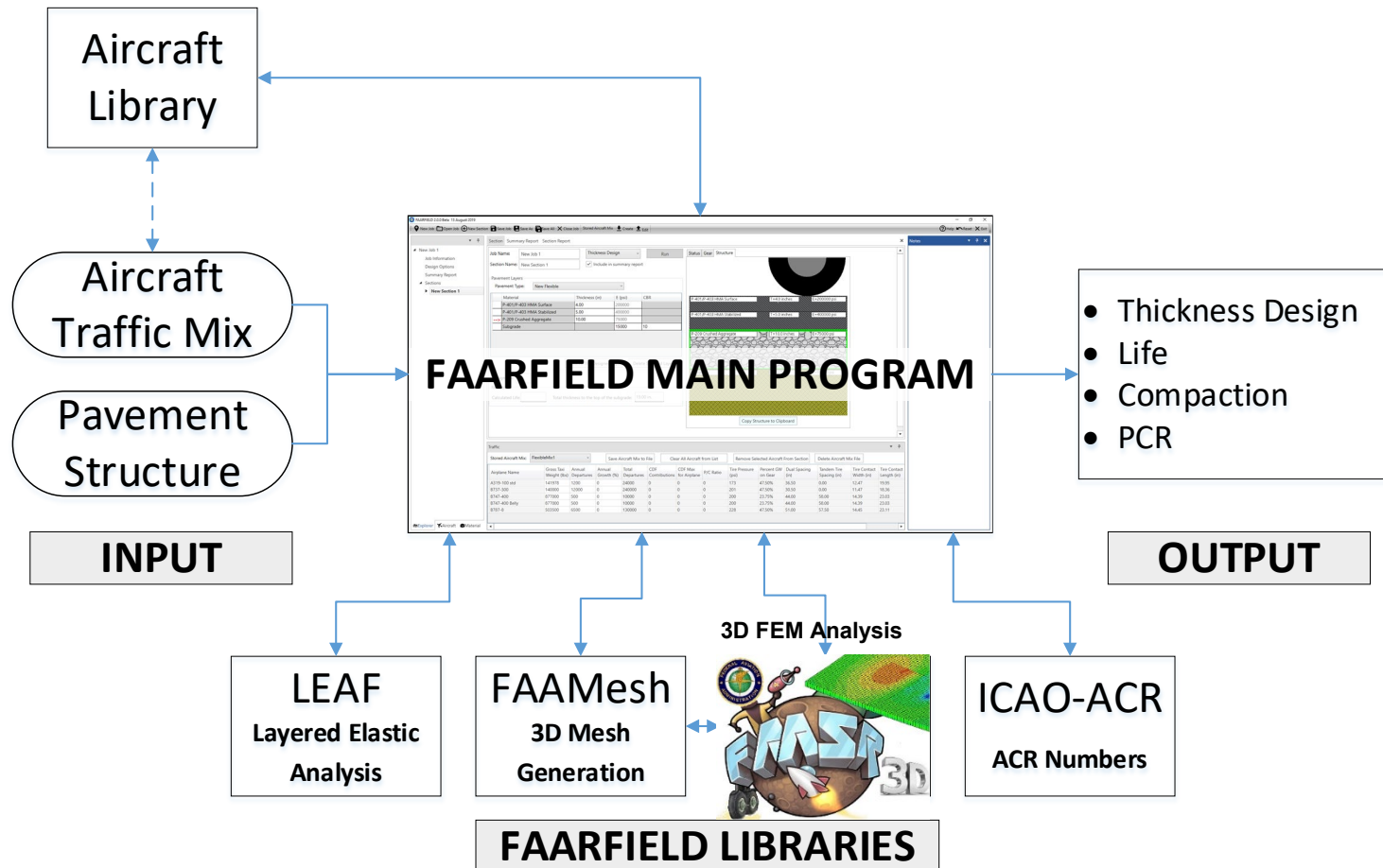
- **New AC 150/5320-6G, *Airport Pavement Design and Evaluation*.**
 - Posted 6/7/2021
- **New AC 150/5335-5D, *Standardized Method of Reporting Airport Pavement Strength - PCR*.**
 - In FAA final review. Some remaining PCR reporting issues to be resolved.
 - Release expected Fall 2021.
- **Both ACs incorporate FAARFIELD 2.0 for design & PCR computations.**

FAARFIELD 2.0

- **Current Version 2.0.5**
- **Major update from version 1.4:**
 - Completely redesigned GUI with improved screen flow and explorer-based navigation.
 - A new 3D finite element computational library, FAASR3D.
 - Support for the new ICAO ACR-PCR system.
 - Ability to add, save and edit user-defined vehicles.
 - Ability to work with multiple jobs/sections at once.
 - Updated aircraft library.
- **No change to thickness design requirements in this version.**



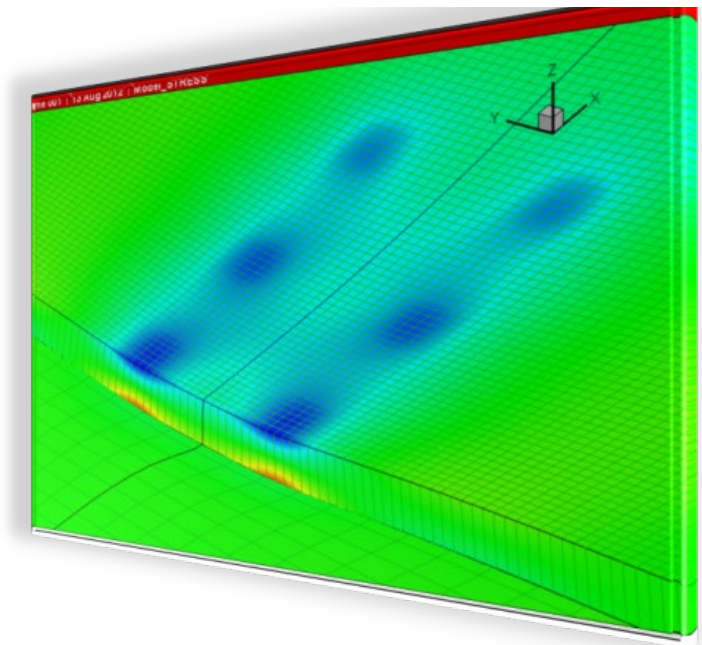
FAARFIELD 2.0 Organization



FAASR3D – FAA Structural Analysis in 3D



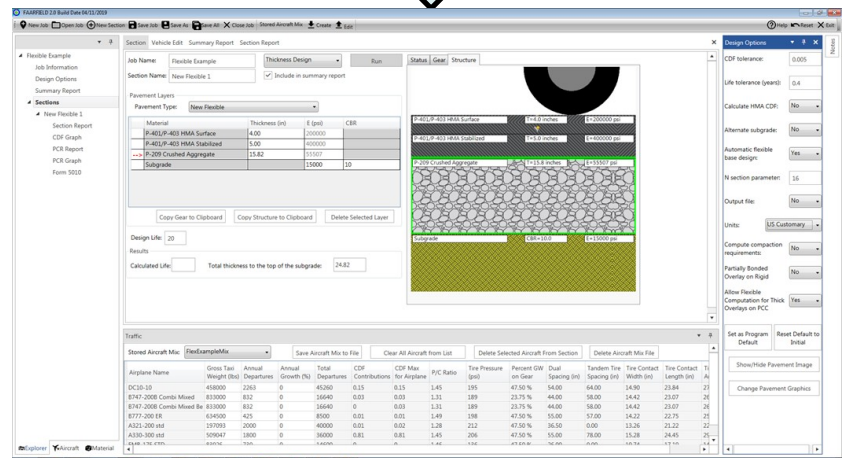
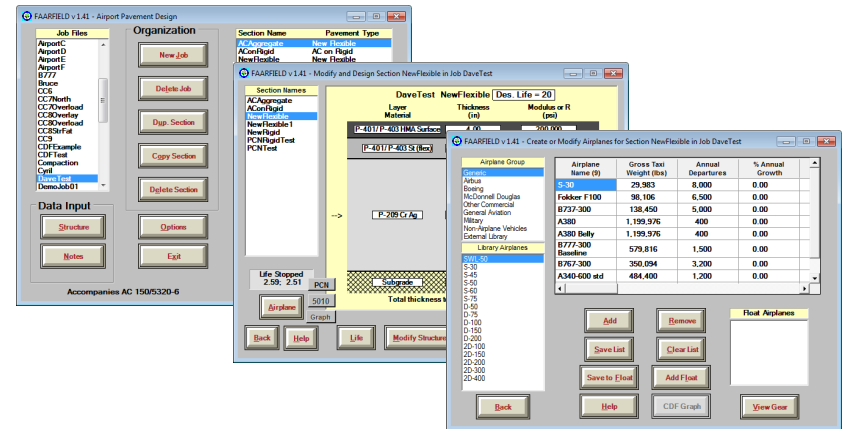
- **Visual Basic.NET library.**
- **Replaces obsolete NIKE3D Fortran program.**
 - Managed Code - compatible with Microsoft .NET memory management services.
 - Improves performance. Old code was subject to memory conflicts and crashing.
 - Freely distributable code.
- **Continued updates to improve speed & efficiency.**



GUI Modernization

Major improvements:

- Easier job and section entry.
- Explorer-based navigation.
- Improved screen re-sizing and appearance.
- Improved flow between screens.
- Ability to store traffic mixes.
- Rationalized data file structure.
- On-demand report generation.
- Remove program logic from GUI controls.
- Etc.



Navigating in FAARFIELD 2.0

TOOLBAR

The screenshot displays the FAARFIELD 2.0 software interface. The top toolbar includes buttons for New Job, Open Job, New Section, Save Job, Save As, Save All, Close Job, Stored Aircraft Mix, Create, Edit, Batch Run Selection, Select All, Deselect All, Help, Reset, and Exit.

EXPLORER (Left Panel): A tree view showing the project structure. It includes sections for Airport A, Airport B, and PCC Overlay Example, each with sub-items for Job Information, Design Options, Summary Report, and various reports (Section Report, CDF Graph, PCR Report, PCR Graph, Form 5010).

SECTION AREA (Center Panel): A detailed view of a pavement section. It includes fields for Job Name (Airport A), Section Name (Section 01), and Pavement Type (New Flexible). A table lists the pavement layers:

Material	Thickness (in.)	E (psi)	CBR
P-401/P-403 HMA Surface	5.0	200000	
P-401/P-403 HMA Stabilized	5.0	400000	
P-209 Crushed Aggregate	10.0	75000	
Subgrade		15000	10

Below the table are buttons for 'Select As The Design Layer' and 'Delete Selected Layer'. A 'Results' section shows 'Calculated Life (Years):' and 'Total thickness to the top of the subgrade: 20.0 in.' A 'Traffic' table is also visible at the bottom.

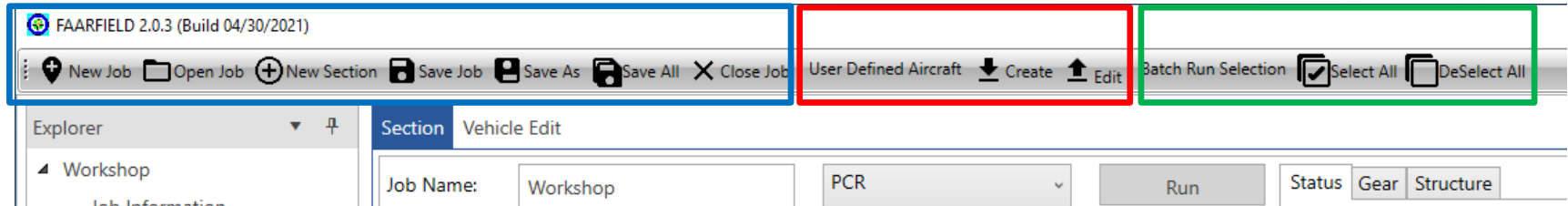
Options (Right Panel): A panel for configuring design options. It includes settings for 'Calculate HMA CDF' (No), 'Automatic flexible base design' (Yes), 'Output file' (No), 'Units' (US Customary), 'Allow Flexible Computation for Thick Overlays on PCC' (Yes), and 'Compute ACR for All Subgrade Categories' (No). There are also buttons for 'Show Advanced Options', 'Show/Hide Pavement Image', and 'Change Pavement Graphics'.

FAARFIELD 2.0 Toolbar

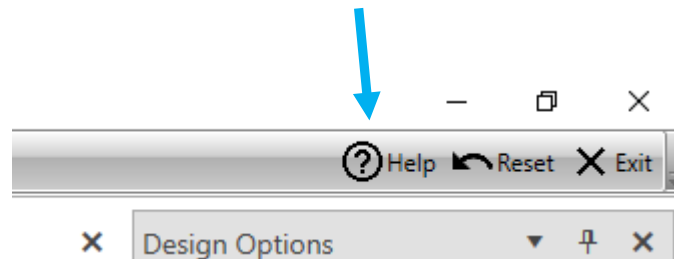
Job & Section Tools

User-Defined Aircraft Tools

Batch Job Tools

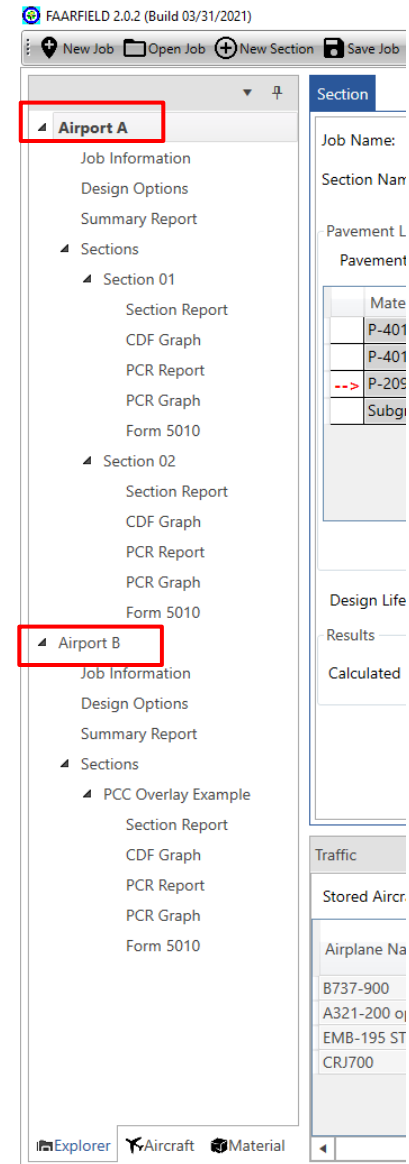


Help File



Explorer Navigation

- **FAARFIELD 2.0 supports multiple jobs open at the same time.**
- **Use the Explorer to navigate between jobs, and display:**
 - Sections
 - Section Reports
 - PCR Reports/Graphs
 - 5010 Reports
 - Summary Reports (high-level run information on selected sections in a job)



Aircraft Library

Aircraft library has been completely reorganized and updated for the FAARFIELD 2.0 release!

Aircraft	Aircraft	Aircraft	Aircraft	Aircraft	Aircraft	Aircraft	Aircraft
FAARFIELD Aircraft Group	FAARFIELD Aircraft Group	FAARFIELD Aircraft Group	FAARFIELD Aircraft Group	FAARFIELD Aircraft Group	FAARFIELD Aircraft Group	FAARFIELD Aircraft Group	FAARFIELD Aircraft Group
Generic	Generic	Generic	Generic	Generic	Generic	Generic	Generic
Airbus	Airbus	Airbus	Airbus	Airbus	Airbus	Airbus	Airbus
Boeing	Boeing	Boeing	Boeing	Boeing	Boeing	Boeing	Boeing
McDonnell Douglas	McDonnell Douglas	McDonnell Douglas	McDonnell Douglas	McDonnell Douglas	McDonnell Douglas	McDonnell Douglas	McDonnell Douglas
Other Large Jet	Other Large Jet	Other Large Jet	Other Large Jet	Other Large Jet	Other Large Jet	Other Large Jet	Other Large Jet
Regional/Commuter	Regional/Commuter	Regional/Commuter	Regional/Commuter	Regional/Commuter	Regional/Commuter	Regional/Commuter	Regional/Commuter
General Aviation	General Aviation	General Aviation	General Aviation	General Aviation	General Aviation	General Aviation	General Aviation
Military	Military	Military	Military	Military	Military	Military	Military
Non-Airplane Vehicles	Non-Airplane Vehicles	Non-Airplane Vehicles	Non-Airplane Vehicles	Non-Airplane Vehicles	Non-Airplane Vehicles	Non-Airplane Vehicles	Non-Airplane Vehicles
External Library	External Library	External Library	External Library	External Library	External Library	External Library	External Library
FAARFIELD Aircraft Library	FAARFIELD Aircraft Library	FAARFIELD Aircraft Library	FAARFIELD Aircraft Library	FAARFIELD Aircraft Library	FAARFIELD Aircraft Library	FAARFIELD Aircraft Library	FAARFIELD Aircraft Library
SWL-2	A300-B2	B707-320C	DC3	An-124	BAe 146-300/300QC/300QT	Beechcraft Baron 55	A400M LH
SWL-5	A300-B2K	B717-200 HGW	DC8-63/73	An-225	BeechJet-400/400A	Beechcraft Bonanza F33A	A400M LN1
SWL-10	A300-B4/C4 Std Bogie	B727-100C Alternate	DC9-32	Bombardier CS100	Bombardier CL-604/605	Beechcraft King Air 300	A400M TLL1
SWL-50	A300-B4/C4 LGA Bogie	B727-200 Advanced Basic	DC9-51	COMAC C919	Cessna Citation II/Bravo C550	Beechcraft King Air 350	A400M TLL2
S-3	A300-600 Std Bogie	B727-200 Advanced Option	DC/MD-10-10/10F	COMAC C919 ER	Cessna Citation V	Beechcraft King Air B100	B-52
S-5	A300-600 LGA Bogie	B737-100	DC/MD-10-30/30F/40	Fokker-F-100	Cessna Citation VI/VII	Beechcraft King Air B200	C-5
S-10	A310-200	B737-200 Advanced QC	MD-11	Fokker-F-28-1000/2000	Cessna Citation X	Beechcraft King Air C90	C-17A
S-12.5	A310-300	B737-200	MD-83	F-28-3000/4000/6000	CRJ100/200	Cessna 172 Skyhawk	C-123
S-15	A318-100 std	B737-300	MD-90-30 ER	IL-62	CRJ100ER/200ER	Cessna 182 Skylane	C-130
S-20	A318-100 opt	B737-400		IL-76T	CRJ100LR/200LR	Cessna 206 Stationair	C-130-57
S-25	A319-100 std	B737-500		IL-86	CRJ700	Cessna 208B Grand Caravan	C-130-70
S-30	A319-100 opt	B737-600		L-100-20	CRJ900	Cessna 414/414A Chancellor	F-15C
S-30 HTP	A319neo	B737-700		L-1011	CRJ1000	Cessna C210 Centurion	F-16C
S-35 HTP	A320-200 std	B737-800		TU-134A	Dassault Falcon 50/50EX	Cessna C441 Conquest II	F/A-18C
S-40 HTP	A320-200 opt	B737-900		TU-154B	Dassault Falcon 900B/C	Cessna Citation M2 C525	KC-10
S-45	A320-200 WV000 Bogie	B737-900 FR					P-3C

Four Functions in FAARFIELD 2.0

FAARFIELD 2.0.0 Beta 22 January 2020

New Job Open Job New Section Save Job Save As Save All Close Job Stored Aircraft Mix Create Edit

Section Section Report CDF Graph Form 5010

New Job 1

Job Information

Design Options

Summary Report

Sections

New Section 1

Section Report

CDF Graph

PCR Report

PCR Graph

Form 5010

Job Name: New Job 1

Section Name: New Section 1

Pavement Layers

Pavement Type: New Flexible

Material Thickness (in) E (psi) CBR

P-401/P-403 HMA Surface	4.0	200000	
P-401/P-403 HMA Stabilized	5.0	400000	
P-209 Crushed Aggregate	18.3	65665	
Subgrade		15000	10

Select As The Design Layer Delete Sel

Design Life: 20

Results

Calculated Life: Total thickness to the top of the subgrade: 27.30 in.

Traffic

Stored Aircraft Mix: FlexExampleMix Save Aircraft Mix to File

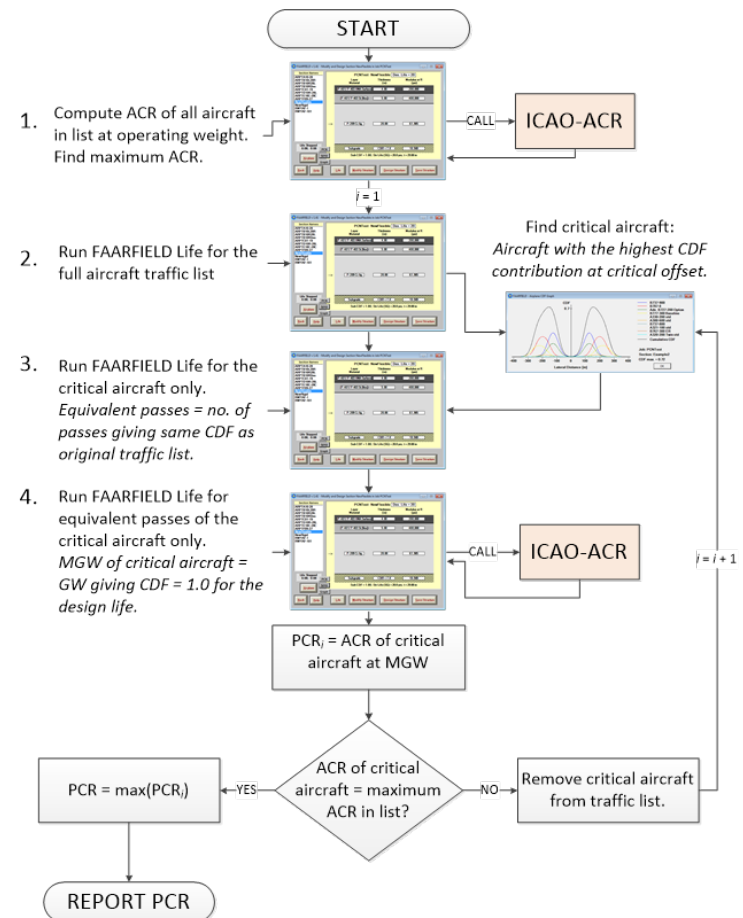
Airplane Name	Gross Taxi Weight (lbs)	Annual Departures	Annual Growth (%)	Total Departures	CI
A320-100	150796	600	0	12000	0
A340-600 std	807333	1000	0	20000	0
A340-600 std Belly	807333	1000	0	20000	0
A380	1238998	300	0	6000	0
A380 Belly	1238998	300	0	6000	0
B737-800	174700	2000	0	40000	0
B777-300 ER	777000	1000	0	20000	0

Explorer Aircraft Material

- **THICKNESS DESIGN** – Compute required thickness per AC 150/5320-6.
- **LIFE** – Compute structural life for a given structure and traffic mix.
- **COMPACTION** – Compute subgrade compaction requirements per AC 150/5320-6 for a given structure and traffic mix. (Applies to completed designs.)
- **PCR** – Compute Pavement Classification Rating (PCR) for the structure and traffic mix.

FAARFIELD 2.0 Provides PCR

- **Directly uses FAARFIELD structure and traffic list.**
- **Replacement for COMFAA 3.0 & support spreadsheets.**
- **Method yields uniquely defined PCR – no more looping through all aircraft in the list.**
- **Implemented in FAARFIELD 2.0**
 - Solves problem of computing PCR for mixed traffic (narrow bodies and LR aircraft) without unnecessary operating weight restrictions.
 - Seamlessly handles HMA overlays on rigid pavements.



User-Defined Aircraft Mode

Create, edit and save user-defined aircraft within the program.

FAARFIELD 2.0.0 Beta 22 January 2020

New Job Open Job New Section Save Job Save As Save All Close Job Stored Aircraft Mix Create Edit Help Reset Exit

Aircraft Section **Vehicle Edit**

FAARFIELD Aircraft Group

- Generic
- Airbus
- Boeing
- McDonnell Douglas
- Other Commercial
- General Aviation
- Military
- Non-Airplane Vehicles
- External Library

FAARFIELD Aircraft Library

- C-141A ICAO Flexible
- 2D-400 Ext1 (UDA)
- B737-900xt (UDA)
- B737-9ext (UDA)
- B767 ER Growth (UDA)
- Test3D (UDA)

User Defined Aircraft Info

Select Aircraft: B767 ER Growth (UDA)

Gross Taxi Weight (lbs): 413000

Percent Gross Weight On Whole Main Gear: 0.95

PCR Percent Gross Weight On Gear: 0.924

Tire Pressure (psi): 200

User Defined Gear

Design Options

Calculate HMA CDF: No

Automatic flexible base design: Yes

Output file: No

Units: US Customary

Allow Flexible Computation for Thick Overlays on PCC: Yes

Set as Program Default Reset Default to Initial

Show/Hide Pavement Image

Change Pavement Graphics

Tires

X Coord. (in)	Y Coord. (in)
-224.3	28.0
-179.3	28.0
-224.3	-28.0
-179.3	-28.0

Evaluation Points

X Coord. (in)	Y Coord. (in)
-201.8	0.0
-201.8	-8.8
-201.8	-17.5
-197.3	-19.6
-192.8	-21.7
-188.3	-23.8

Delete Tire Delete Eval. Point Update Gear Image Update User Defined Aircraft

Traffic

Stored Aircraft Mix: Save Aircraft Mix to File Clear All Aircraft from List Remove Selected Aircraft From Section Delete Aircraft Mix File

Airplane Name	Gross Taxi Weight (lbs)	Annual Departures	Annual Growth (%)	Total Departures	CDF Contributions	CDF Max for Airplane	P/C Ratio	Tire Pressure (psi)	Percent GW on Gear	Dual Spacing (in)	Tandem Tire Spacing (in)	Tire Contact Width (in)	Tire Contact Length (in)
A320-100	150796	600	0	12000	0	0	0	200	47.50%	36.5	0.0	11.9	19.1
A340-600 std	807333	1000	0	20000	0	0	0	234	35.98%	55.0	78.0	15.7	25.2
A340-600 std Belly	807333	1000	0	20000	0	0	0	222	23.04%	46.3	77.9	12.9	20.7
A380	1238998	300	0	6000	0	0	0	218	19.00%	53.1	66.9	14.7	23.5
A380 Belly	1238998	300	0	6000	0	0	0	218	28.50%	0.0	0.0	14.7	23.5
B737-800	174700	2000	0	40000	0	0	0	204	47.50%	34.0	0.0	12.7	20.4

Design Options Notes




User-Defined Aircraft

- **FAARFIELD treats UDA just like other library aircraft, except they have (UDA) appended to the aircraft name.**
- **UDA data are stored in files in:**
C:\Users\[user]\Documents\My FAARFIELD\User Defined Aircraft
- **UDA data are also saved to the job file – useful if a job is sent to another user.**

FAARFIELD 2.0 Download

<http://www.airporttech.tc.faa.gov/Products/Airport-Pavement-Software-Programs>

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FAARFIELD 2.0

FAARFIELD 2.0 is the standard software accompanying the following FAA Advisory Circulars: AC 150/5320-6G - Airport Pavement Design and Evaluation, AC 150/5335-5D - Standardized Method of Reporting Pavement Strength - PCR




FAARFIELD 2.0 is the FAA's standard software for airport pavement thickness design and evaluation (AC 150/5320-6G, Airport Pavement Design and Evaluation) and pavement strength reporting using the ACR/PCR method (AC 150/5335-5D, Standardized Method of Reporting Pavement Strength - PCR). FAARFIELD 2.0 features include:

- A completely redesigned graphical user interface (GUI) with improved screen flow and explorer-based navigation
- A new 3D finite element computational library, FAASR3D (FAA Structural Response - 3D), written in Visual Basic.NET
- Support for the new ICAO ACR-PCR system
- New graphical vehicle editor provides the ability to add, save and edit user-defined vehicles
- Updated aircraft library
- Ability to work with multiple jobs/sections at once


Notes:


- FAARFIELD stands for FAA Rigid and Flexible Iterative Elastic Layered Design. FAARFIELD 2.0 incorporates full 3D finite element responses to aircraft loads (for new rigid pavements and rigid overlays). The 3D finite element models used for rigid pavement designs are computationally intensive and may result in long run times, depending on the computer characteristics. We would appreciate your comments concerning this program and your suggestions on how it could be improved.
- FAARFIELD 2.0 runs on Windows operating systems. Windows 7 or higher is recommended. Please follow installation instructions in the readme file.
- For questions, comments or further information concerning this program, please contact Dr. David R. Brill, FAA Airport Technology R&D Branch, ANG-E262.


FAARFIELD 2.0 replaces all previous versions of FAARFIELD. To download the previous version, FAARFIELD 1.42, use the following link: [FAARFIELD 1.42](#)

 9853

Documents to download

 FAARFIELD 2.0.5 Installer (.zip, 46.24 MB) - 158 download(s)

 FAARFIELD 2.0.5 readme 2021-08-02 (.pdf, 154.69 KB) - 71 download(s)

 FAARFIELD 2.0.5 Source (.zip, 263.68 MB) - 57 download(s)



FAARFIELD Training Workshops

(All Virtual)

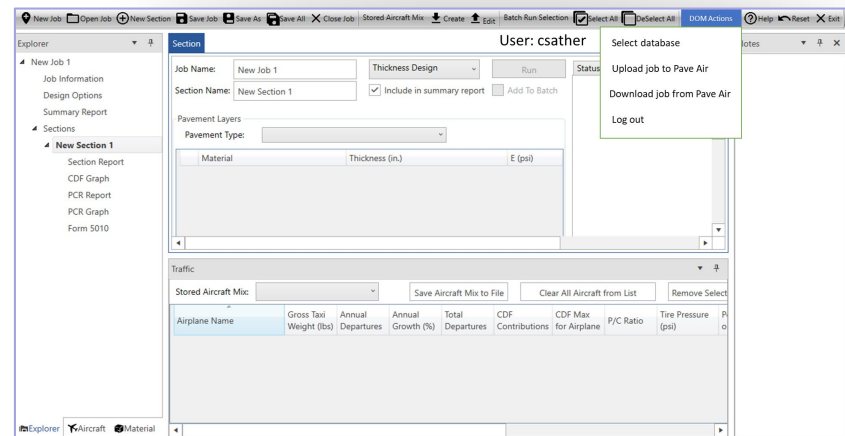
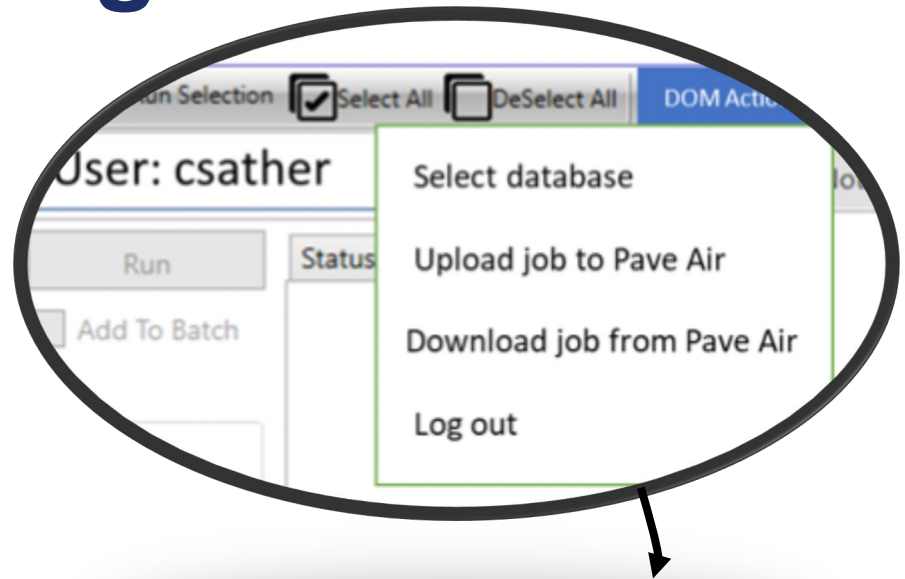
- **May 11, 2021 – ASCE Transportation & Development Institute (T&DI)**
 - *308 participants from 33 countries*
- **May 24, 2021 – International Conference on Transportation Geotechnics (ICTG)**
- **Sept. 27, 2021 – International Conference on Concrete Pavements (ICCP)**

Current Projects

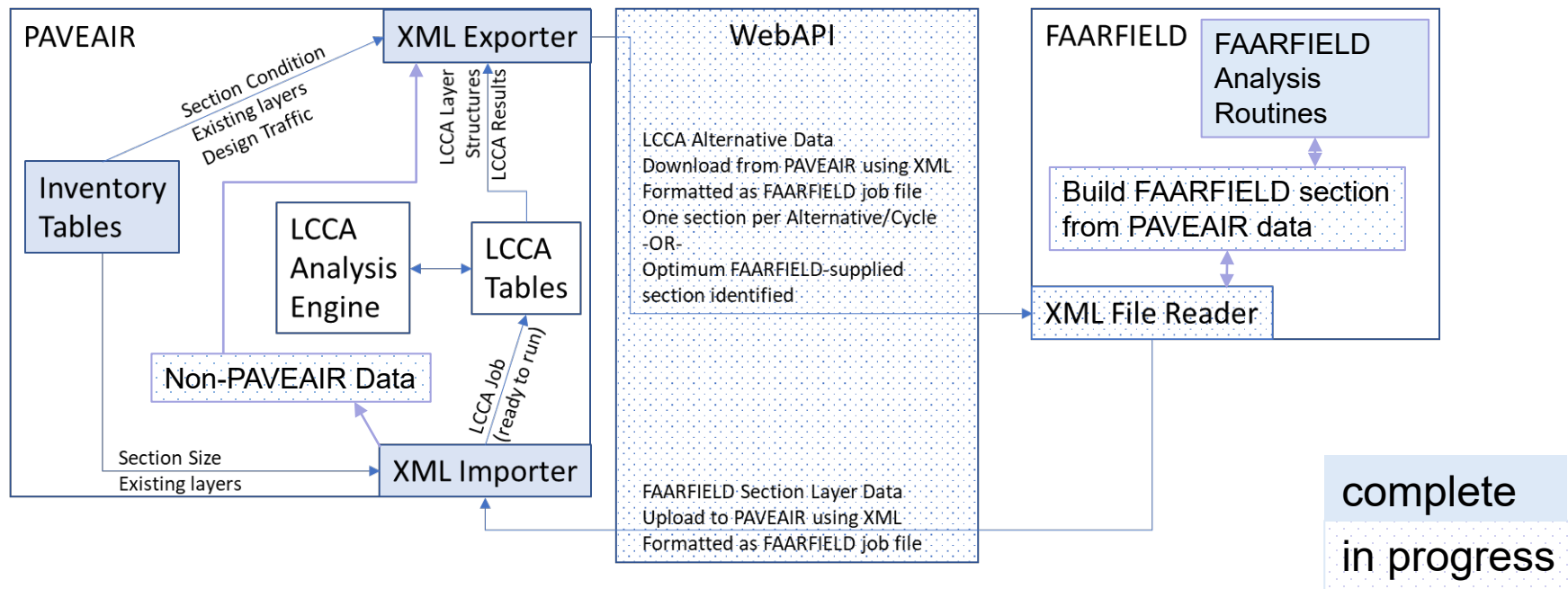
- **FAARFIELD / PAVEAIR Integration**
- **Design Criteria for Seasonal Frost and Permafrost.**
- **Design Criteria for Stabilized Bases**
- **Machine Learning (ML) for Design Stresses**
- **Reflection Cracking Model Development**

FAA PAVEAIR Integration

- Use your PAVEAIR login for library updates
- Data exchange with PAVEAIR via WebAPI.
- Access to user-owned databases.
 - Download: Job information, existing sections, NDT data.
 - Upload: FAARFIELD job files (alternate designs).



Improve Data Exchange via WebAPI in PAVEAIR



Design Criteria for Seasonal Frost and Permafrost

- **Research request dated 1/27/20.**
- **Collaboration with Alaskan Region (AAL) and Alaska DOT.**
- **Major Subtasks:**
 - TASK 1: Identify Subject Airports
 - TASK 2: Collect Relevant Documentation
 - TASK 3: Conduct Interviews
 - TASK 4: Design Review and Analysis
- **Focus on identifying design criteria used at airports exhibiting frost-related performance issues.**
- **Account for global warming trends.**
- **Final report may recommend revisions to FAA design guidance.**

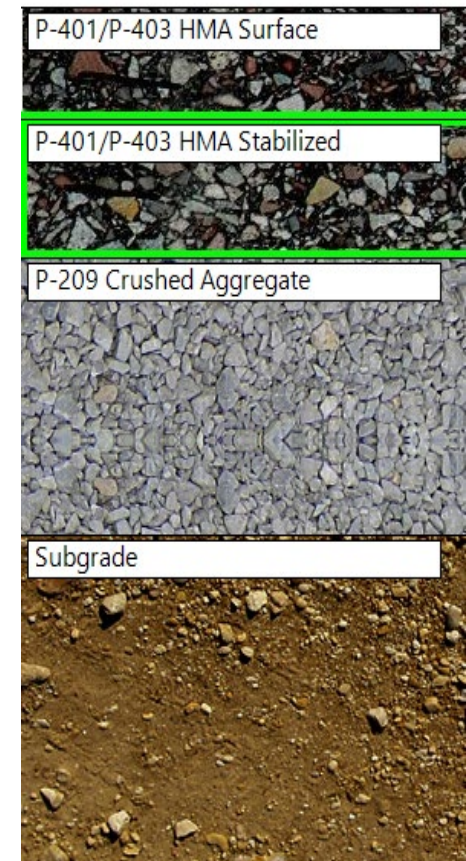


Seasonal Frost and Permafrost Status and Current Activities

- **Selected four airports for detailed study:**
 - Nome (discontinuous permafrost zone)
 - Barrow (continuous permafrost zone)
 - Kotzebue (continuous permafrost zone)
 - Noorvik (continuous permafrost zone, gravel-surfaced)
- **Interim report (Tasks 1-3) completed Nov. 2020.**
- **Task 4 (Design Review and Analysis) was delayed due to contract transition, but now in progress.**
 - Completed detailed design review of Nome and Kotzebue airports for seasonal frost and permafrost design criteria.
 - Final report anticipated March 2022.

Design Criteria for Stabilized Bases and Subbases

- **Research request dated 8/13/18.**
 - When should stabilized base be required or recommended?
 - What are the minimum requirements for a material to be considered a stabilized base?
 - What performance benefits are expected from use of stabilized base courses?
 - What are the appropriate stabilized base thickness requirements for rigid pavements/ flexible pavements?
- **Major Subtasks:**
 - TASK 1: Literature Search
 - TASK 2: Desktop Study
 - TASK 3: Laboratory Study
 - TASK 4: Full-Scale Test (CC11)



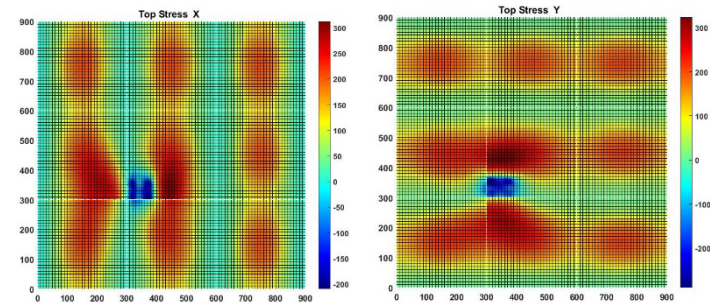
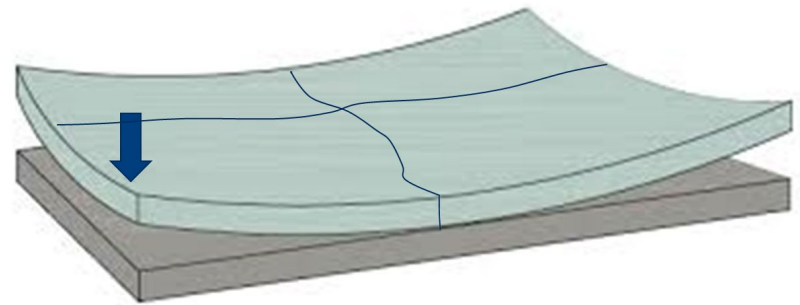
Stabilized Base Design

Status and Current Activities

- **Interim report covering tasks 1 and 2 completed Nov. 2020.**
- **Tasks 3-4 were delayed due to contract transition, but now in progress.**
 - Identified list of materials and tests.
 - Reviewed AIP 2021 funded airport construction projects as potential sources for base materials. Several airports including FLL have shown interest in this research. Working with AAS-110 to facilitate sample production.
 - Preliminary full-scale test plan for incorporation in CC11 anticipated November 2021.

Machine Learning for Top-Down Cracking

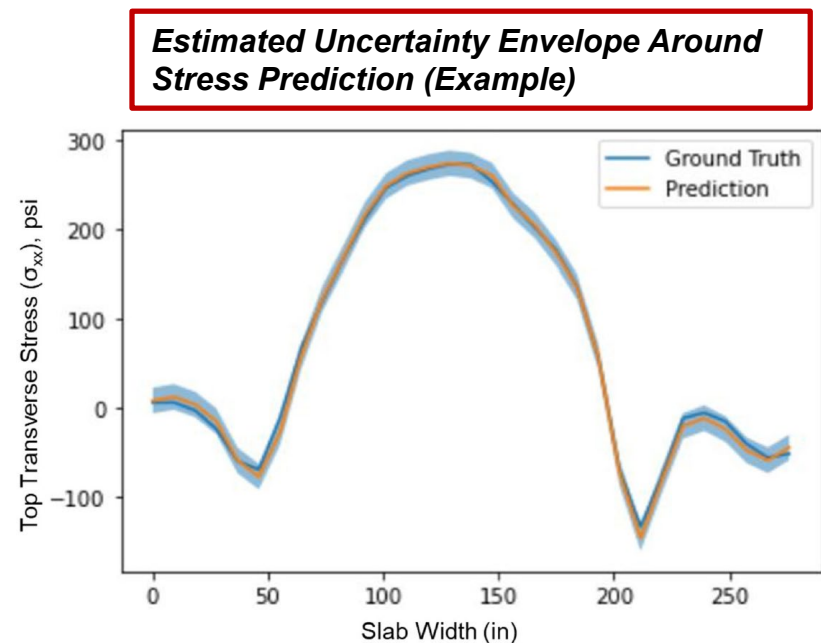
- OTA to ARA Inc., under BAA solicitation (ARAP0002).
- Rapidly compute stress for top-down cracks (rigid).
- Combined curling and aircraft loading.
- **Replace direct 3D-FEM computation for most gears.**
 - “Deep Learning” approach removes the need to train a separate neural network for each aircraft.
 - General model is suitable for D, 2D and 3D gear configurations.



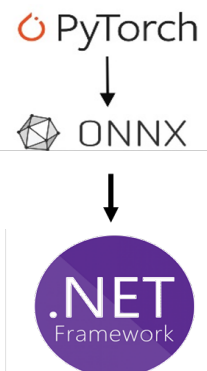
FEAFAA Response Model

Machine Learning for Top-Down Cracking

- **Task 1 – Training Database. (COMPLETED).**
 - Contractor ran >125,000 combinations of structural, thermal, and aircraft gear parameters.
 - Used output matrix to train the deep ANN model.
- **Task 2 – Machine Learning Model Development (COMPLETED).**
 - Report submitted July 12.
 - Models are significantly more accurate than previous ML techniques for similar problems.
- **Task 3 – Implement ML Model (IN PROGRESS).**
- **Final model and report delivery expected March 2022.**



Next: Use Open Neural Network Exchange (ONNX) to port the developed Pytorch ML model to a .NET framework (so it will run in FAARFIELD).



Reflection Cracking Model Development

- OTA to Arizona State University (ASU), with participation from University of Illinois, under BAA solicitation ARAP0002.
- Project awarded May 5, 2021.
- Three-year effort will produce a practical reflective cracking model using fracture mechanics principles, for implementation in FAARFIELD.
- Data from NAPTF reflection cracking rig and outdoor full-scale tests.
- Model inputs include both aircraft load and temperature cycling (joint opening/closing).

NAPTF Reflective Cracking Rig



The “Real World”



A key element in this project is the development of transfer functions to relate the theoretical crack growth (governed by Paris' Law) to the condition of the affected pavement (PCI). This project will make use of real-world data in FAA PAVEAIR and related databases.

Questions?

