

ICAO AERODROME PAVEMENT WORKSHOP

Introduction to FAARFIELD 2.1

Presented to: ICAO Aerodrome Pavement Workshop
Bangkok, Thailand

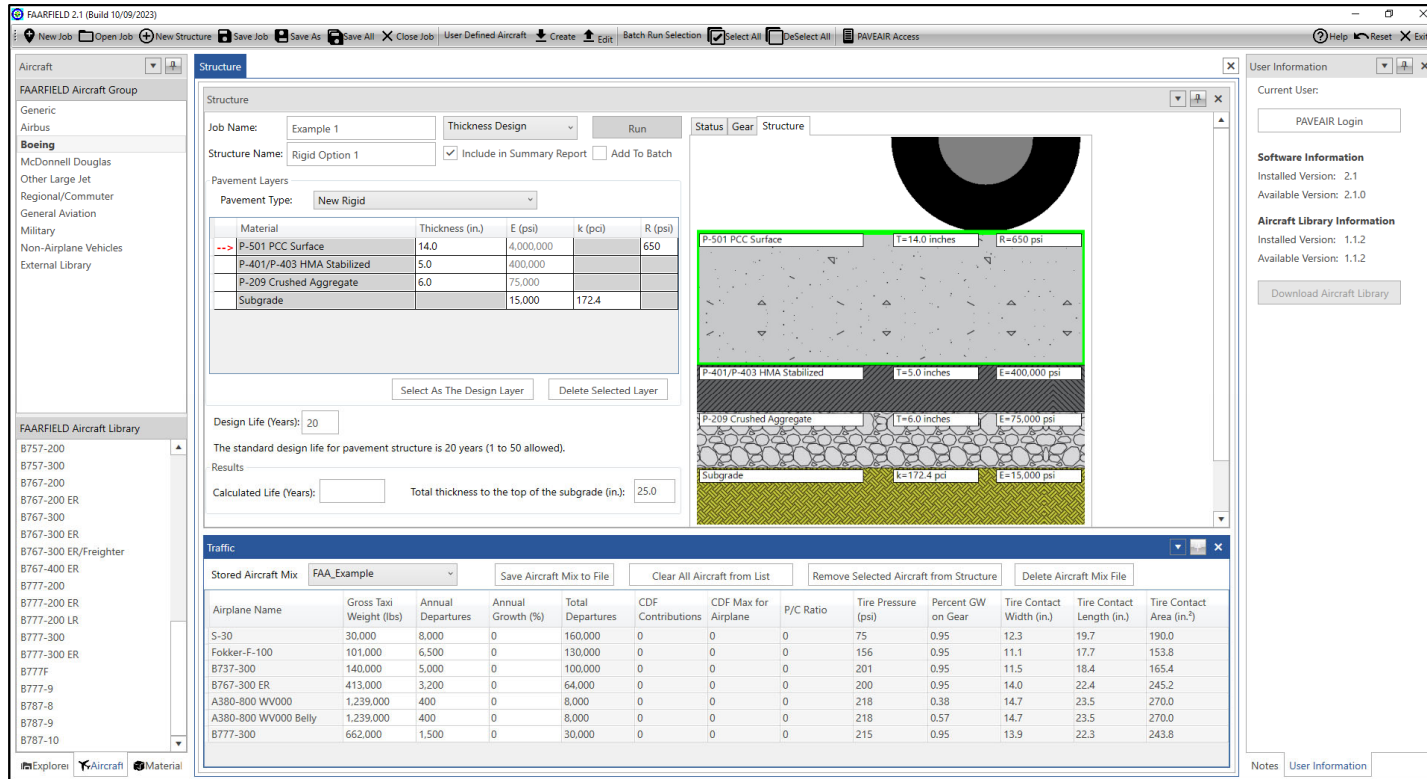
By: Harold Muniz
David R. Brill, P.E., Ph.D.

Date: 7 February 2024



**Federal Aviation
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Download & Install FAARFIELD 2.1 Software

7 February 2024

Intro to FAARFIELD 2.1

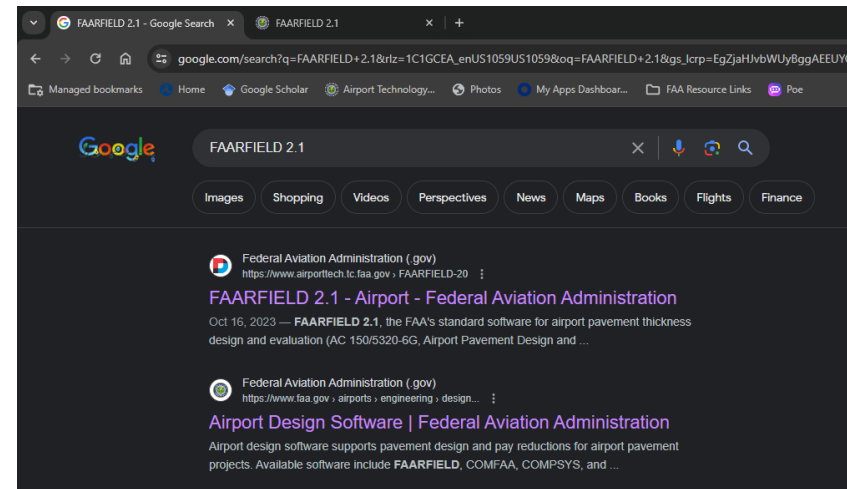


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Download FAARFIELD 2.1

- **Link:** <https://airporttech.tc.faa.gov/Products/Airport-Safety-Papers-Publications/Airport-Safety-Detail/faarfield-21>
 - Alternate - Search “FAARFIELD 2.1”

FAARFIELD can only be installed on Windows OS



Download FAARFIELD 2.1

- **Click “Installation Files” to download**
 - Approximately 50 MB
 - Downloaded as compressed ZIP file
- **Source Code is also available at this webpage**

Monday, October 16, 2023

FAARFIELD 2.1

FAARFIELD 2.1 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 2.1, 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 150/5335-6D, Standardized Method of Reporting Pavement Strength – PCR), features the following:

- Improved User Interface (UI) functionalities.
- The UI displays Slab Edge Stress and Slab Interior Stress for all aircraft in the Traffic mix, when performing Thickness Design or Life analysis of New Rigid pavement. The UI also shows the Most Demanding Aircraft.
- Performs Reduced Cross Section design for New Flexible and New Rigid.
- Enhanced capabilities to create and save Traffic Mix in the job file.
- Automatically downloads the most up-to-date aircraft library from PAVEAIR when users open the program.
- Improved ACR-PCR analysis.
- Modified information for numerous aircraft in the aircraft library.

Please note that:

- FAARFIELD stands for FAA Rigid and Flexible Iterative Elastic Layered Design. FAARFIELD 2.1 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. Your comments on this program and your suggestions for improvement are appreciated.
- FAARFIELD 2.1 is compatible with Windows™ operating systems. Windows 10 or higher is recommended. Installation instructions are available in the readme file.
- For questions, comments, or further information regarding this program, please contact [Dr. David R. Brill](#), FAA Airport Technology R&D Branch, ANG-E262.

FAARFIELD 2.1 replaces all previous versions of FAARFIELD. To download the previous version FAARFIELD 1.42, use the following link: [FAARFIELD 1.42](#)

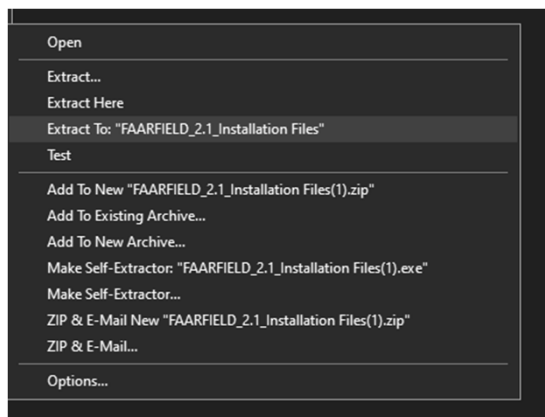
Documents to download

-  [FAARFIELD 2.1 readme](#)
-  [FAARFIELD_2.1_Installation Files](#)
-  [FAARFIELD_2.1_SourceCode](#)



Install FAARFIELD 2.1

- Extract the downloaded ZIP file
- Run .MSI file to begin installation

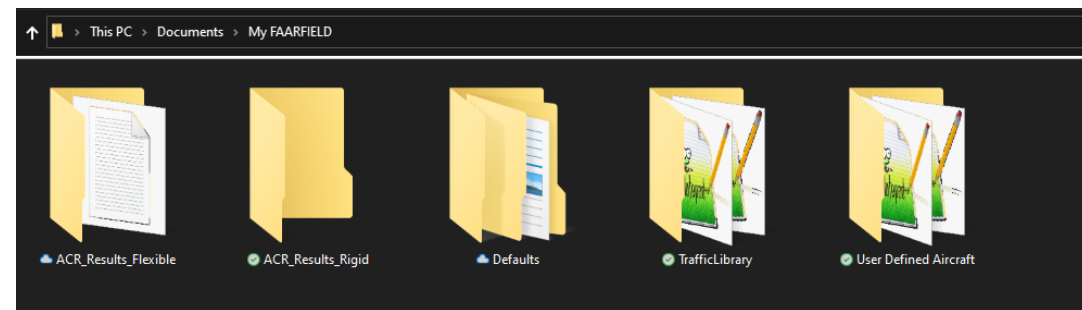
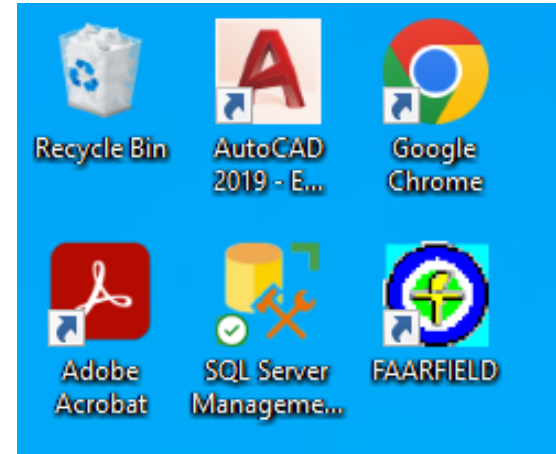


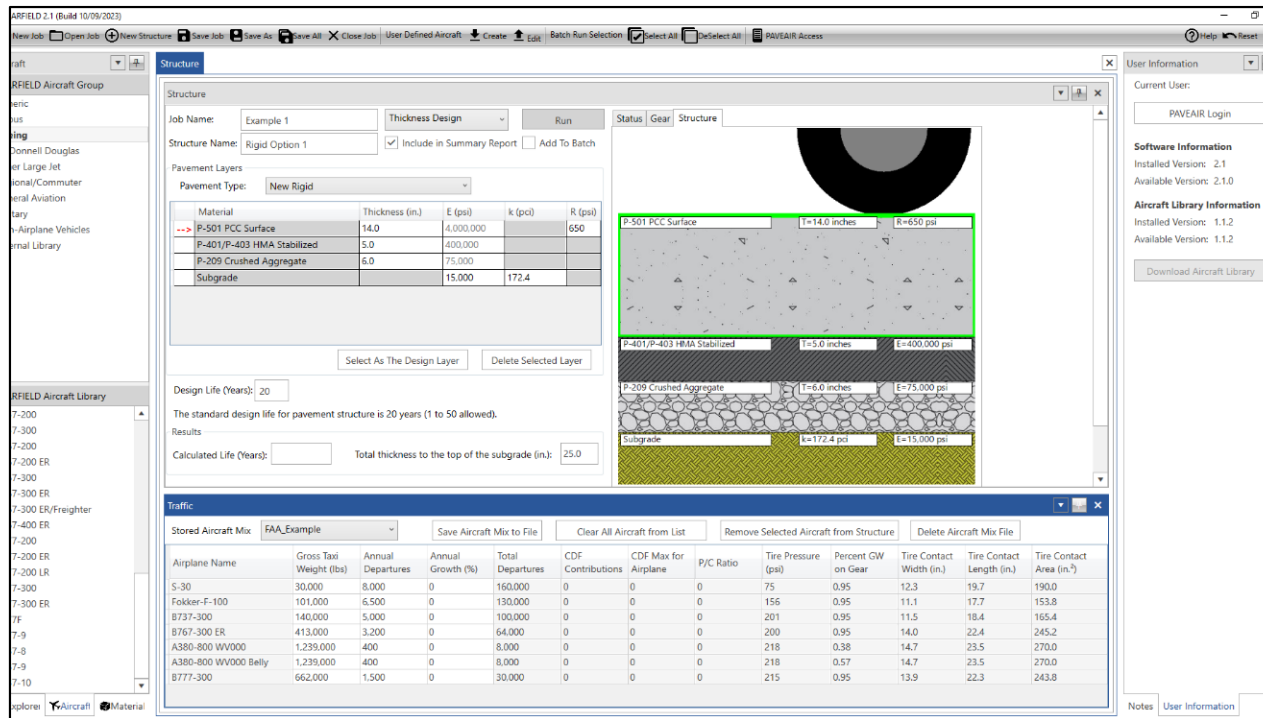
Name	Date modified	Type	Size
FAARFIELD.Installer.msi	10/9/2023 3:09 PM	Windows Installer Packa...	52,092 KB
FAARFIELD.Installer.wixpdb	10/9/2023 3:09 PM	WIXPDB File	594 KB

Install FAARFIELD 2.1

To confirm the installation, look for:

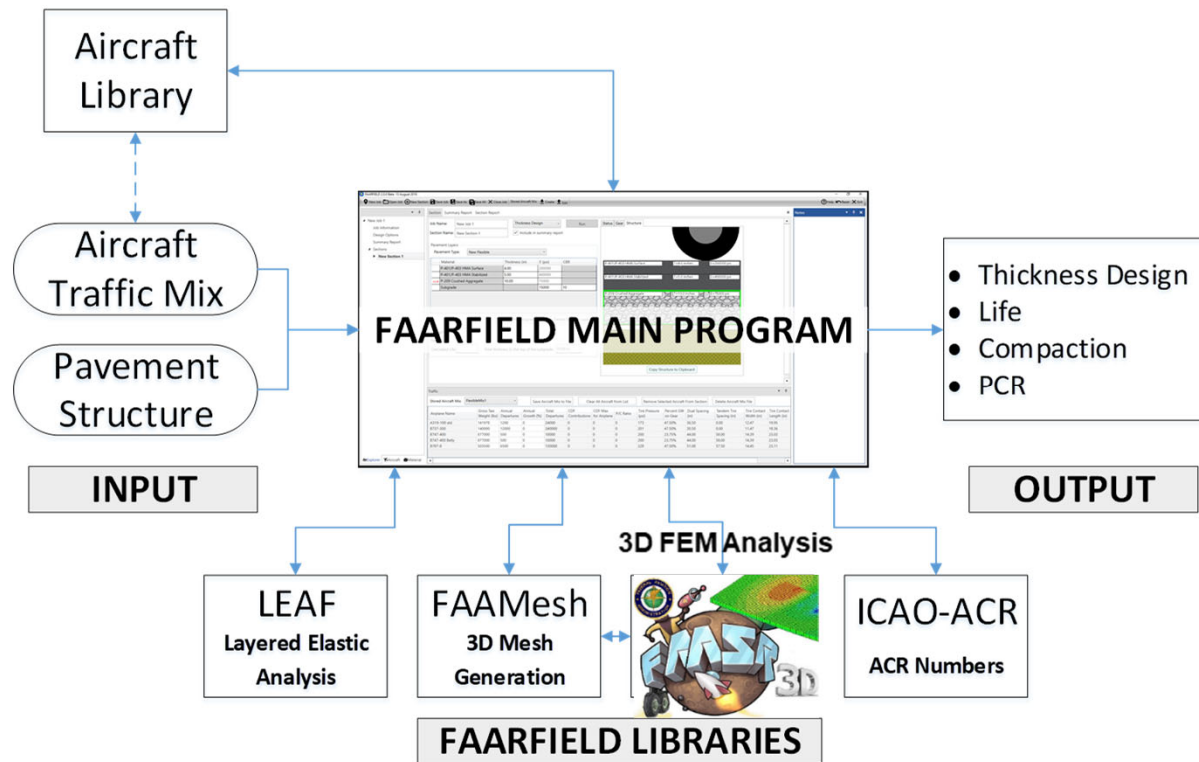
- FAARFIELD application on your desktop
- FAARFIELD in Windows menu
- *My FAARFIELD* folder in your Documents directory





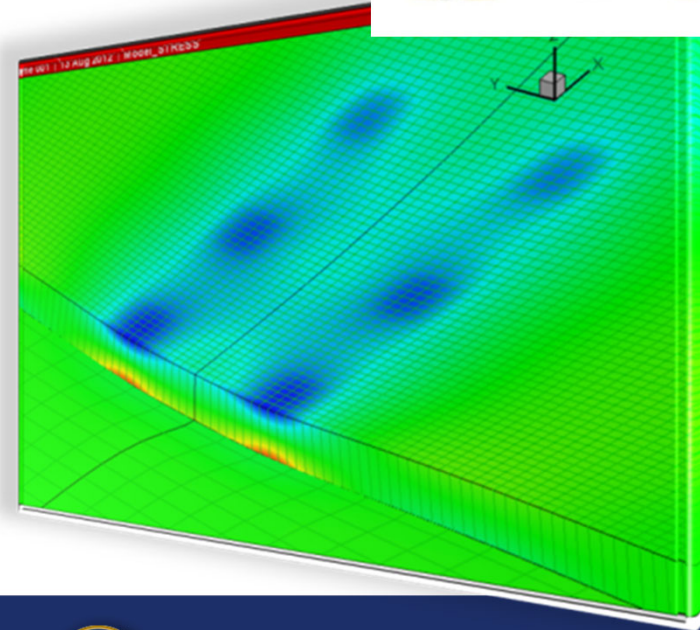
Navigating FAARFIELD 2.1 Software

FAARFIELD 2.1 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.



Navigating FAARFIELD 2.1

TOOLBAR

The screenshot shows the FAARFIELD 2.1 software interface. The interface is divided into several panels:

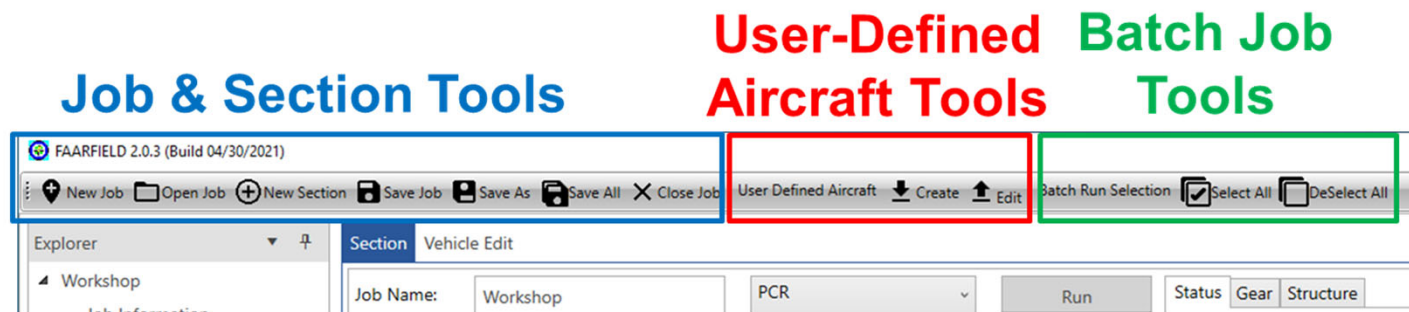
- Explorer (Left Panel):** A tree view showing the project structure. It includes 'Airport A' with sub-items like 'Job Information', 'Design Options', 'Summary Report', and 'Sections'. Under 'Sections', there are 'Section 01' and 'Section 02', each with further sub-items like 'Section Report', 'CDF Graph', 'PCR Report', 'PCR Graph', 'Form 5010', and 'PCC Overlay Example'.
- Section Area (Center Panel):** The main workspace for defining pavement sections. It includes a 'Section' tab with fields for 'Job Name' (Airport A), 'Section Name' (Section 01), and 'Thickness Design'. It also has a 'Pavement Layers' table and a 'Results' section.

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
- Options (Right Panel):** A panel for configuring design options. It includes sections for 'Design Options' (Calculate HMA CDF, Automatic flexible base design, Output file, Units, Allow Flexible Computation for Thick Overlays on PCC, Compute ACR for All Subgrade Categories) and 'Design Options' (Show Advanced Options, Design Program, Default, Initial, Show/Hide Pavement Image, Change Pavement Graphics).
- Traffic Area (Bottom Panel):** A table for managing aircraft data. It includes a 'Stored Aircraft Mix' dropdown and a table with columns for 'Airplane Name', 'Gross Taxi Weight (lbs)', 'Annual Departures', 'Annual Gross Weight', 'Total Gross Weight', 'CDF', 'CDF Max', 'P/C Ratio', 'Tire Pressure', 'Percent GW', 'Dual Tire Spacing (in.)', 'Tandem Tire Spacing (in.)', 'Tire Contact Width (in.)', and 'Tire Contact Length (in.)'.

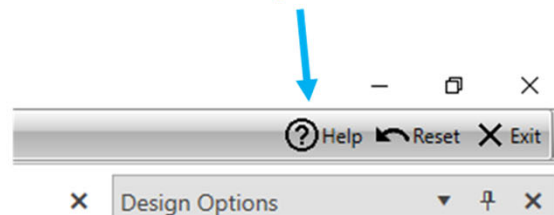
Airplane Name	Gross Taxi Weight (lbs)	Annual Departures	Annual Gross Weight	Total Gross Weight	CDF	CDF Max	P/C Ratio	Tire Pressure	Percent GW	Dual Tire Spacing (in.)	Tandem Tire Spacing (in.)	Tire Contact Width (in.)	Tire Contact Length (in.)
B737-900	174700	3000	0	0	0	0	0	142	0.75	34.0	0.0	12.7	20.4
A321-200 opt	207014	2500	0	0	0	0	0	142	0.495	36.5	0.0	13.6	21.7
EMB-195 STD	107916	4500	0	0	0	0	0	147	0.475	34.0	0.0	11.8	18.8
CRJ700	72500	3500	0	0	0	0	0	142	0.95	0.0	0.0	9.9	15.8



FAARFIELD 2.0 – Toolbar



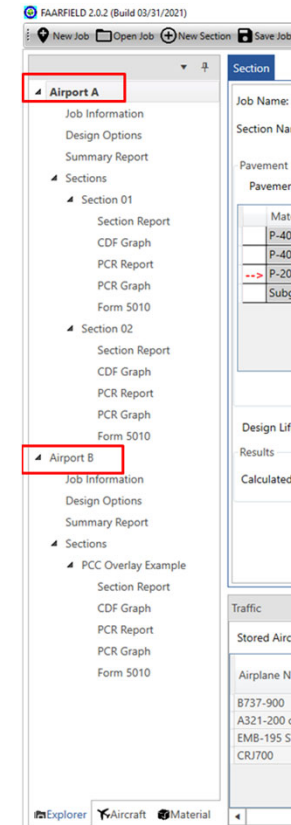
Help File



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FAARFIELD 2.1 – Explorer Navigation

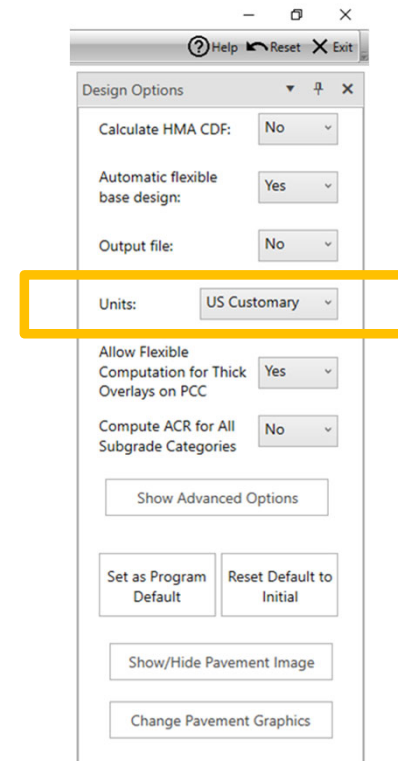
- FAARFIELD 2.1 supports multiple jobs open at the same time.
- Use the Explorer to navigate between jobs, and display:
 - Sections
 - Section Reports
 - PCR Reports/Graphs
 - 5010 Reports
 - Summary Reports (high-level run information on selected sections in a job)



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FAARFIELD 2.1 – Options

- Toggle between U.S. and metric units.
- Set user preferences for graphic display.
- One click restores default options.



FAARFIELD 2.1 – Pavement Section Area

Job and Section Controls

Job Name: Airport A
Section Name: Section 01
Pavement Type: New Flexible

Pavement Layer Table

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	12.7	50889	
Subgrade		15000	10

Results Area

Design Life (Years): 20
Results
Calculated Life (Years):
Total thickness to the top of the subgrade: 22.7 in.

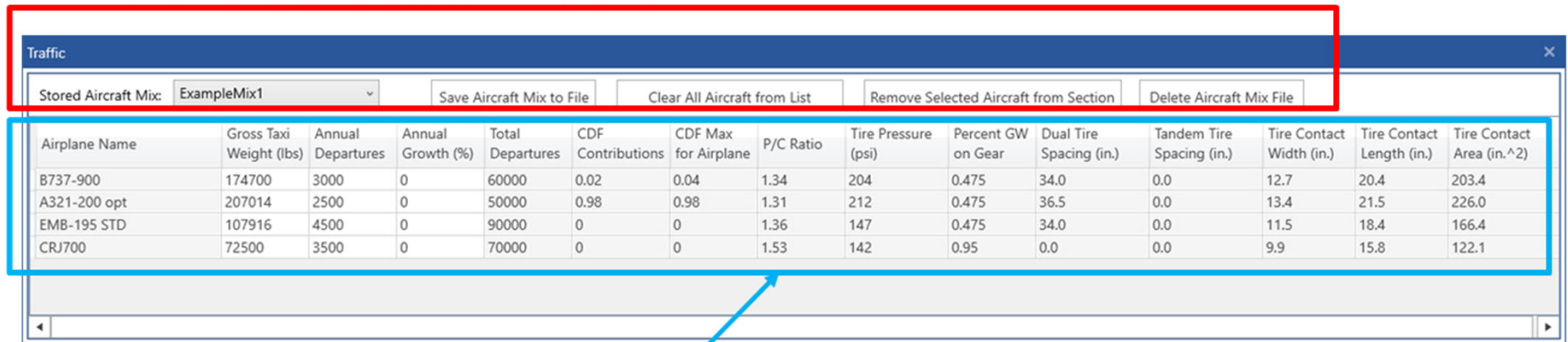
Pavement Section Clickable Image

P-401/P-403 HMA Surface T=5.0 inches E=200000 psi
P-401/P-403 HMA Stabilized T=5.0 inches E=400000 psi
P-209 Crushed Aggregate T=12.7 inches E=50889 psi
Subgrade CBR=10 E=15000 psi

Copy Structure to Clipboard

FAARFIELD 2.1 – Traffic Table (dockable)

Aircraft SelectionTools



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 Tire Spacing (in.)	Tandem Tire Spacing (in.)	Tire Contact Width (in.)	Tire Contact Length (in.)	Tire Contact Area (in.^2)
B737-900	174700	3000	0	60000	0.02	0.04	1.34	204	0.475	34.0	0.0	12.7	20.4	203.4
A321-200 opt	207014	2500	0	50000	0.98	0.98	1.31	212	0.475	36.5	0.0	13.4	21.5	226.0
EMB-195 STD	107916	4500	0	90000	0	0	1.36	147	0.475	34.0	0.0	11.5	18.4	166.4
CRJ700	72500	3500	0	70000	0	0	1.53	142	0.95	0.0	0.0	9.9	15.8	122.1

Selected Aircraft Data

Aircraft Selection

Aircraft library has been completely reorganized and updated for FAARFIELD 2.1!

Aircraft Group

Library Aircraft

Traffic List

Airplane Name	Gross Taxi Weight (kg)	Annual Departures	Annual Growth (%)	Total Departures	CDF Contributions	CDF Max for Airplane	P/C Ratio	Tire Pressure (kPa)	Percent GW on Gear	Dual Tire Spacing (mm)	Tandem Tire Spacing (mm)	Tire Contact Width (mm)
A300-B4/C4 Std Bogie	165900	600	0	12000	0	0	0	1490	47.50%	927	1397	321
A319-100 std	64400	1000	0	20000	0	0	0	1193	47.50%	927	0	316
B727-200 Advanced Basic	84000	1000	0	20000	0	0	0	1020	47.50%	864	0	391
B737-300	63503	1200	0	24000	0	0	0	1386	47.50%	775	0	291
B747-400	397801	300	0	6000	0	0	0	1379	23.75%	1118	1473	366
B747-400 Belly	397801	300	0	6000	0	0	0	1379	23.75%	1118	1473	366
B767-300 ER	179623	2000	0	40000	0	0	0	1310	47.50%	1143	1422	351
B777-300 ER	298460	1000	0	20000	0	0	0	1413	47.50%	1397	1448	361

FAARFIELD 2.0 – Aircraft Library

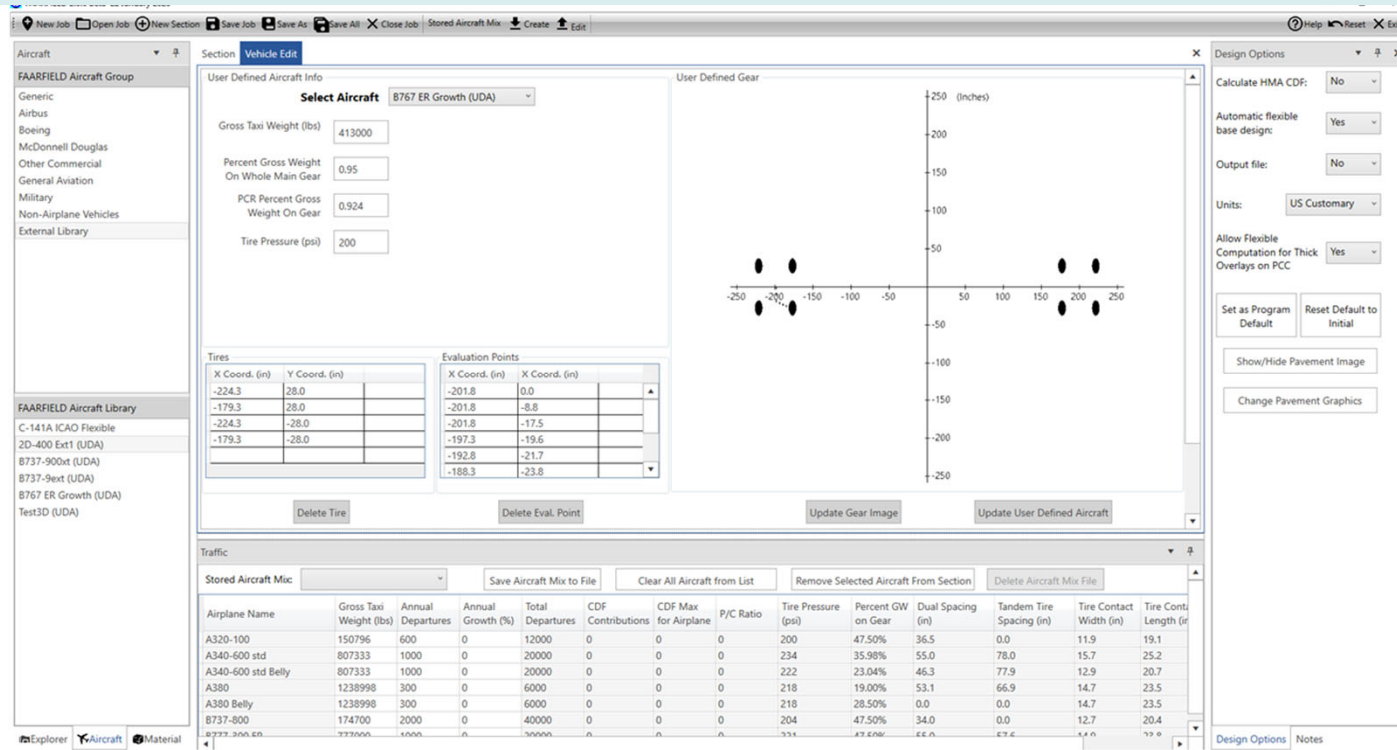
Aircraft	Aircraft	Aircraft	Aircraft	Aircraft	Aircraft	Aircraft	Aircraft
FAARFIELD Aircraft Group	FAARFIELD Aircraft Group	FAARFIELD Aircraft Group	FAARFIELD Aircraft Group	FAARFIELD Aircraft Group	FAARFIELD Aircraft Group	FAARFIELD Aircraft Group	FAARFIELD Aircraft Group
Generic	Generic	Generic	Generic	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 CS5	Beechcraft King Air 350	A400M TLL2
S-3	A300-600 Std Bogie	B727-200 Advanced Option	DC/MD-10-10/10F	Fokker-F-100	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 WW000 Bogie	B737-900 ER					P-3C



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User-Defined Aircraft Mode

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



User-Defined Aircraft Mode

- **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 2.1 – User Defined Aircraft

The screenshot displays the FAARFIELD 2.0.3 software interface. A red box highlights the 'User Defined Aircraft' toolbar at the top right, which includes 'Create' and 'Edit' buttons. Another red box highlights the 'Thickness Design' dropdown menu in the 'Section' panel. A red arrow points from the 'User Defined Aircraft' toolbar to the 'Thickness Design' dropdown. A text box with a red border contains the text: 'Access the editor using the User Defined Aircraft tools on the toolbar.' The interface also shows a list of aircraft types on the left, a 'Pavement Layers' table, and a 'Traffic' table at the bottom.

Access the editor using the User Defined Aircraft tools on the toolbar.

Aircraft 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 Tire Spacing (in.)	Tandem Tire Spacing (in.)	Tire Wic
S-30	30000	8000	0	160000	0	0	1.75	75	0.475	0.0	0.0	12.3
Fokker-F-100	98000	6500	0	130000	0	0	1.33	151	0.475	23.1	0.0	11.1
B737-300	138500	5000	0	100000	0	0	1.26	199	0.475	30.5	0.0	11.5
B767-300 ER	350000	3200	0	64000	0.01	0.02	1.14	171	0.475	45.0	56.0	13.5
A380-800 WV000	1200000	400	0	8000	0.35	0.4	1.15	211	0.19	53.1	66.9	14.7
A380-800 WV000 Belly	1200000	400	0	8000	0.02	0.76	1.25	211	0.285	0.0	0.0	14.7
B777-300	580000	1500	0	30000	0.62	0.62	1.19	188	0.475	55.0	57.0	13.5



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FAARFIELD 2.1 – User Defined Aircraft Mode

FAARFIELD 2.0.18 (Build 05/26/2022)

Section: **Vehicle Edit**

User Defined Aircraft Info

New User Defined Aircraft:

Gross Taxi Weight (lbs)

Percent Gross Weight on Whole Main Gear

PCR Percent Gross Weight on Gear

Tire Pressure (psi)

Gear Orientation

Tires

X Coord. (in.)	Y Coord. (in.)

Evaluation Points

X Coord. (in.)	Y Coord. (in.)

Buttons: Delete Tire, Delete Eval. Point, Update Gear Image, Save New User Defined Aircraft

1. Enter a name for the new UDA
2. Enter the gross weight (lbs.)
3. Enter percent gross weight on the main gear as a decimal value (e.g., 0.95)
4. Enter the percent gross weight on the main gear for PCR calculations as a decimal value.
5. Enter the tire pressure (psi)

User-Defined Aircraft Mode

Define the tire coordinates.

- X-coordinate is lateral.
- Y-coordinate is longitudinal (in direction of travel)
- Only enter coordinates for one set of wheels (left or right, doesn't matter). They will be reflected on the centerline.

Define the evaluation points. These are used for layered elastic analysis computations.

- Must have at least one evaluation point.
- Typically, under the wheel, at the gear CG, and evenly spaced between.
- Again, only enter coordinates for one set of points (left or right, doesn't matter).

Vehicle Edit

User Defined Aircraft Info

New User Defined Aircraft: 877

Gross Taxi Weight (lbs) 145,000

Percent Gross Weight on Whole Main Gear 0.95

PCR Percent Gross Weight on Gear 0.95

Tire Pressure (psi) 200

Gear Orientation 0

Tires

X Coord. (in.)	Y Coord. (in.)
-118.3	0.0
-87.8	0.0

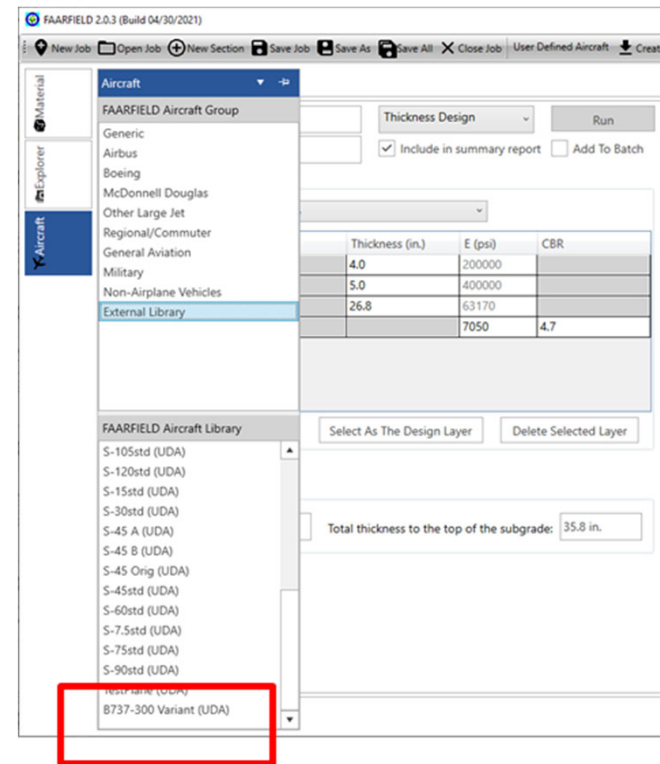
Evaluation Points

X Coord. (in.)	Y Coord. (in.)
-103.1	0.0
-100.0	0.0
-97.0	0.0
-93.9	0.0
-90.9	0.0
-87.8	0.0

Buttons: Delete Tire, Delete Eval. Point, Update Gear Image, Save New User Defined Aircraft

User-Defined Aircraft Mode

- New UDA will appear in your External Library group.
- Identified by the suffix (UDA)
- Can be used in designs the same as internal library aircraft.
- Use the editor to define non-airplane vehicles (ARFF vehicles, tugs, etc.) not in the internal library.



Editing an Existing UDA

The screenshot shows the 'UDA Tools' window. At the top, there is a menu bar with options: Section, Save Job, Save As, Save All, Close Job, User Defined Aircraft, Create, Edit, Batch Run Selection, Select All, and DeSelect All. The 'Edit' button is highlighted with a red box, and a red arrow points to it from a callout box that says 'Select "Edit" from the UDA Tools'. Below the menu bar, the 'Section' tab is selected. The main area contains fields for 'Job Name' (Workshop), 'Section Name' (Flexible Example), and a 'Thickness Design' dropdown menu. There is also a checkbox for 'Include in summary report'. Below these fields, the 'Pavement Layers' section shows 'Pavement Type' set to 'New Flexible'. A table lists the pavement layers:

	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	26.8	63170	
	Subgrade		7050	4.7

On the right side of the window, there is a preview of the pavement structure with three layers: 'P-401/P-403 HMA Surface' (top, dark grey), 'P-401/P-403 HMA Stabilized' (middle, light grey), and 'P-209 Crushed Aggregate' (bottom, green and white patterned). The 'P-209 Crushed Aggregate' layer is highlighted with a green border.

1

Two screenshots of the RAUPREP 2.0.0.0 software interface are shown side-by-side. Both screenshots display the 'Select Aircraft' dropdown menu, which is open and showing a list of aircraft options. The left screenshot shows the 'Aircraft' tab selected, and the right screenshot shows the 'Engine' tab selected. Both screenshots have a callout box pointing to the 'Aircraft' dropdown menu with the text: "Select the aircraft you want to edit from the drop-down list."

2

3

Four Functions in FAARFIELD 2.1

FAARFIELD 2.0.0 Beta 22 January 2020

Job Name: New Job 1
Section Name: New Section 1

Pavement Type: New Flexible

Material

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

Design Life: 20

Results

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

Traffic

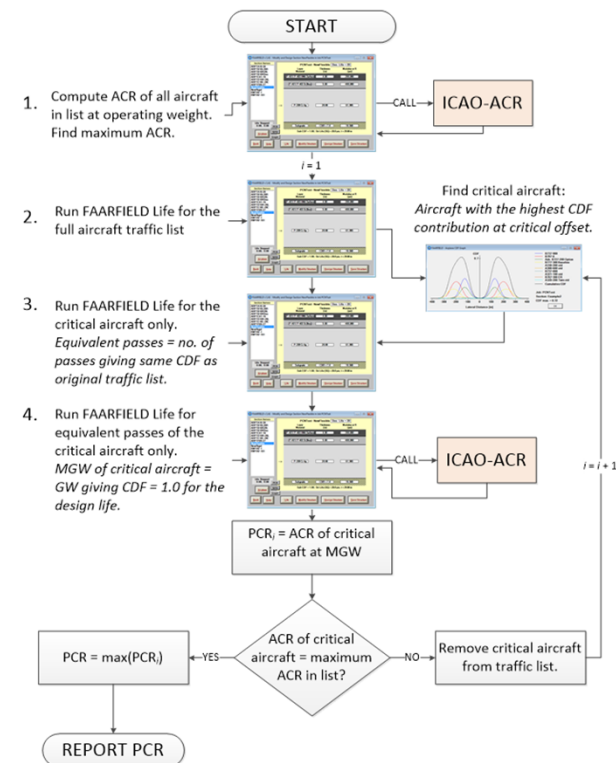
Stored Aircraft Mix: FlexExampleMix

Airplane Name	Gross Taxi Weight (lbs)	Annual Departures	Annual Growth (%)	Total Departures	C
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

- **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 following AC 150/5335-5D.

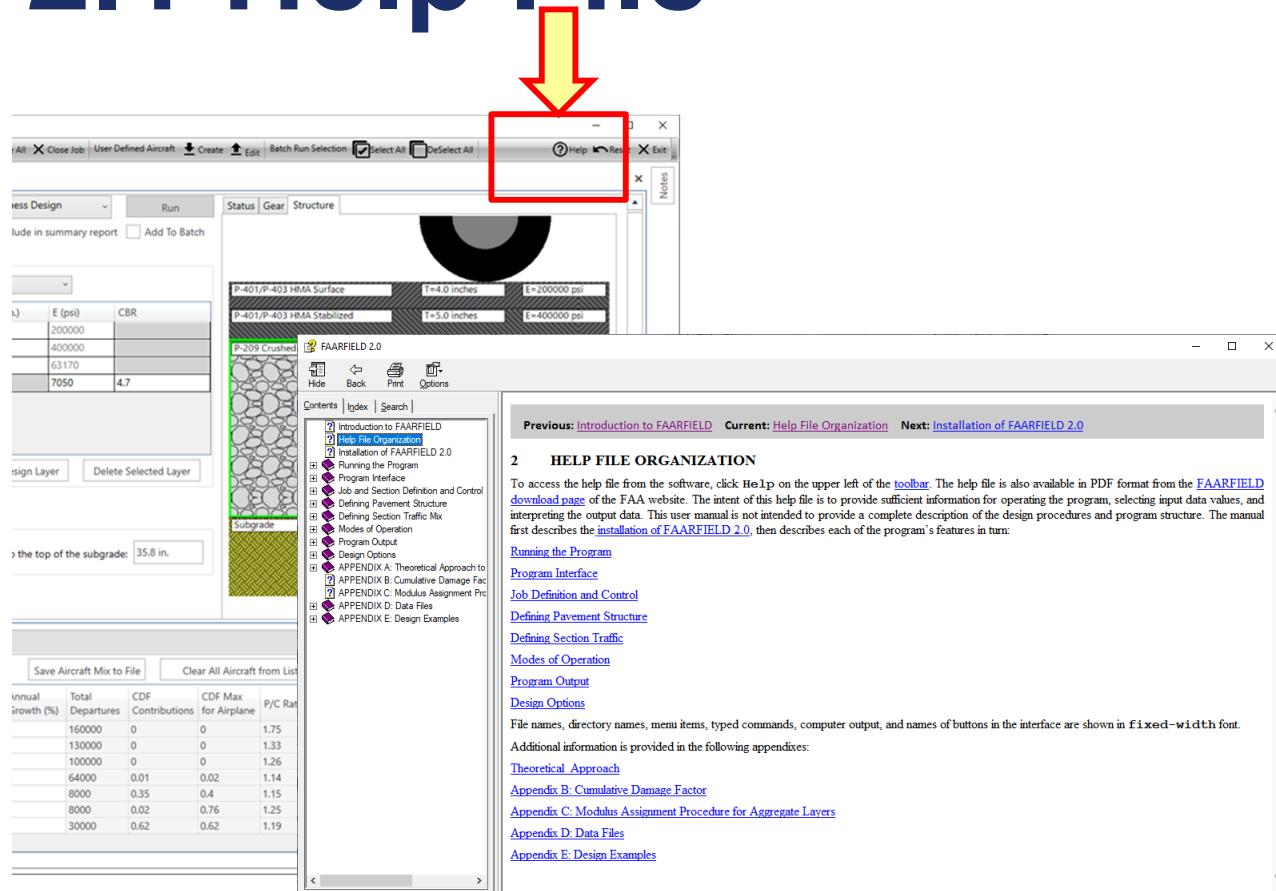
FAARFIELD 2.1 Provides PCR

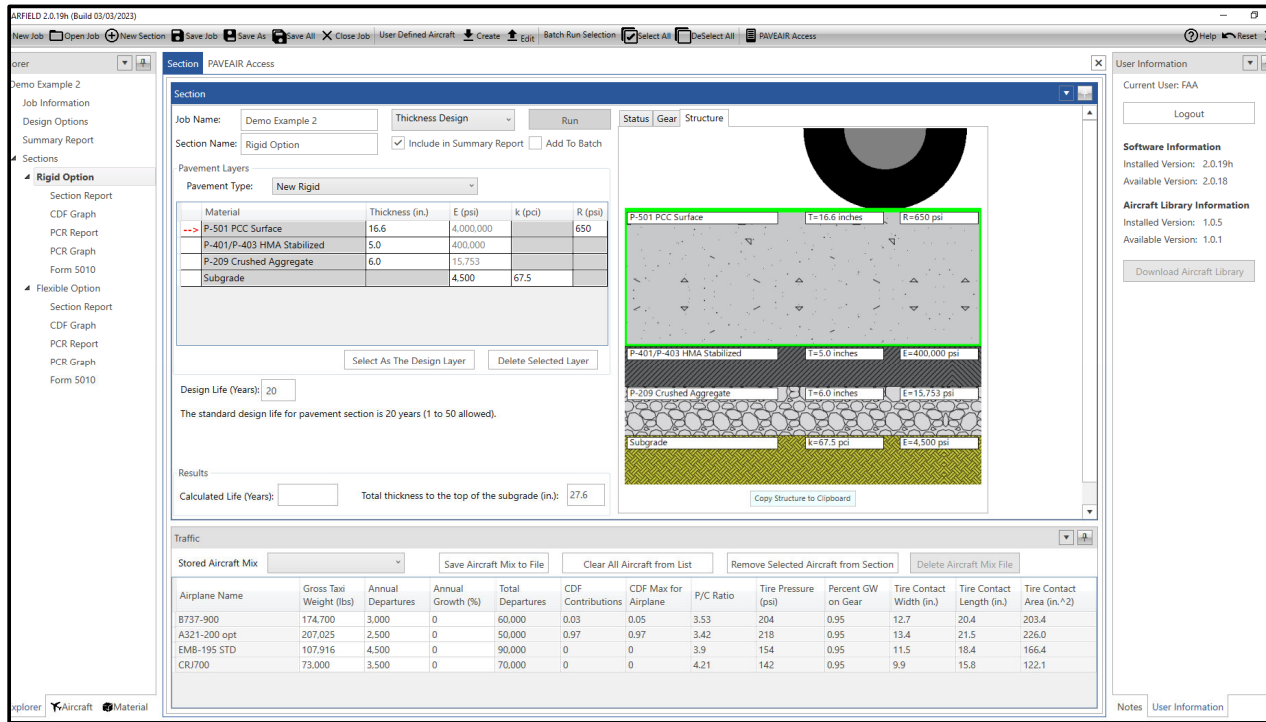
- **Directly uses FAARFIELD structure and traffic list.**
- **Replacement for COMFAA 3.0 & support spreadsheets.**
- **Method yields uniquely defined PCR – no more looping through all aircraft in the list.**
- **Implemented in FAARFIELD 2.1**
 - Solves problem of computing PCR for mixed traffic (i.e., many narrow bodies and few long range aircraft) without unnecessary operating weight restrictions on the LRs.
 - Seamlessly handles HMA overlays on rigid pavements (topic of afternoon presentation).



FAARFIELD 2.1 Help File

- Completely rewritten for FAARFIELD 2.0.
- This is the first resource you should go to with your questions on FAARFIELD.
- Contains examples.



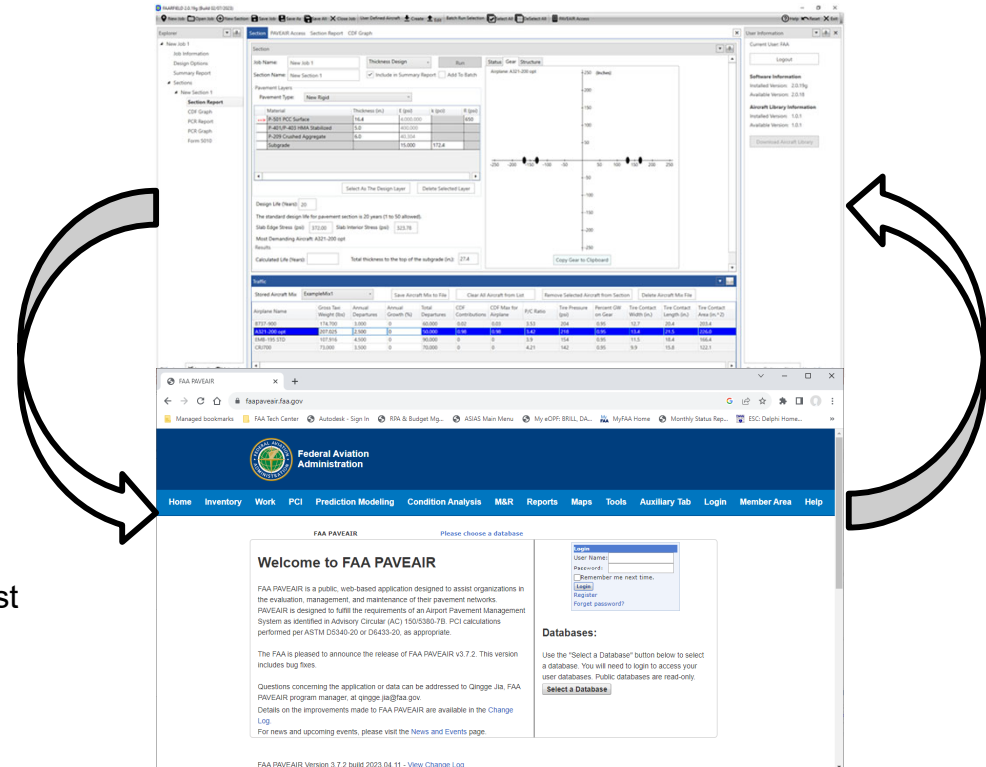


New Features in FAARFIELD 2.1



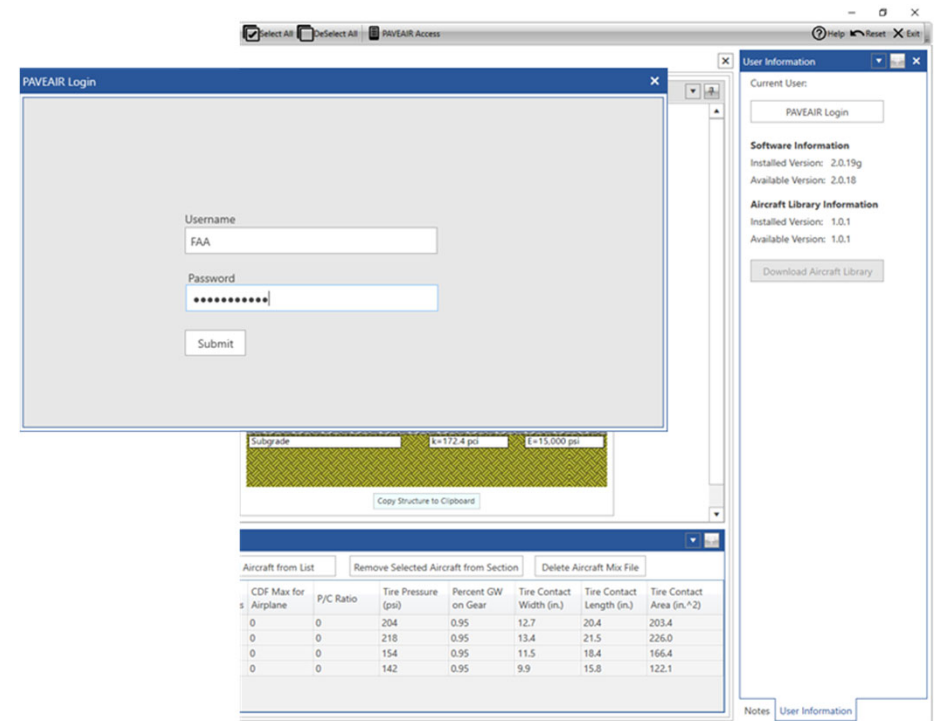
FAARFIELD 2.1 – New Features and Links to FAA PAVEAIR

- **FAA PAVEAIR**
 - FAA's web-based airport pavement management system (APMS)
 - <https://faapaveair.faa.gov/>
- **Data Integration with FAA PAVEAIR**
 - Log in to PAVEAIR using PAVEAIR user credentials
 - Update to current library version (and eventually to current software version) online
 - Access user-owned PAVEAIR databases
 - Populate Job Information from PAVEAIR data
 - Upload/download/store FAARFIELD job files
- **More New Features**
 - Display critical design stresses for rigid slabs (and most demanding aircraft for A-1 joint design).
 - Option to automatically perform reduced cross section design (1% of traffic).



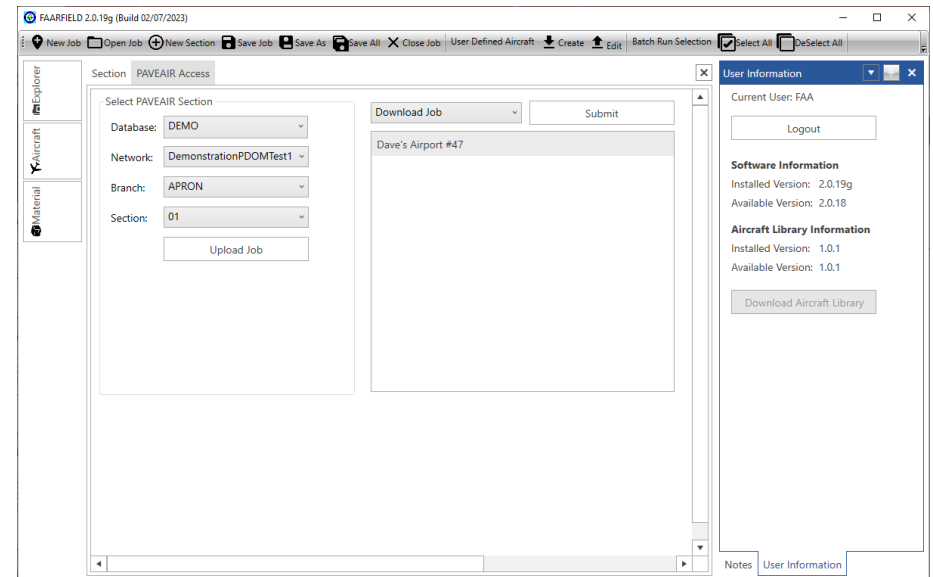
FAARFIELD User Sign-In

- Select “User Information” tab at right
- Sign in using existing PAVEAIR account login and password.
- Panel displays installed and currently available versions of software and aircraft library.
- If your aircraft library is out of date, you have the opportunity to download the latest version.
- In the future, you will be able to update to a newer version of FAARFIELD, run software patches and bug fixes, etc.



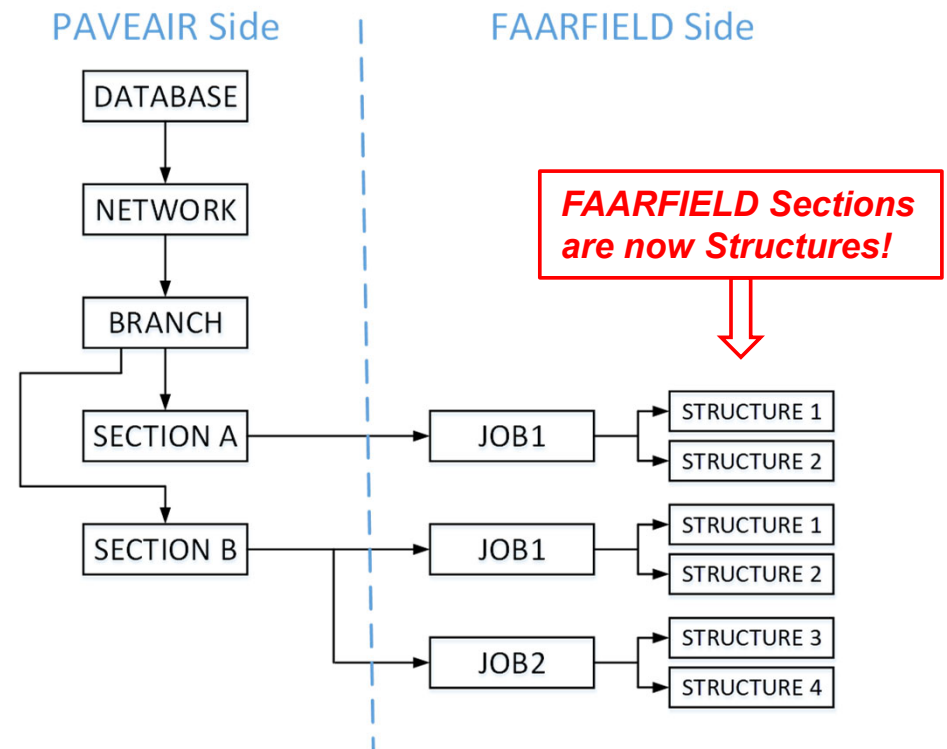
FAARFIELD – PAVEAIR Access Screen

- Once signed in, you have access to all user-owned databases in PAVEAIR.
- Navigate to Network/Branch/Section
- Four possible actions:
 - **Upload Job** – Uploads the current FAARFIELD job to the selected PAVEAIR Network/Branch/Section
 - **Download Job** – Downloads and opens the selected job from the PAVEAIR list in FAARFIELD
 - **Update Job** – Overwrites the selected job
 - **Delete Job** – Deletes the selected job from the PAVEAIR database. (Does not delete from FAARFIELD or the FAARFIELD job file).



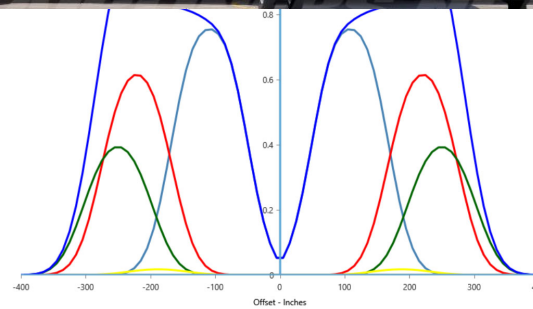
Data Organization

- The same FAARFIELD job can be uploaded to multiple locations in a PAVEAIR database.
- Note to users of FAARFIELD 2.0: “Sections” have been renamed to “Structures.” This is to avoid confusion with sections as defined in APMS.
- For the PAVEAIR user, structures can represent:
 - Asphalt vs. concrete options, for use in PAVEAIR LCCA tool
 - Before/after overlay or replacement of section
 - Different possible traffic mixes
 - Etc.





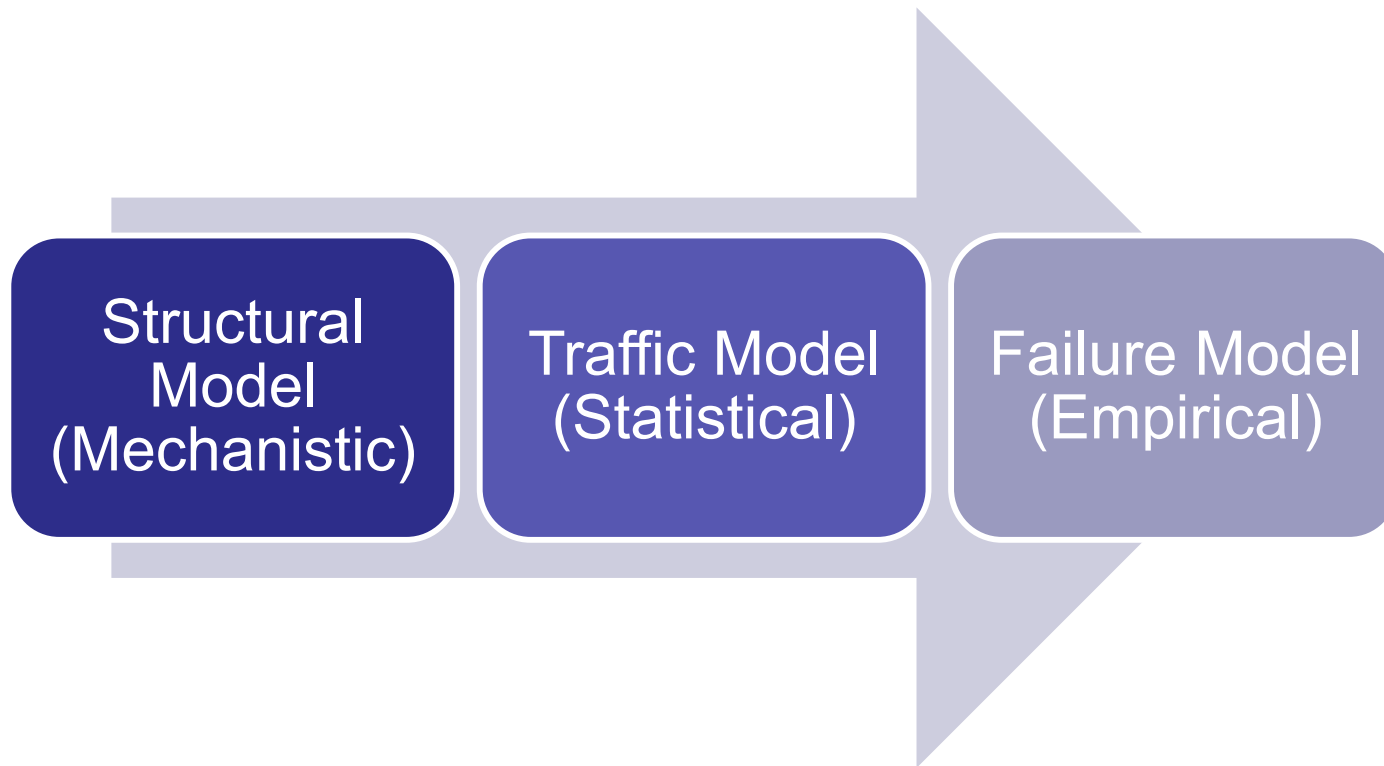
Alex Beltyukov - RuSpotters Team, CC BY-SA 3.0 GFDL 1.2, via Wikimedia Commons



Review of Key Concepts in FAARFIELD

Mechanistic/Empirical Design; Pass-to-coverage; Cumulative Damage Factor (CDF)

Mechanistic-Empirical Design



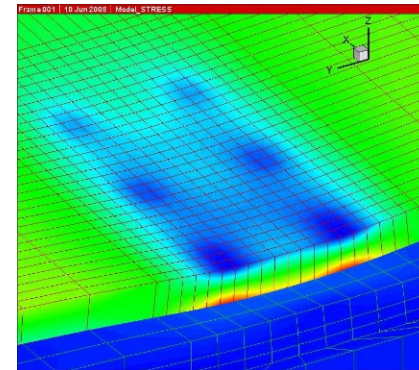
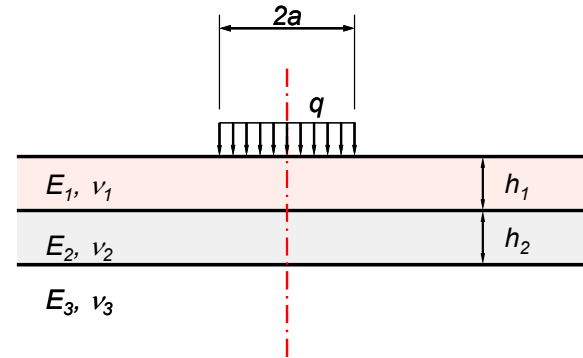
Key Concepts in FAARFIELD

- **Layered Elastic Analysis**
- **Wander**
- **Pass/Coverage Ratio (P/C)**
- **Miner's Rule (linear summation of damage)**
- **Cumulative Damage Factor (CDF)**



Structural Models in FAARFIELD

- Both layered elastic (LEAF) and 3D-FEM (FAASR3D) are used in FAARFIELD.
- Flexible pavement design
 - LEAF is used for all structural computations.
 - For flexible, no advantage to using 3D-FEM.
- Rigid pavement design
 - LEAF to generate a preliminary thickness design.
 - Final iterations are done using FAASR3D.



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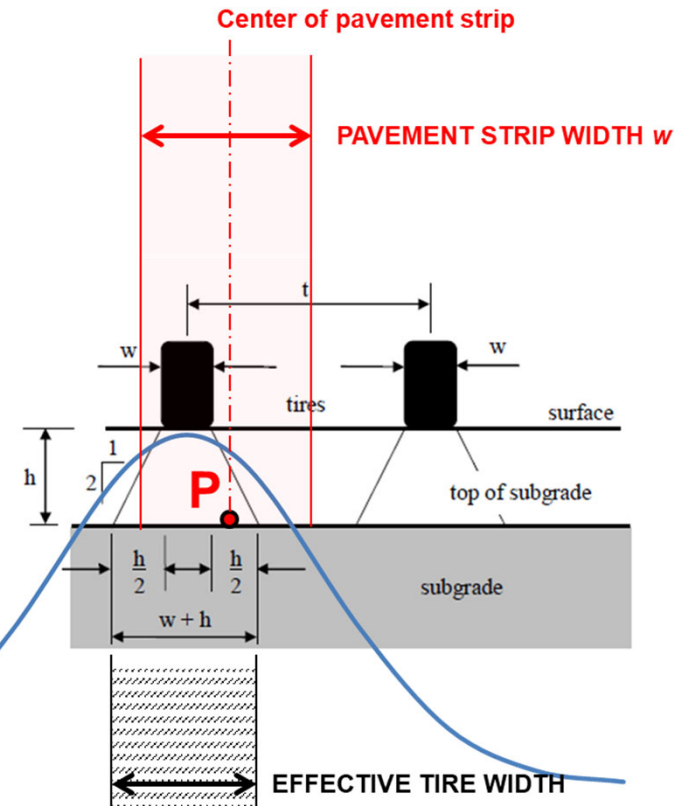
Definitions

- **Coverage** = application of the maximum stress or strain at a point on the pavement.
- **Pass/Coverage Ratio** = the number of aircraft passes resulting in one coverage on a given strip.
- **Wander** = the width over which the centerline of the aircraft is distributed 75% of the time.
- **Effective Tire Width** = the width of a horizontal surface assumed to be affected by a tire load at a given depth.



P/C Ratio in FAARFIELD

- Assume the tire has a normal lateral distribution with wander width = 1.78 m (70 in.).
 - Equivalent to standard distribution $\sigma = 30.54$ in.
- The probability that, for a given pass, any part of the effective tire width covers point P, is defined as the coverage/pass ratio (C/P) for point P.
- P/C is the reciprocal of C/P.
 - P/C is always greater than or equal to 1.0.
 - When does $P/C = 1.0$?
- On a pavement strip of width w , P is the center point of the strip, and we define P/C as applying to the whole strip.
- Depending on which layer is being evaluated, the P/C ratio may vary with thickness!

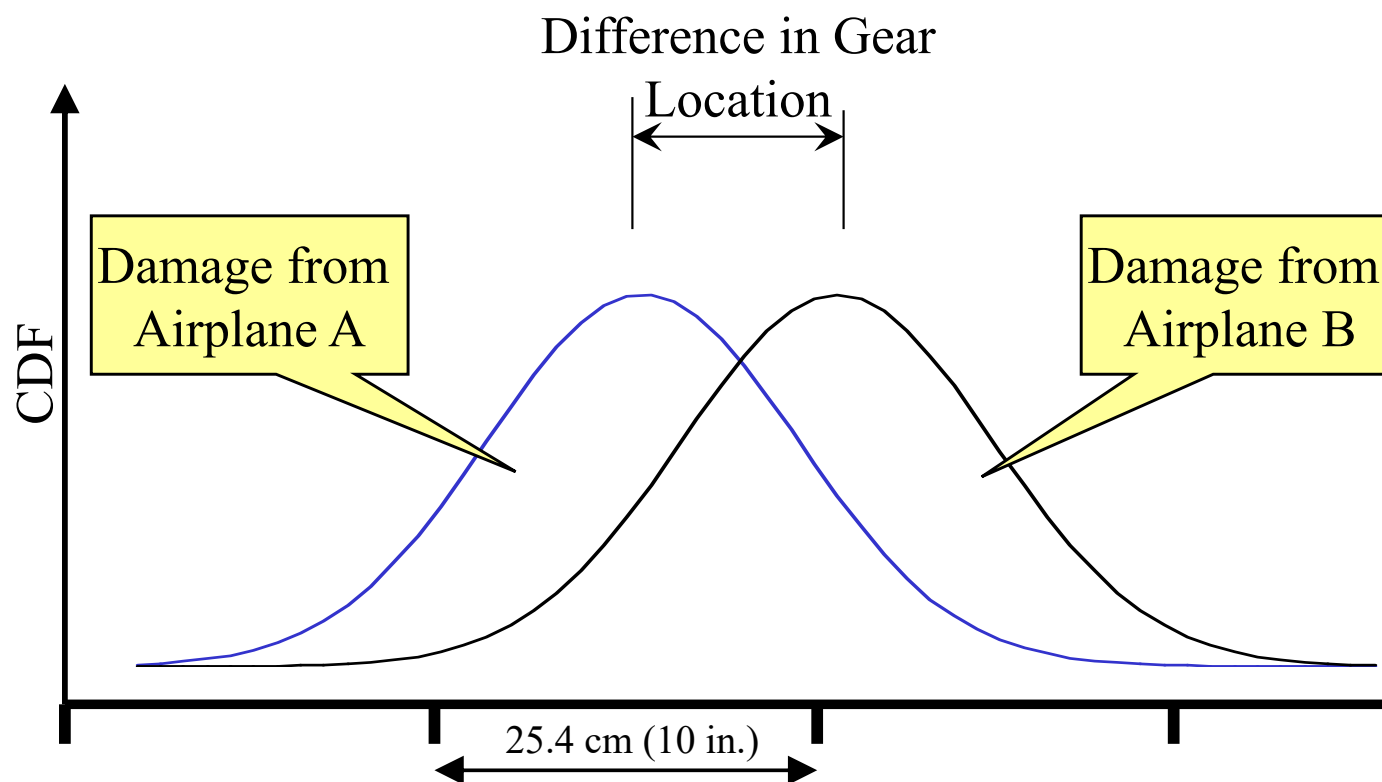


Cumulative Damage Factor (CDF)

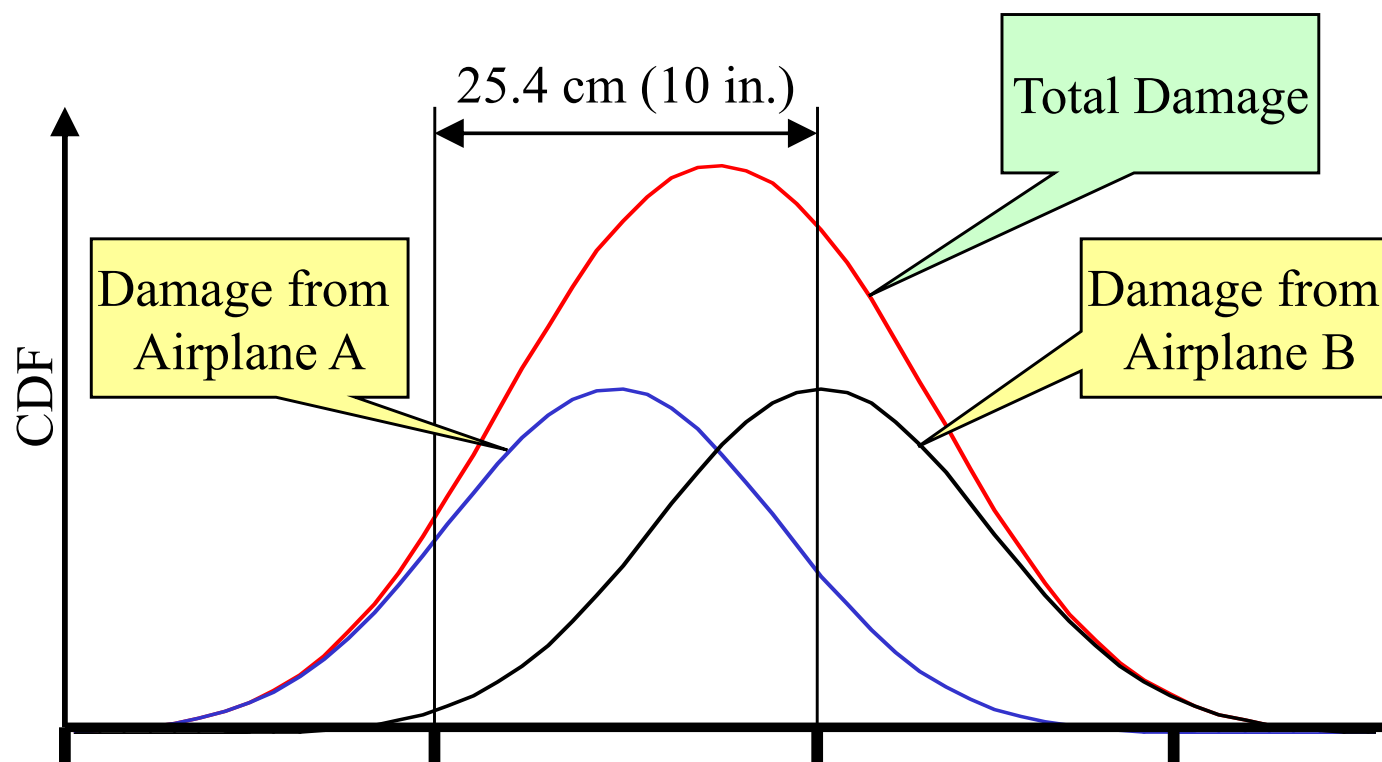
- Sums the damage contributed from each aircraft - not from equivalent aircraft.
 - **CDF = $\Sigma (n_i / N_i)$, where:**
 - n_i = actual passes of individual aircraft i
 - N_i = allowable passes of individual aircraft i
 - **When CDF = 1, design life is exhausted.**
 - **In FAARFIELD:**
 - The gear location and wander are considered separately for each aircraft in the total mix.
 - CDF is calculated for each 25.4 cm (10 inch) wide strip over a total 20.83 m (820 inch) width.
 - Use Miner's rule to sum damage for each strip.
- **Important: Input the fleet mix, NOT equivalent departures of design aircraft.**



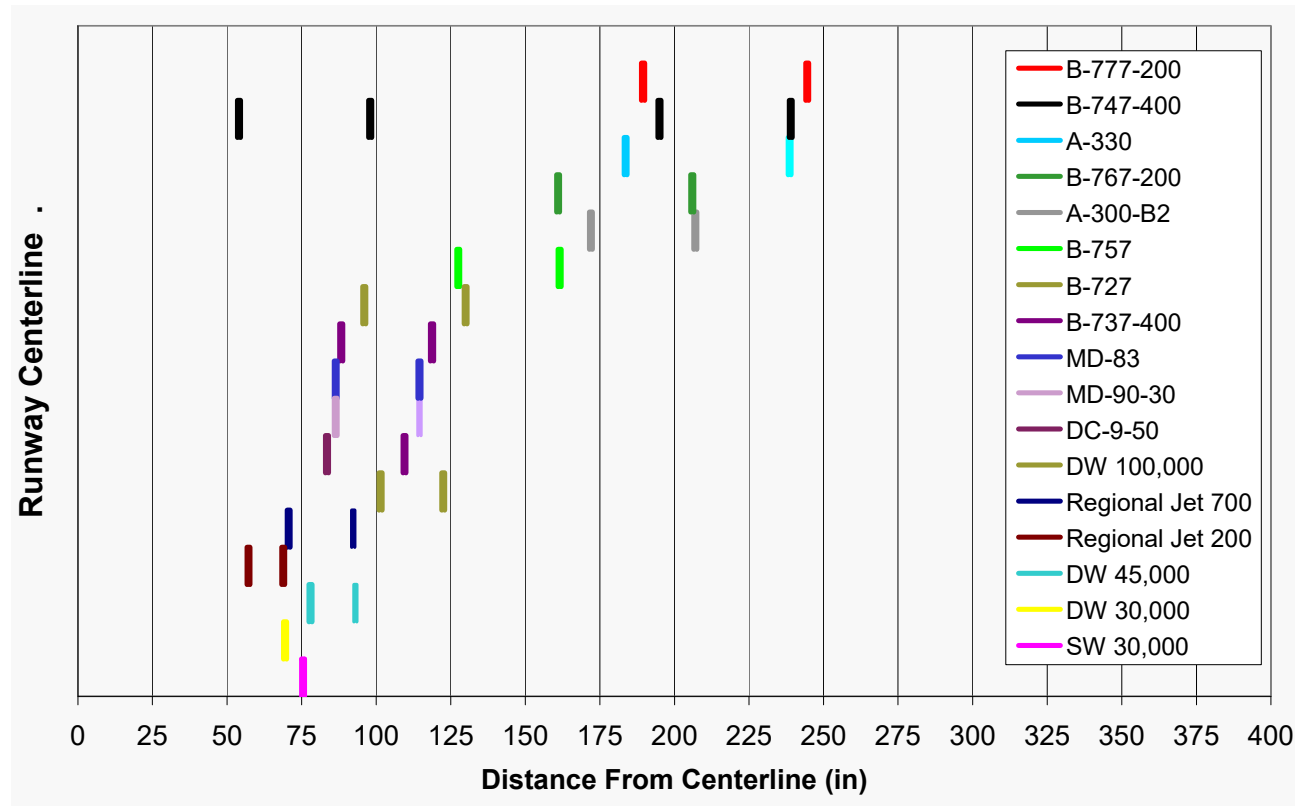
Cumulative Damage Factor (CDF)



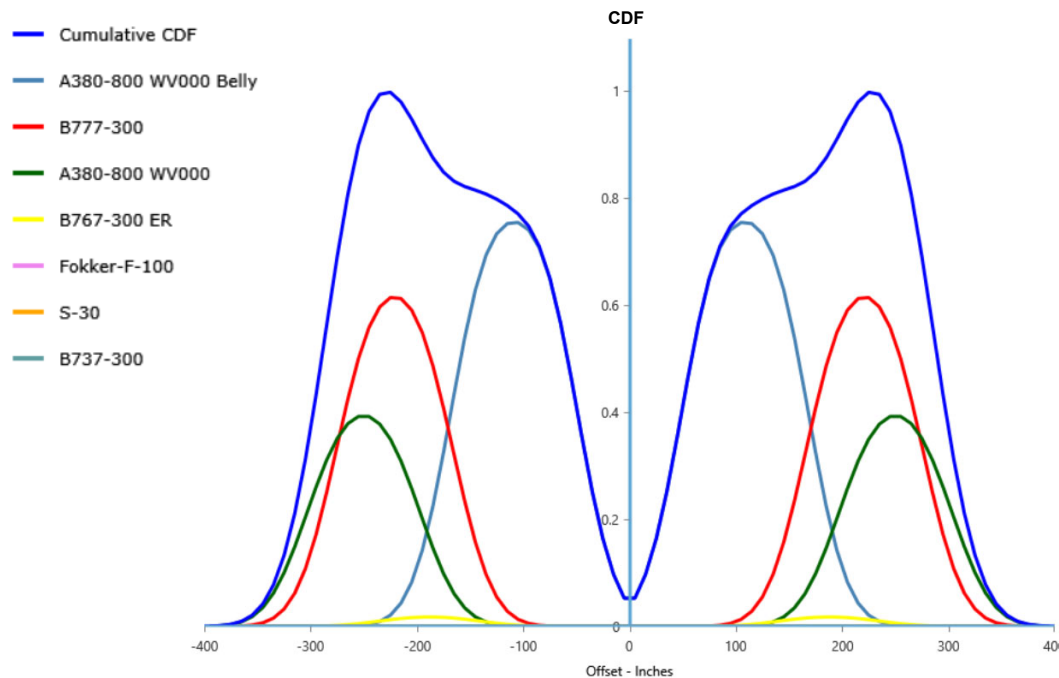
Cumulative Damage Factor (CDF)



Large Airplane Traffic Mix Gear Locations



FAARFIELD – CDF Graphical Display

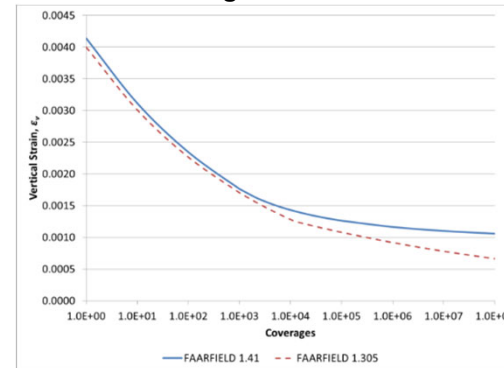


- **Design based on critical offset from centerline.**
- **Does not necessarily agree with track of “most demanding” aircraft.**

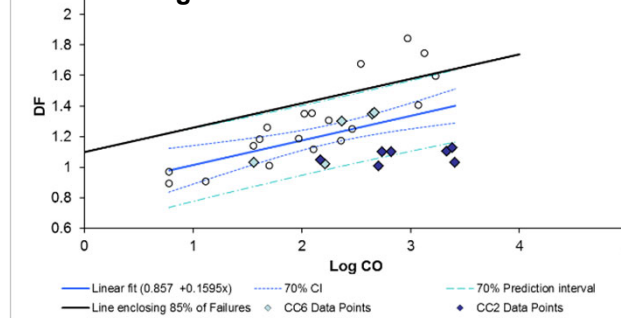
Failure Models in FAARFIELD

- This is the “empirical” part of mechanistic-empirical.
 - Derived from full-scale traffic tests at the **FAA National Airport Pavement Test Facility (NAPTF)**.
 - Relates strain or stress to allowable coverages (fatigue).
 - Tied to CDF through P/C ratio.
- **Flexible: Function of maximum vertical strain at the top of the subgrade.**
- **Rigid: Function of maximum horizontal stress in concrete slab.**

Flexible Subgrade Failure Model



Rigid “First Crack” Failure Model



Full-Scale Testing at the NAPTF

- FAA / Boeing (CRDA) Partnership at \$21M – Opened 1999.
- Fully enclosed instrumented test track 900 feet long by 60 feet wide.
- Fully automated computerized data acquisition system.
- Rail-based test vehicle capable of simulating aircraft weighing up to 1.3 million pounds.
- Wheel loads independently adjustable up to 75,000 pounds per wheel.
- Controlled aircraft wander simulation.
- Radial aircraft tires (52X21.0R22).
- Vehicle is capable of speeds up to 15 mph. In practice, tests are conducted at 2.5 – 3.0 mph.
- Ability to simulate all common landing gear configurations up to 5 axles (i.e., An-124).



B777 Landing Gear NAPTF Simulated Gear

NAPTF Construction (1995-1999)



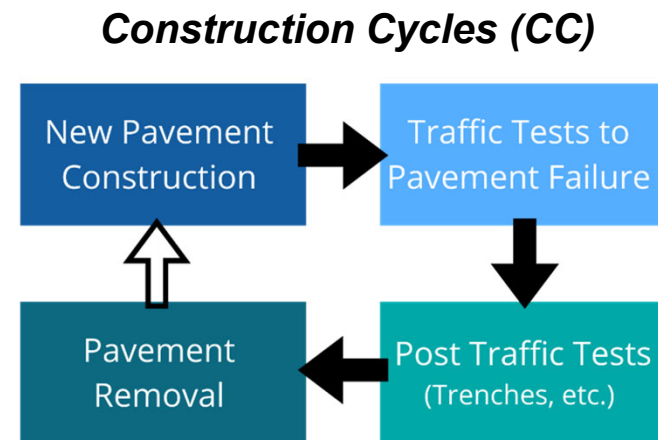
Aerial view of NAPTF facility under construction



20 mil membrane on the floor of the low-strength subgrade

Full-Scale Testing at the NAPTF

- Completed 9 Construction Cycles (CC) to date. CC10 in planning.
- Flexible and rigid pavements.
- Full-scale test data improve the standard FAA pavement design software, FAARFIELD.
 - Required software for Federally funded airport pavement projects.
 - Current version is FAARFIELD 2.1
- Test data available online:
<https://www.airporttech.tc.faa.gov/Airport-Pavement/National-Airport-Pavement-Test-Facility-NAPTF/NAPTF-Program/Construction-Cycles>



The timeline for a construction cycle is 2-3 years and includes the construction of the test pavement, installation of embedded pavement sensors, traffic testing to failure, post-traffic testing (trenching activities and other tests), and pavement removal.

Construction Cycle 9 Construction (2019)

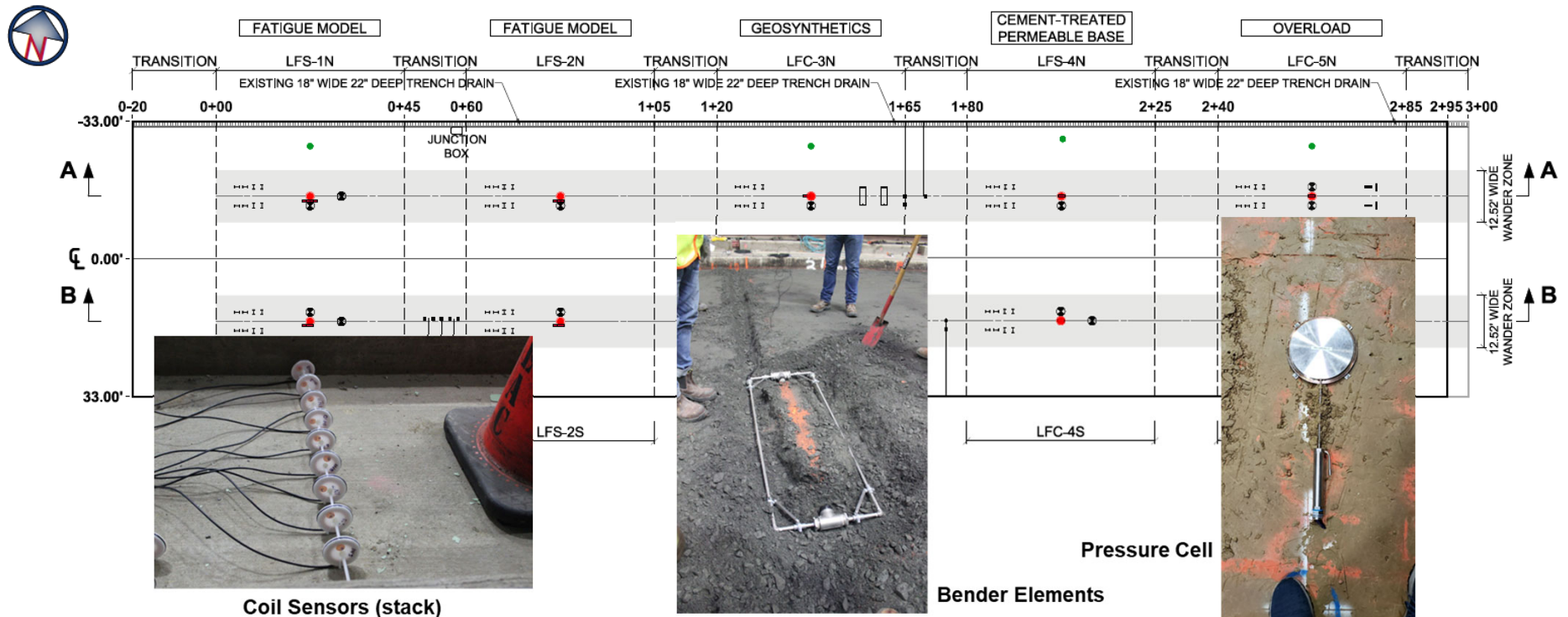
Flexible Pavement



Construction Cycle 9 (CC9) Test Objectives:

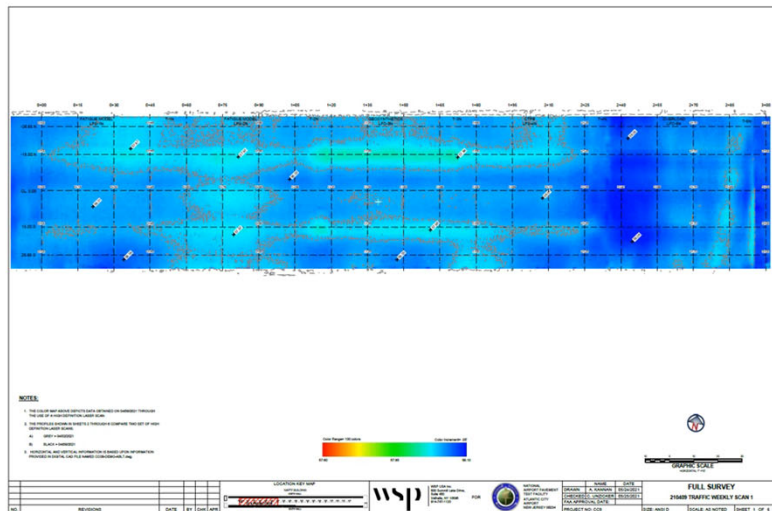
- **Fatigue Model and Base Thickness Test**
 - Improve the asphalt concrete fatigue cracking model.
 - Test sensitivity of thickness design model to base course thickness.
- **Geosynthetics Test**
 - Investigate the effects of geogrids on airport pavement performance.
 - Responds to Sec. 558, FAA Reauthorization Act 2018.
- **Cement-Treated Permeable Base (CTPB) Test**
 - Evaluate performance of P-307 CTPB course.
 - Follow-on to ATPB Test in CC7.
- **Overload Test**
 - Develop criterion for allowable overload in flexible airport pavement.
 - Supports ICAO ACR-PCR system.

CC9 Instrumentation Overview



CC9 – Evolution of Surface Distortion

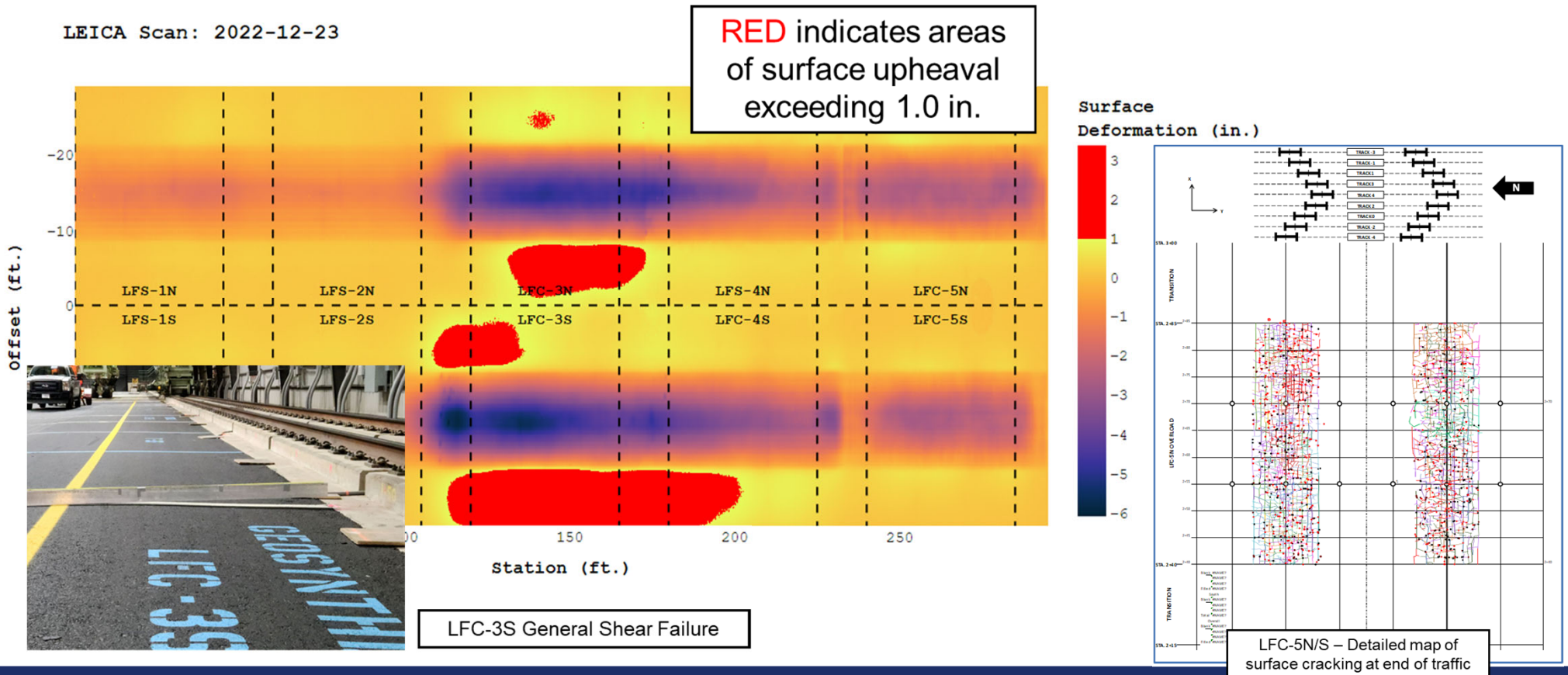
2021-04-09



Dates	Passes on Test Items:			Description of Loading
	LFS 1-2	LFC 3-4	LFC 5	
4/5/2021 – 6/3/2021	5544	5544	0	Traffic test items 1-4
7/1/2021	0	0	66	Overload LFC 5N
7/1/2021 – 7/28/2021	0	0	5478	Traffic LFC 5 only
8/2/2021 – 10/14/2021	7066	7066	7066	Traffic all test items
1/15/2021 – 2/21/2022	0	0	0	Vehicle down for maintenance
2/22/2022 – 3/28/2022	3956	3956	3956	Resume traffic all test items
3/29/2022	0	0	66	2 nd overload LFC 5N
3/29/2022 – 10/5/2022	24354	24354	24288	Traffic all test items
10/12/2022	0	0	396	3 rd overload LFC 5N
10/13/2022 – 12/21/2022	0	0	15312	Traffic LFC 5 only
1/3/2023 – 2/1/2023	2244	0	0	Traffic test items LFS 1-2
Total (as of 2/1/2023)	43164	40920	56628	

CC9 – Post-Traffic Failure Condition

LEICA Scan: 2022-12-23



7 February 2024

Intro to FAARFIELD 2.1

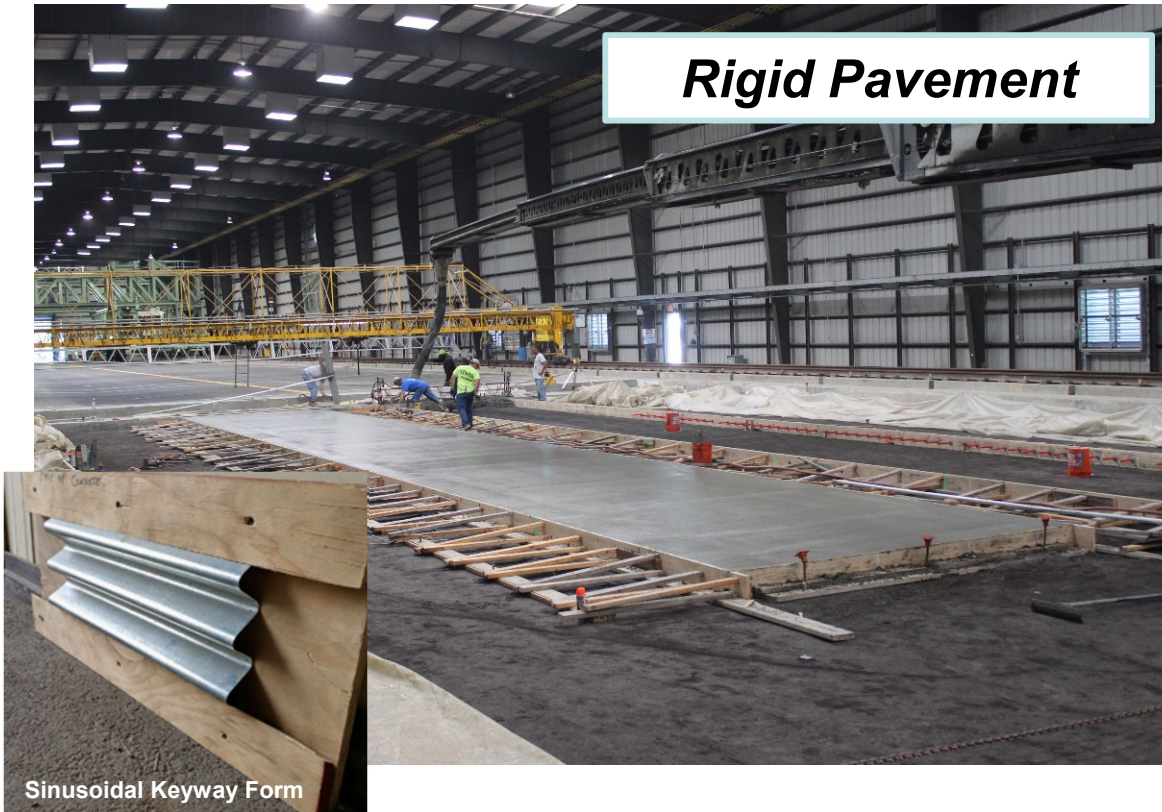


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Construction Cycle 8 Construction (2015)

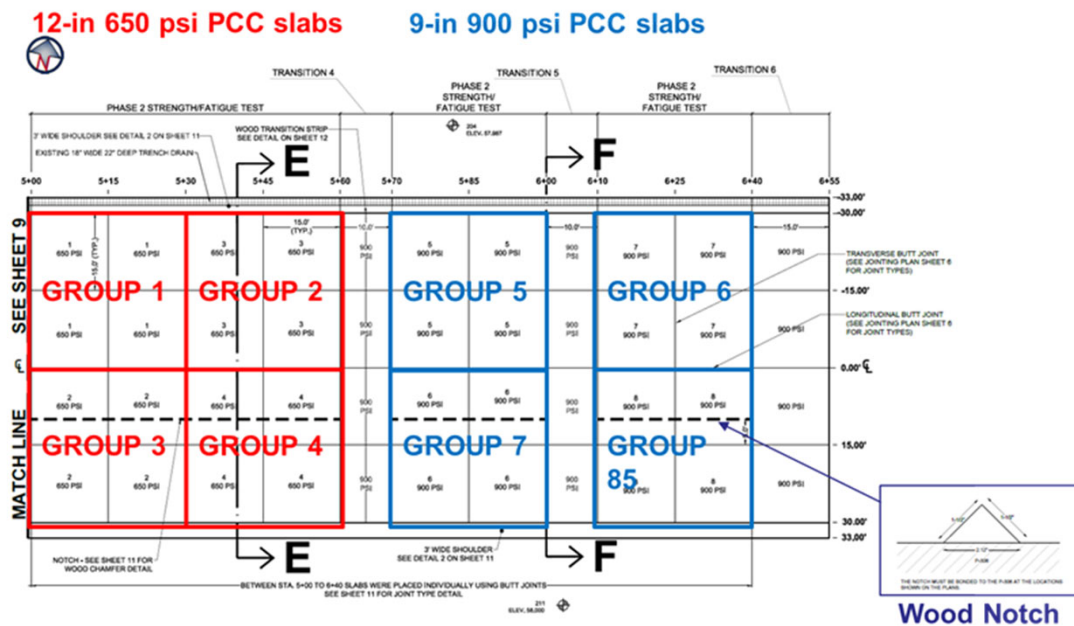
Rigid Pavement



Construction Cycle 8 (CC8) Test Objectives:

- **Phase 1 – Overload Test**
 - Develop rational criteria for allowing **occasional overloads** of rigid airport pavements.
 - Supports ICAO Annex 14 international standards.
- **Phase 2 – PCC-on-Rigid Overlay Test**
 - Develop design criteria for concrete overlays of old rigid pavement.
 - Utilized failed test pavement from Phase 1.
- **Phase 3 – Joint Comparison Test**
 - Compare performance of standard (Type E) doweled longitudinal construction joints to new sinusoidal keyway joints (see inset).
- **Phase 4 – Strength and Fatigue Full-Scale Test**
 - Obtain slab strength (rupture strength) for in-situ slabs, and fatigue life under non-wandered traffic.
 - Find the trade-off between slab thickness and flexural strength in design.

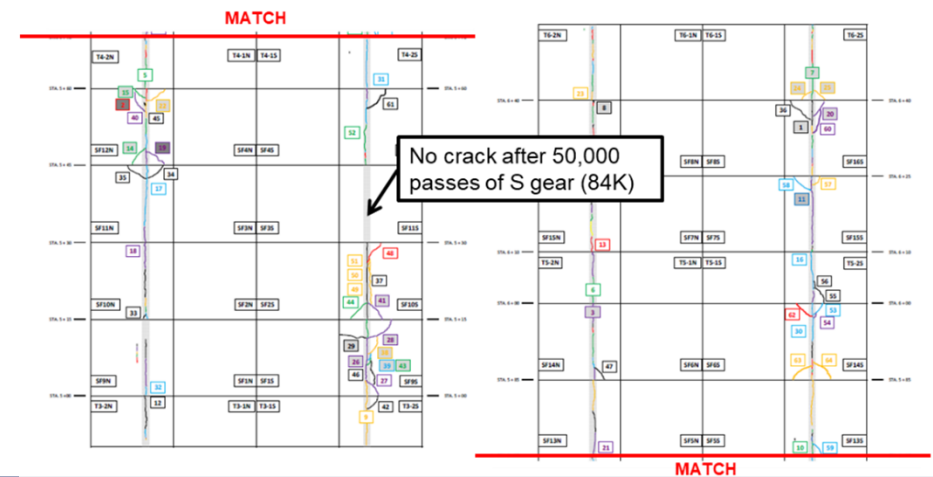
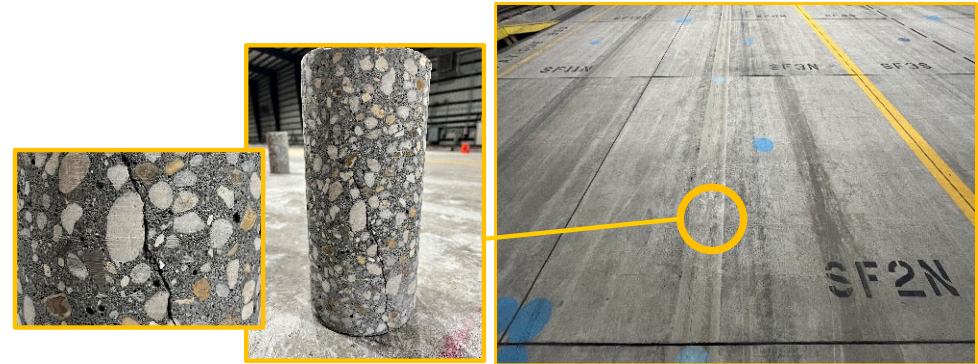
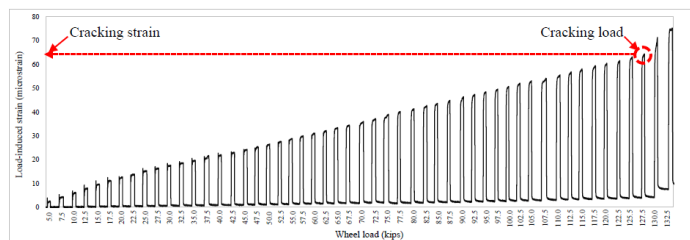
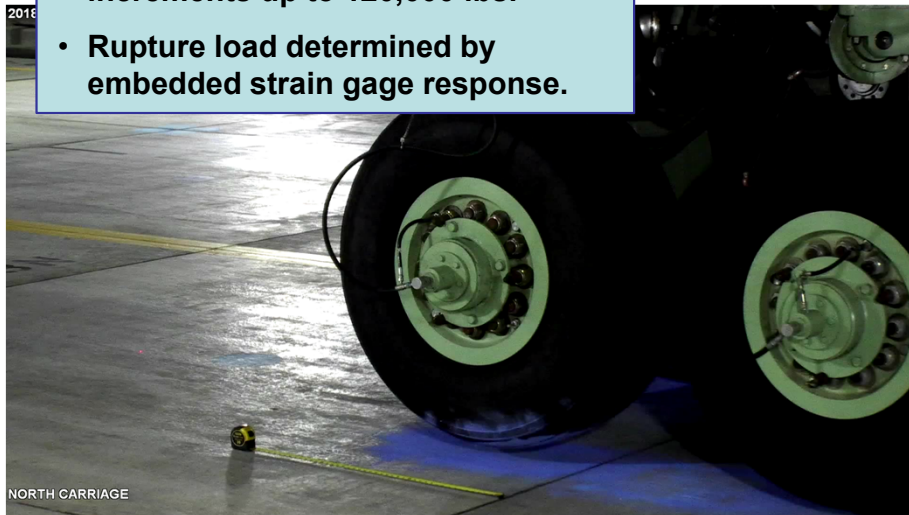
CC8 Phase 4 – Experimental Layout



- **Single wheel load.**
 - Zero wander.
 - Wheel load at estimated 80% slab cracking load.
 - **84.0 kips** on 12-in. - 650 psi concrete.
 - **63.5 kips** on 9-in. - 900 psi concrete.
- **Outside lanes.**
 - North lane: All slabs pre-cracked.
 - South lane: No pre-crack.
- **Inside lanes.**
 - North lane: No notch
 - South lane: Notched at bottom
- **Observe passes to propagate initial bottom-up crack to surface.**
- **FAARFIELD life predicts the *median* number of passes for a given slab to complete the crack.**

CC8 Phase 4 – Testing & Post-Traffic Analysis

- Stepped load in 5,000 lb. increments up to 120,000 lbs.
- Rupture load determined by embedded strain gage response.



Thank You!

Acknowledgments:

FAA Airport Technology R&D Branch:
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