RPA P-5 Airport Pavement Design

FAARFIELD Update

Presented to: REDAC Briefing to Sub-committee on Airports

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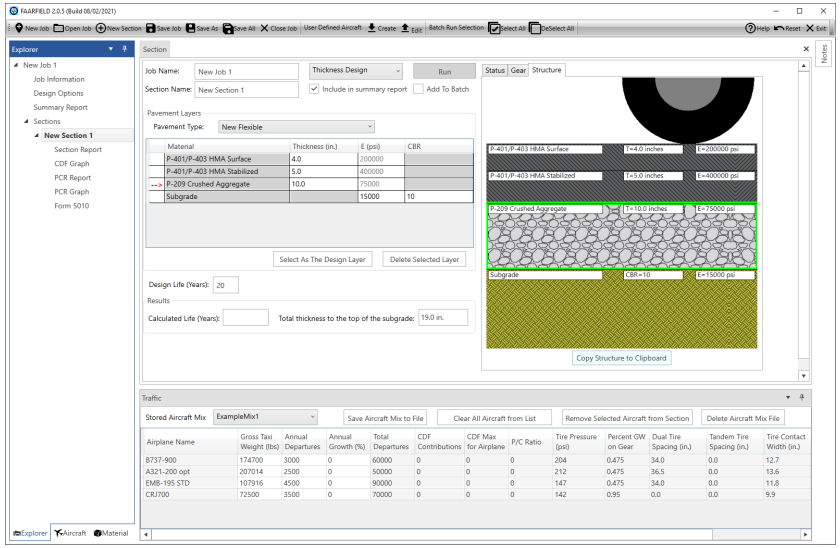
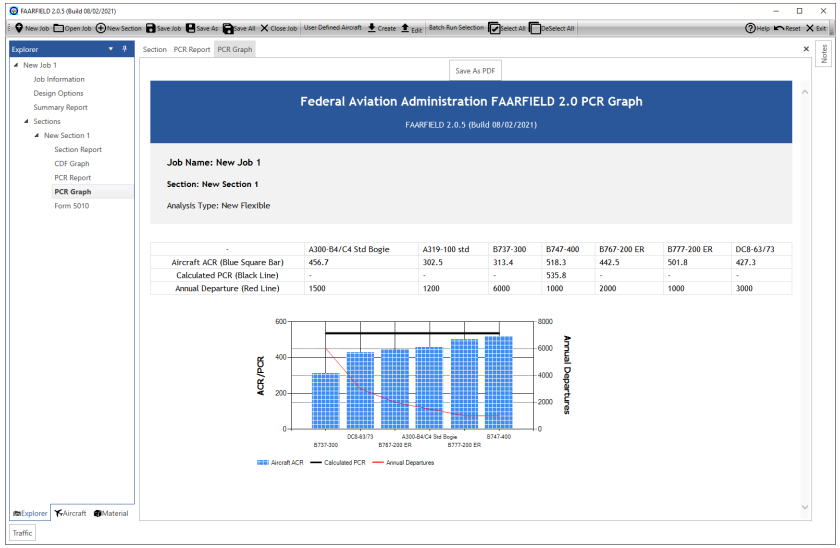
Advisory Circular Status

- **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.**

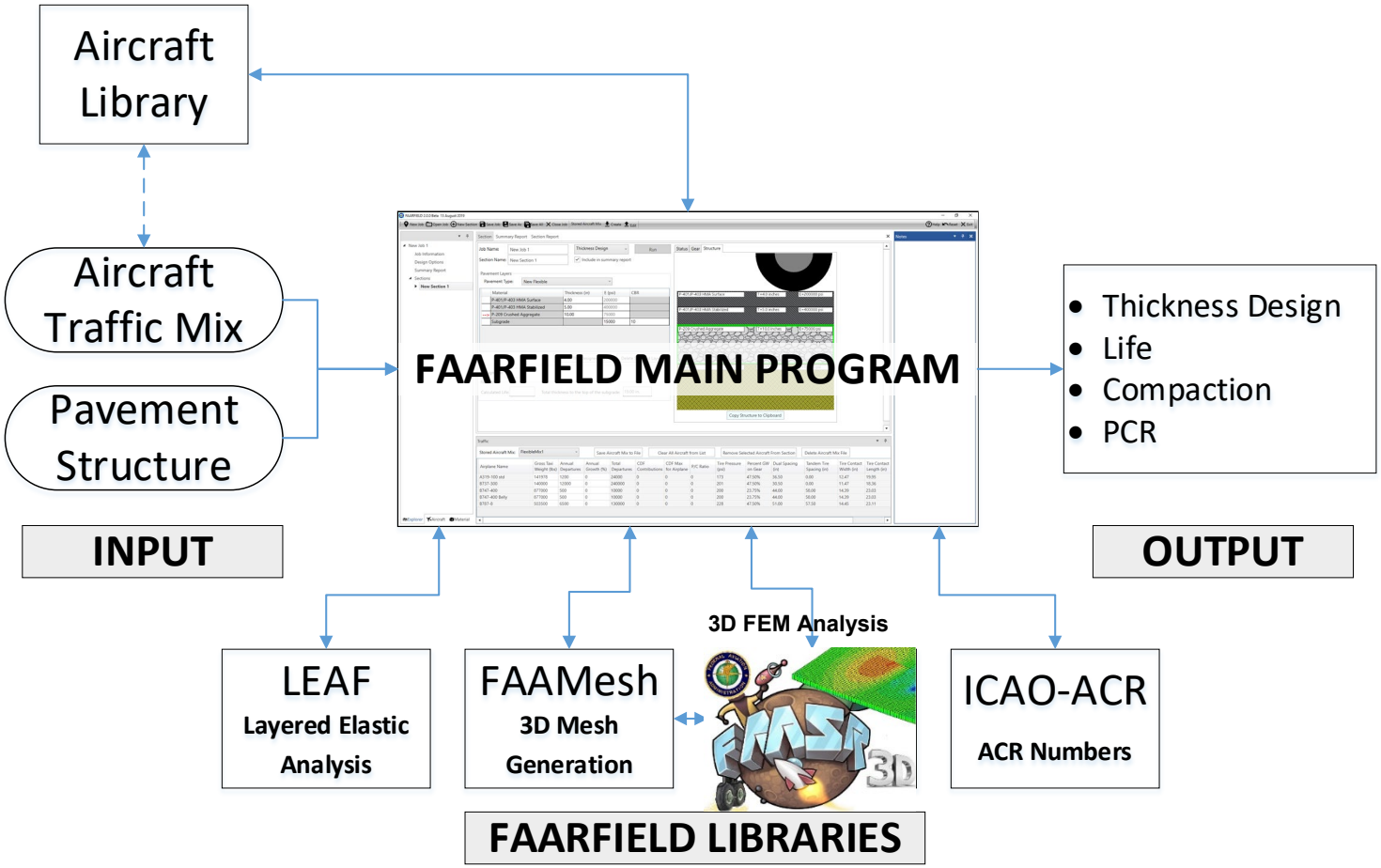
FAARFIELD 2.0

- **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.**



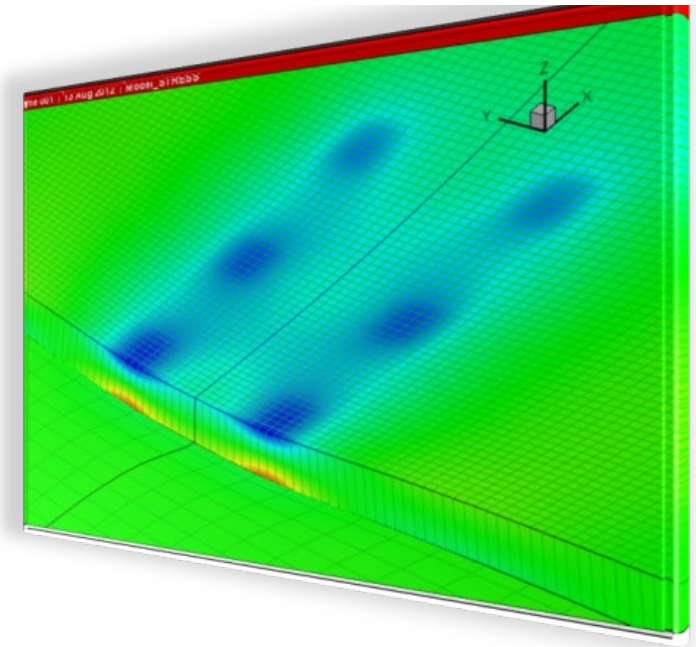


FAARFIELD 2.0 Organization



FAASR3D –
FAA Structural Analysis in 3D

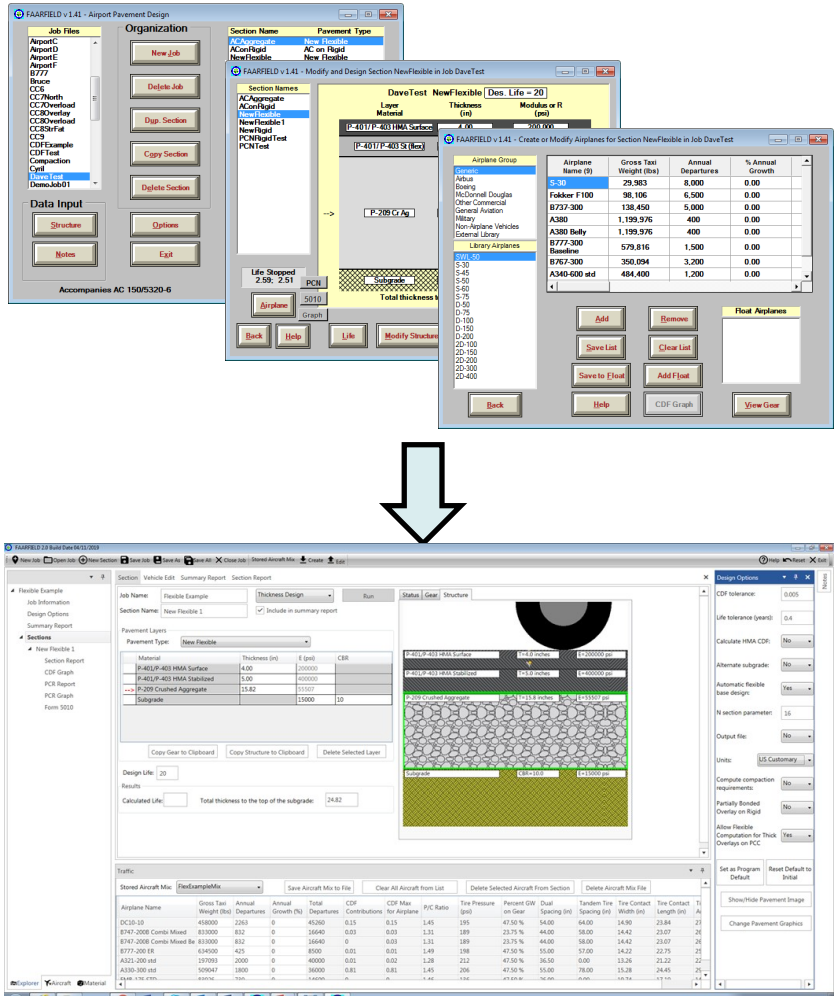
- **Visual Basic.NET library.**
- **Replaces obsolete NIKE3D Fortran program.**
  - Managed Code - compatible with Microsoft .NET memory management services.
  - Improves performance. Old code was subject to memory conflicts and crashing.
  - Freely distributable code.
- **Continued updates to improve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



GUI Modernization

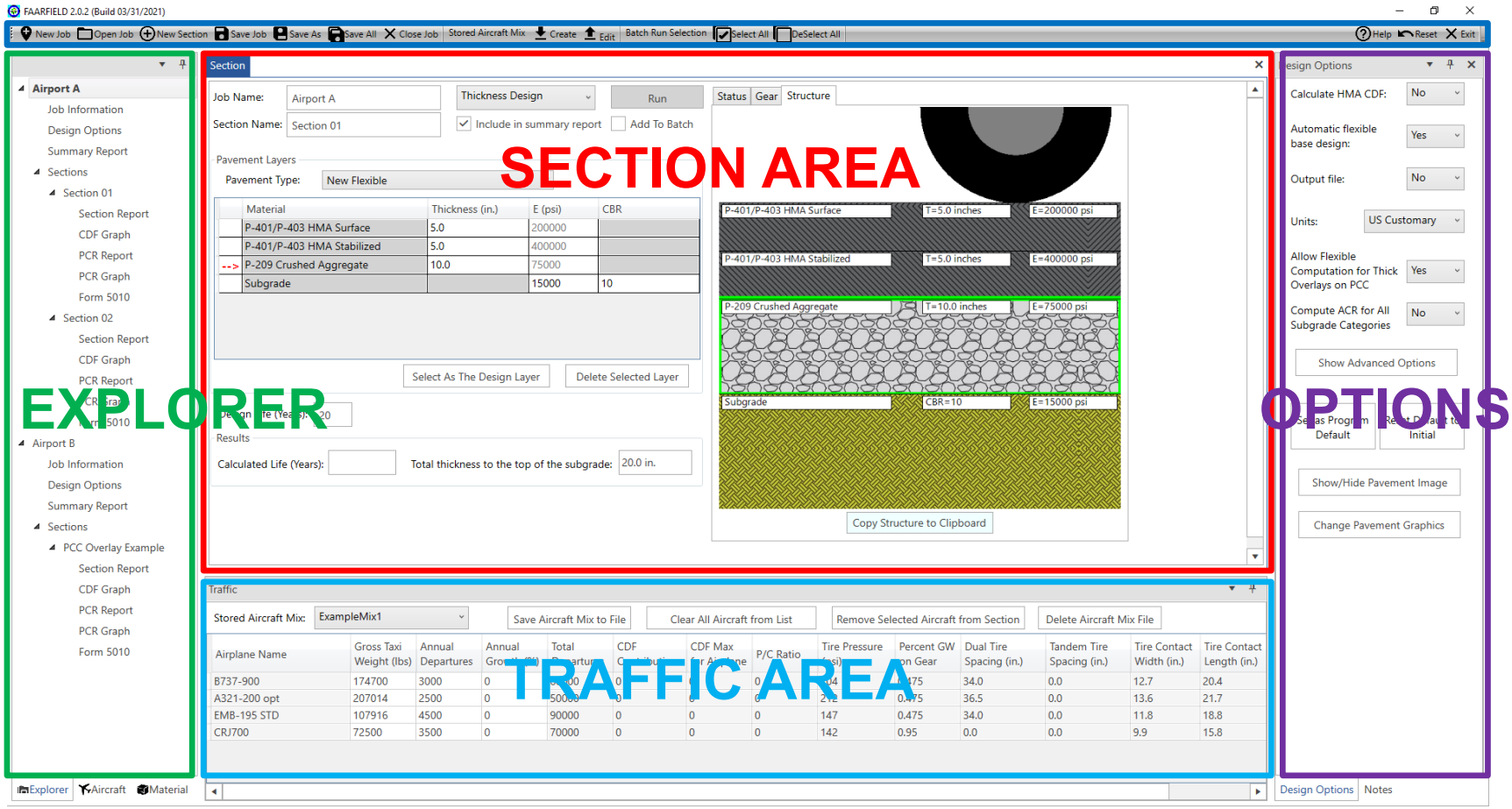
Major improvements:

- 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.

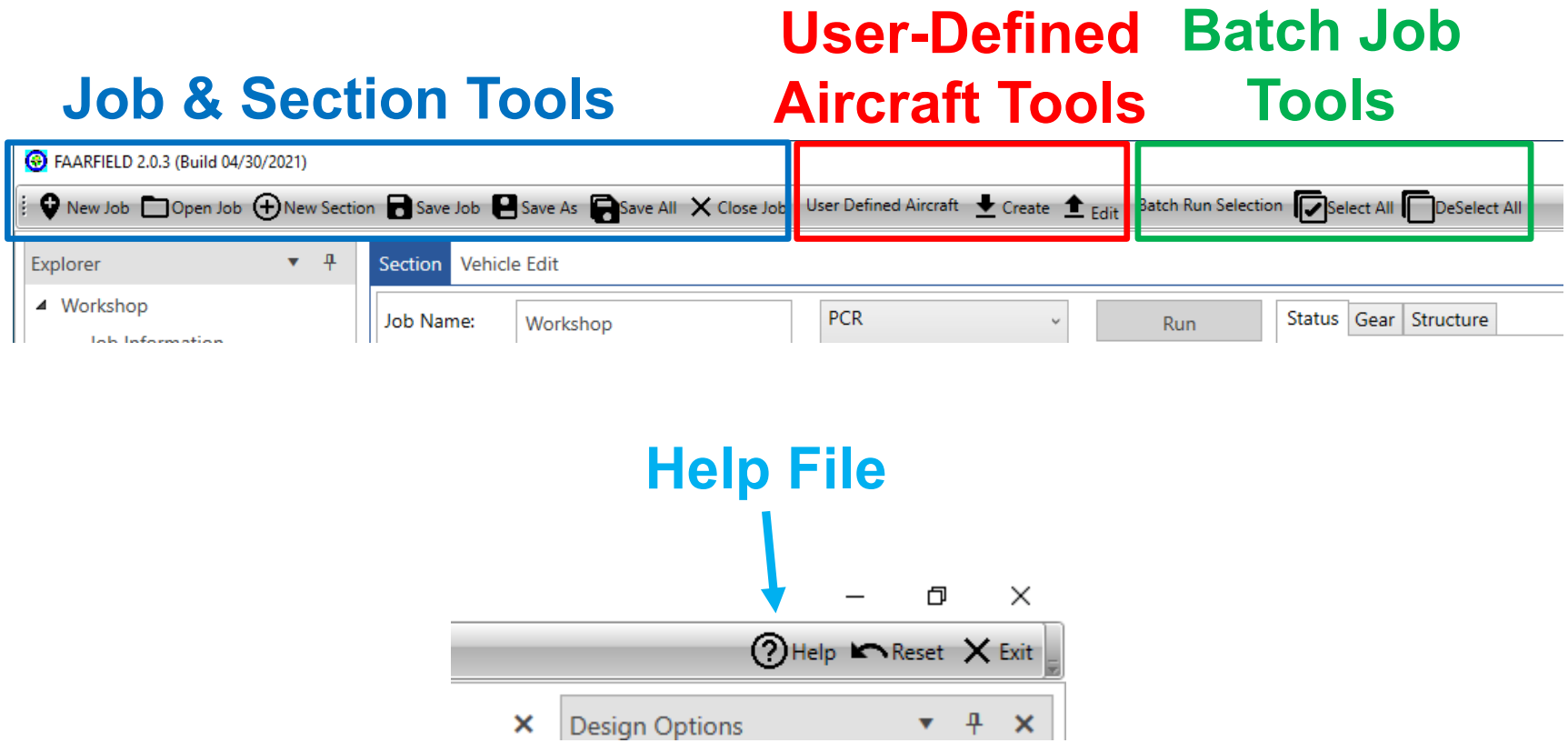


Navigating in FAARFIELD 2.0

TOOLBAR

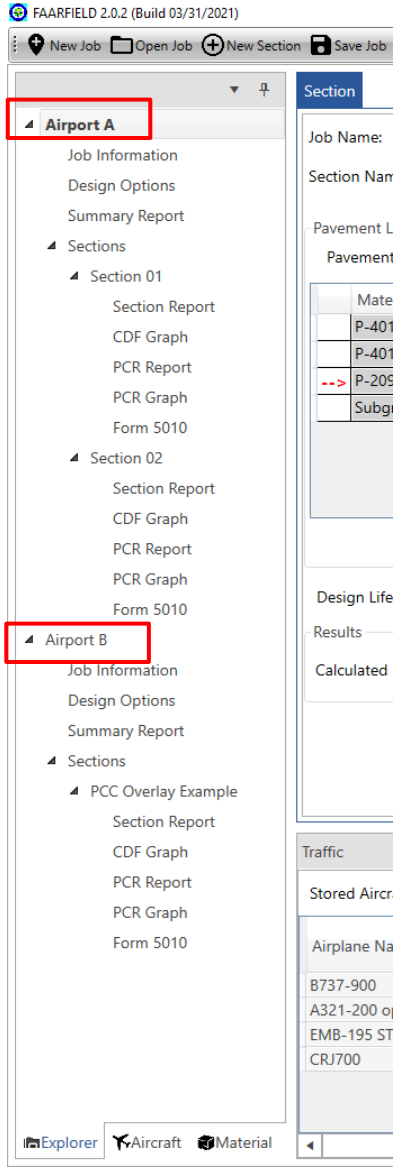


FAARFIELD 2.0 Toolbar



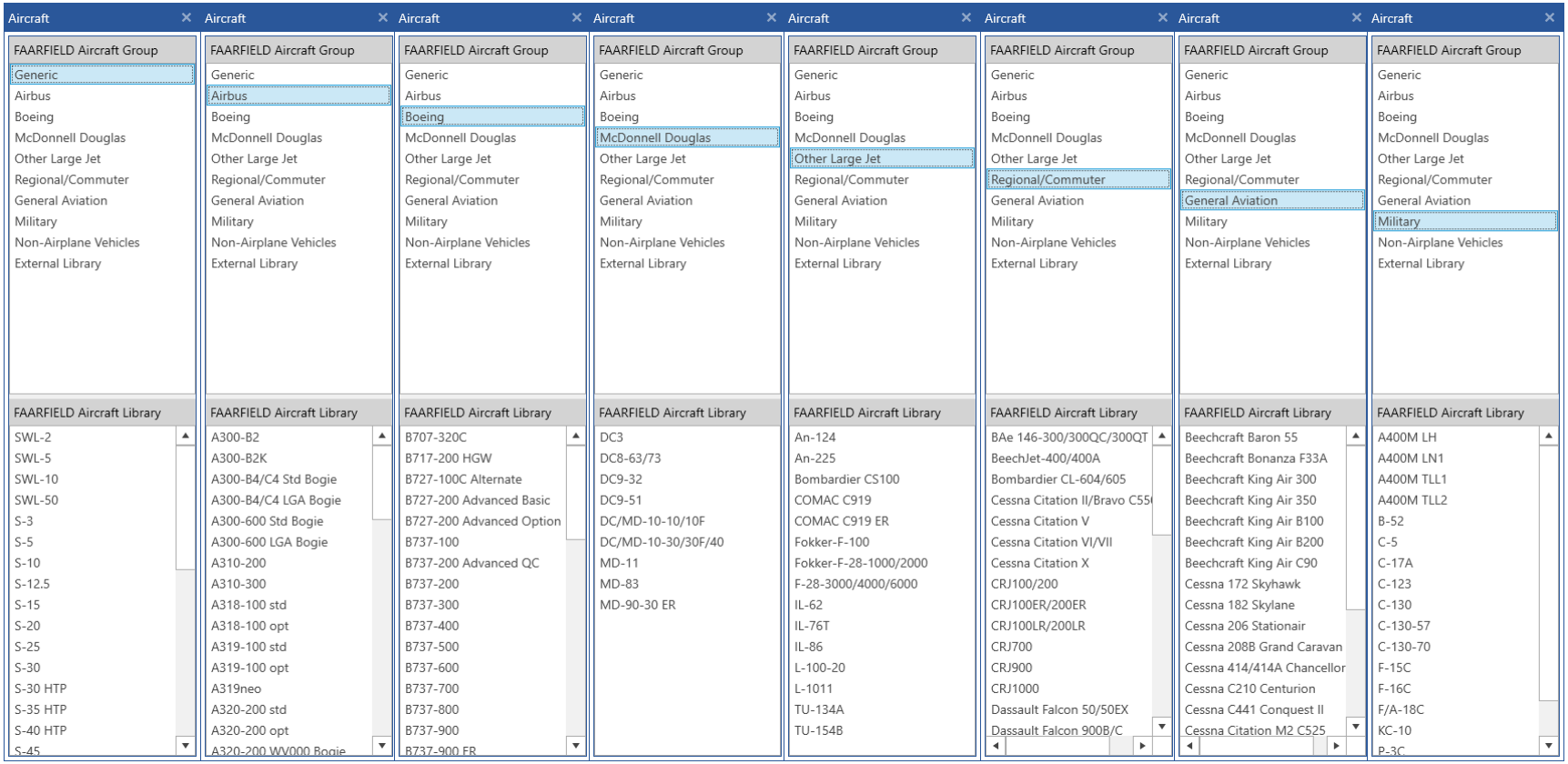
Explorer Navigation

- **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)

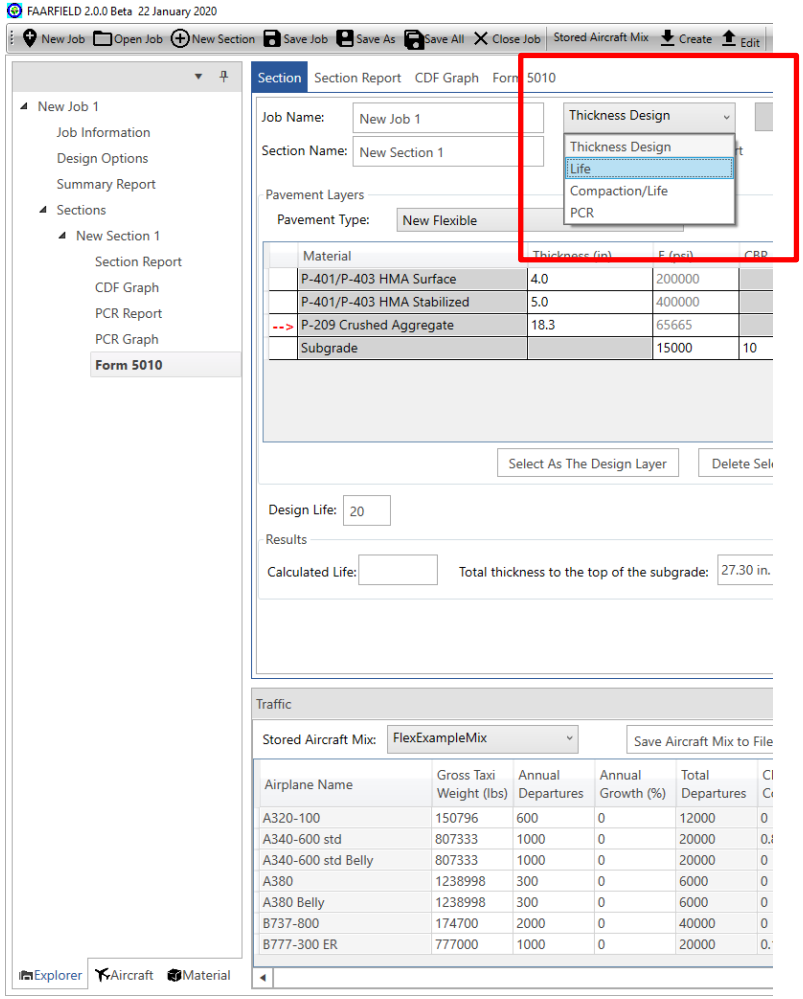


Aircraft Library

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



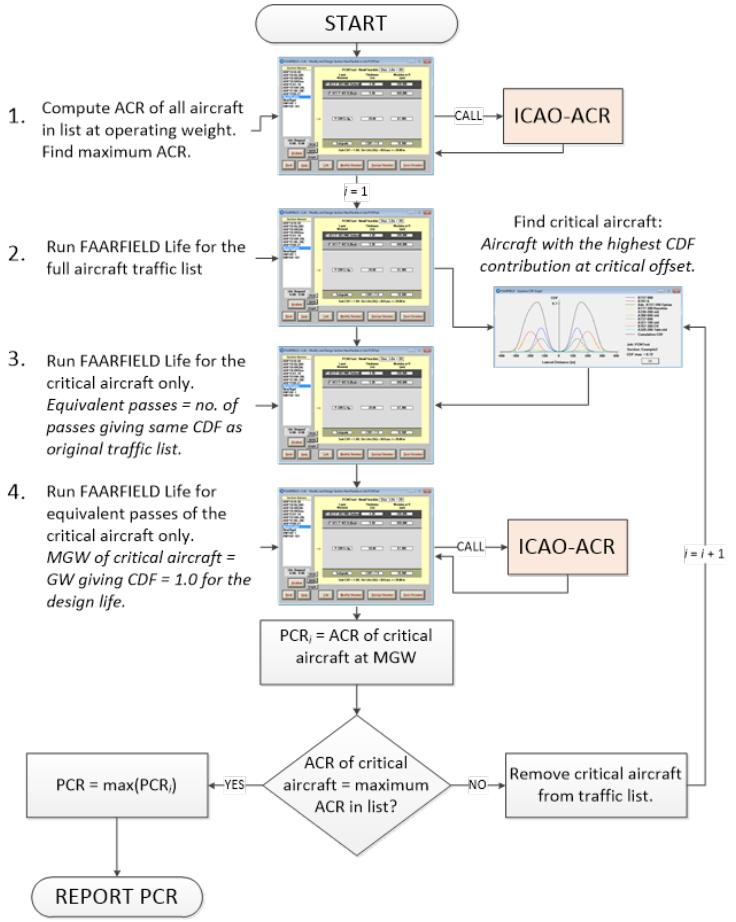
Four Functions in FAARFIELD 2.0



- **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.**

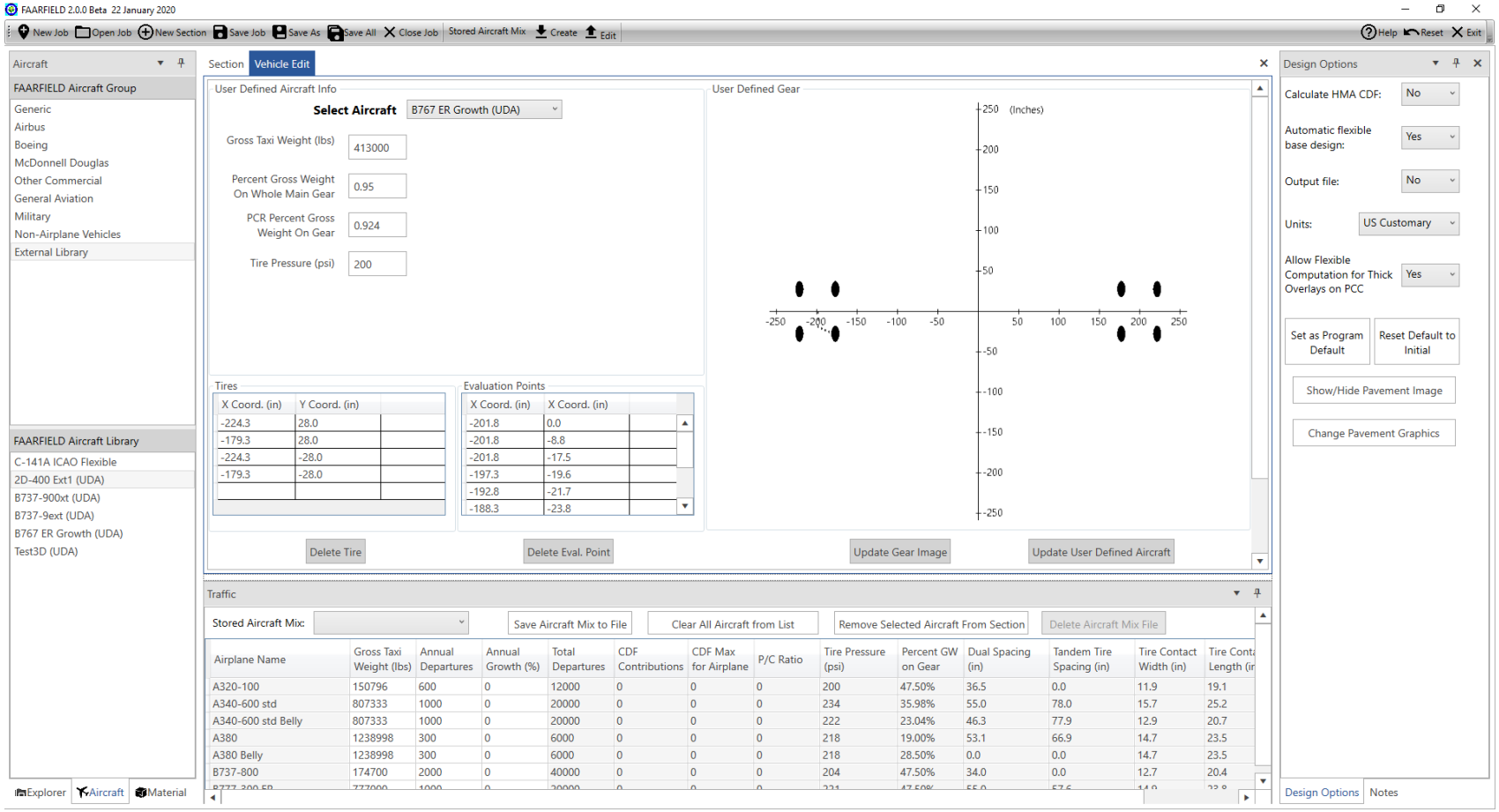
FAARFIELD 2.0 Provides PCR

- **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.

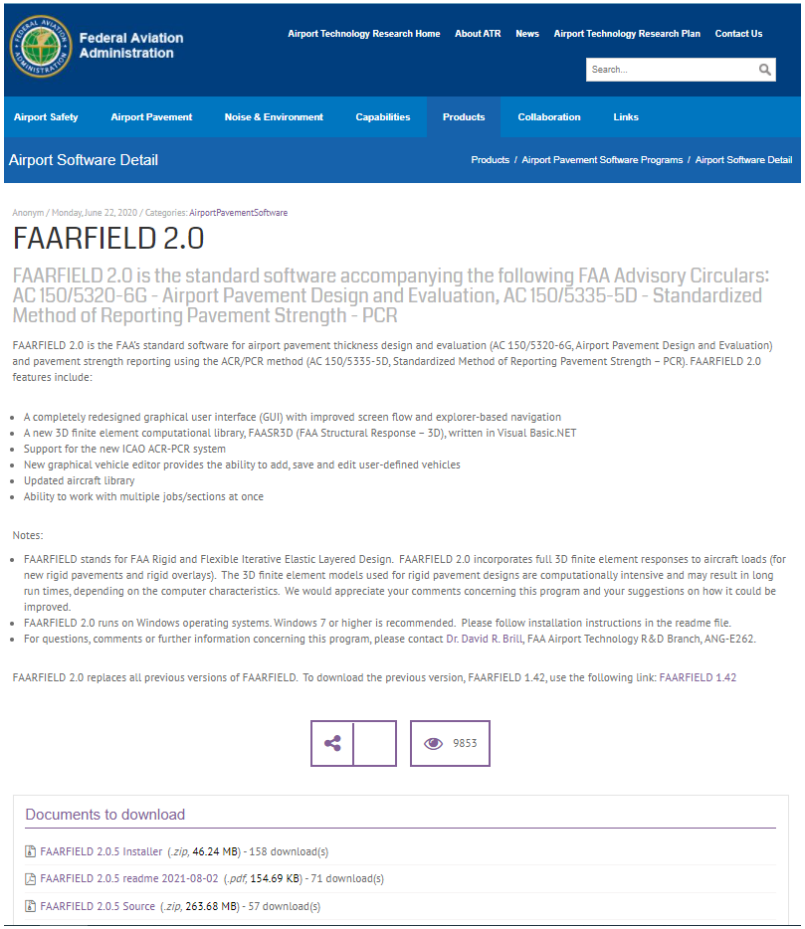


User-Defined Aircraft

- **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



FAARFIELD Training Workshops
(All Virtual)

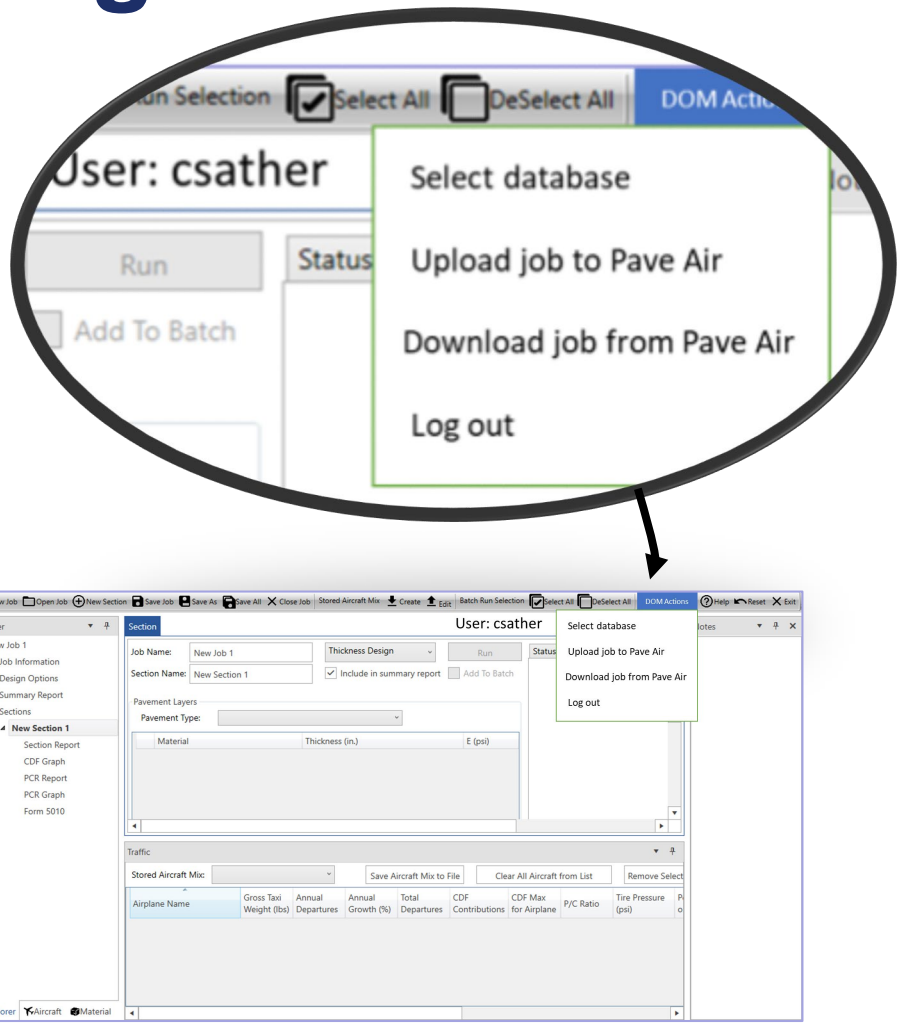
- **May 11, 2021 – ASCE Transportation & Development Institute (T&DI)**
  - *308 participants from 33 countries*
- **May 24, 2021 – International Conference on Transportation Geotechnics (ICTG)**
- **Sept. 27, 2021 – International Conference on Concrete Pavements (ICCP)**

Current Projects

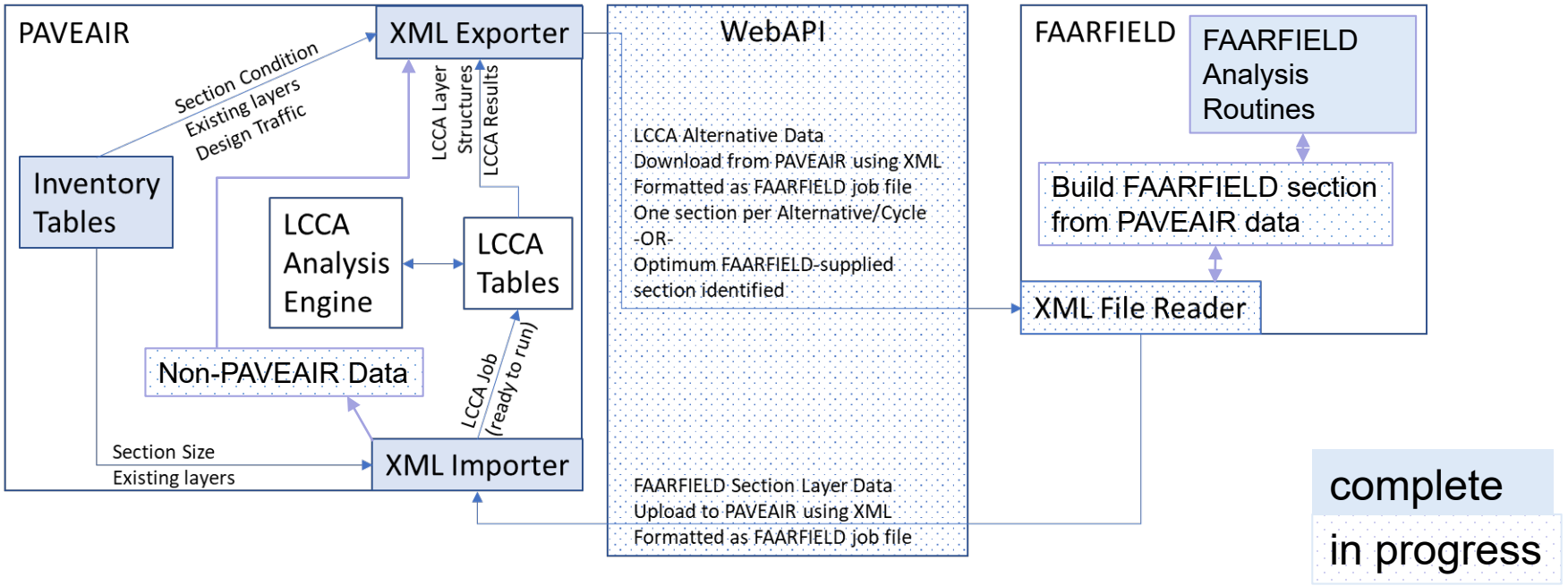
- **FAARFIELD / PAVEAIR Integration**
- **Design Criteria for Seasonal Frost and Permafrost.**
- **Design Criteria for Stabilized Bases**
- **Machine Learning (ML) for Design Stresses**
- **Reflection Cracking Model Development**

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.**

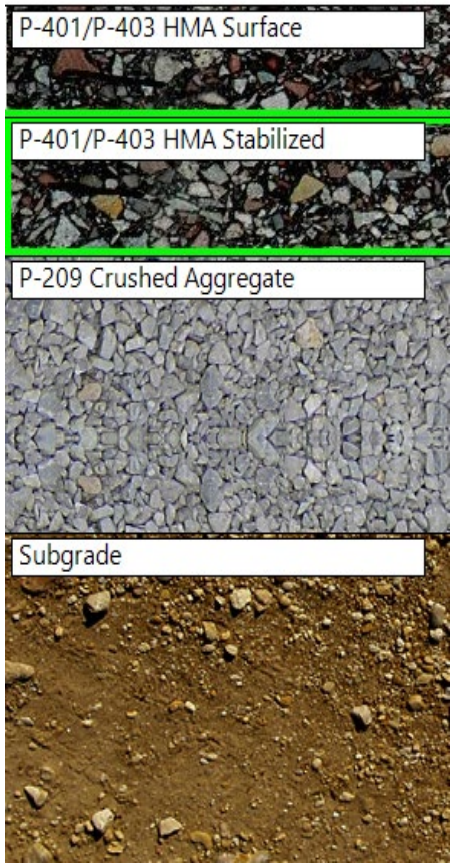
Seasonal Frost and Permafrost

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)



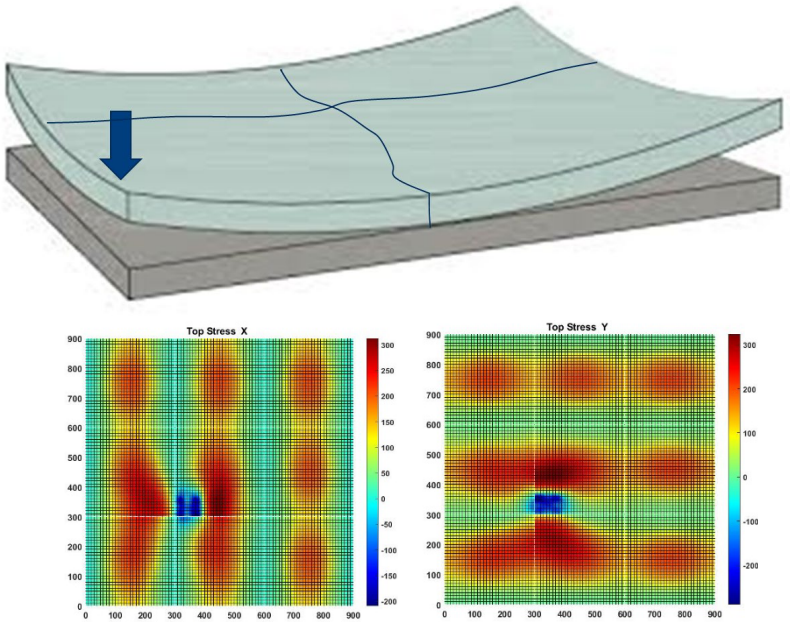
Stabilized Base Design

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.

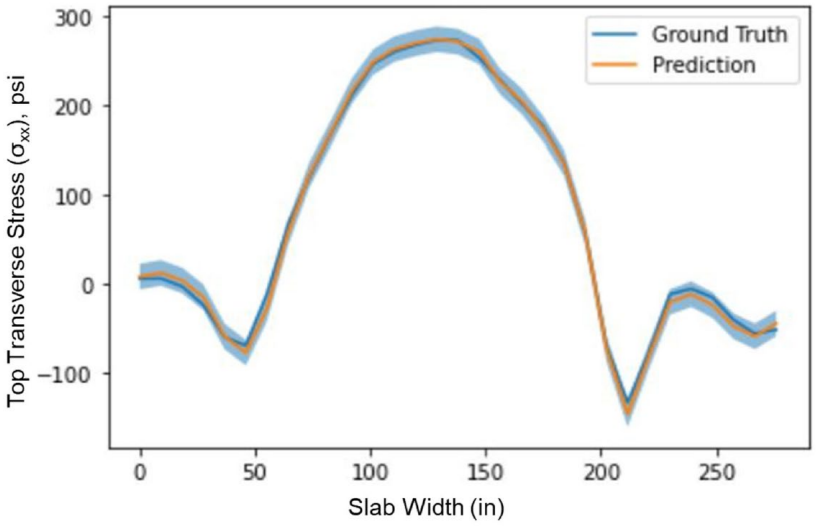


FEAFAA Response Model

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.**

Estimated Uncertainty Envelope Around Stress Prediction (Example)



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

PyTorch → ONNX → .NET Framework

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 <u>transfer functions</u> 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?