SRA INTERNATIONAL, INC.

Honesty and Service®

# Non-Destructive Technology Update

**Federal Aviation Administration**

**Airport Pavement Working Group Meeting**

**April 17, 2013**

**By: Josh Davis**

**Support Contractor for the FAA**

SRA INTERNATIONAL, INC.
Honesty and Service®

# Outline

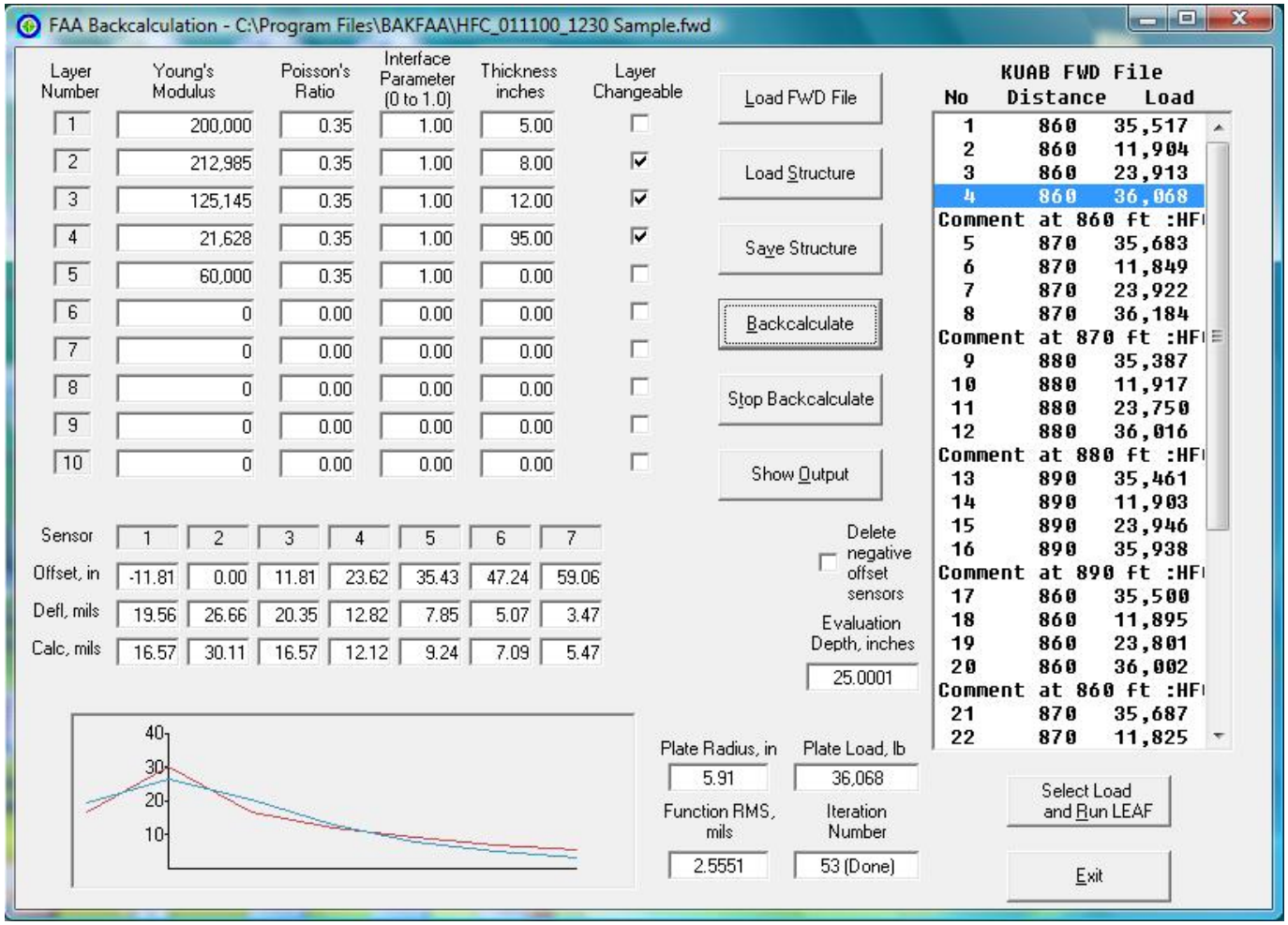
- BAKFAA Background
- BAKFAA 1.0
- BAKFAA 2.0 Beta (New Features)
- F/HWD Round-Up Background
- Raw Data
- Excel Workbook Database
- Interactive Webpage Query System
- Future Work

SRA INTERNATIONAL, INC.
Honesty and Service®

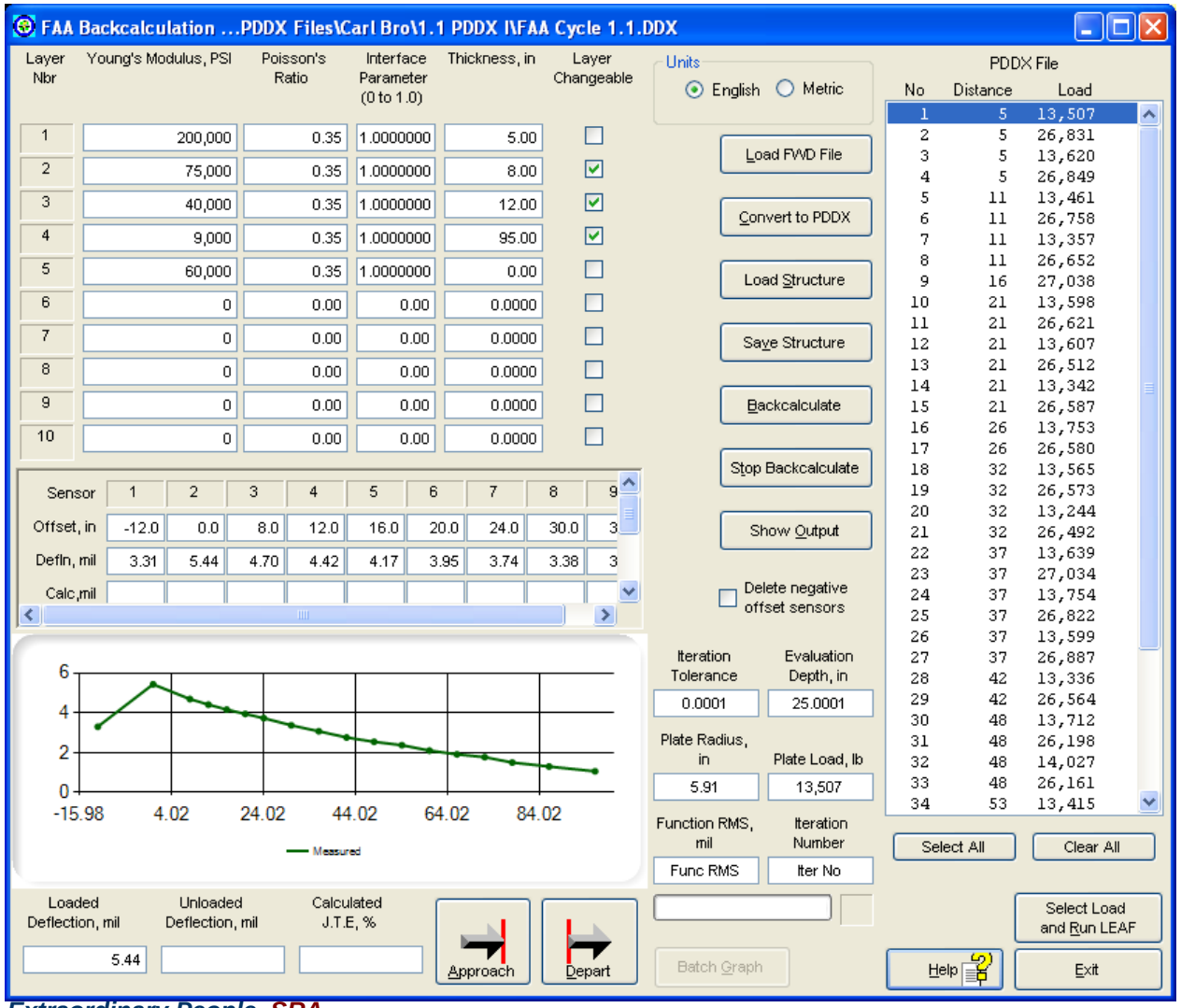
# BAKFAA Background

- **BAKFAA is a software program used to backcalculate FWD/HWD data with layered elastic analysis**
- **LEAF is the layered elastic analysis program and uses a downhill multidimensional simplex minimization methodology**
- **Since the original development, BAKFAA has been modified over time to read additional FWD/HWD file formats**
- **BAKFAA 2.0 represents the first major overhaul of the original programming**

# BAKFAA 1.0

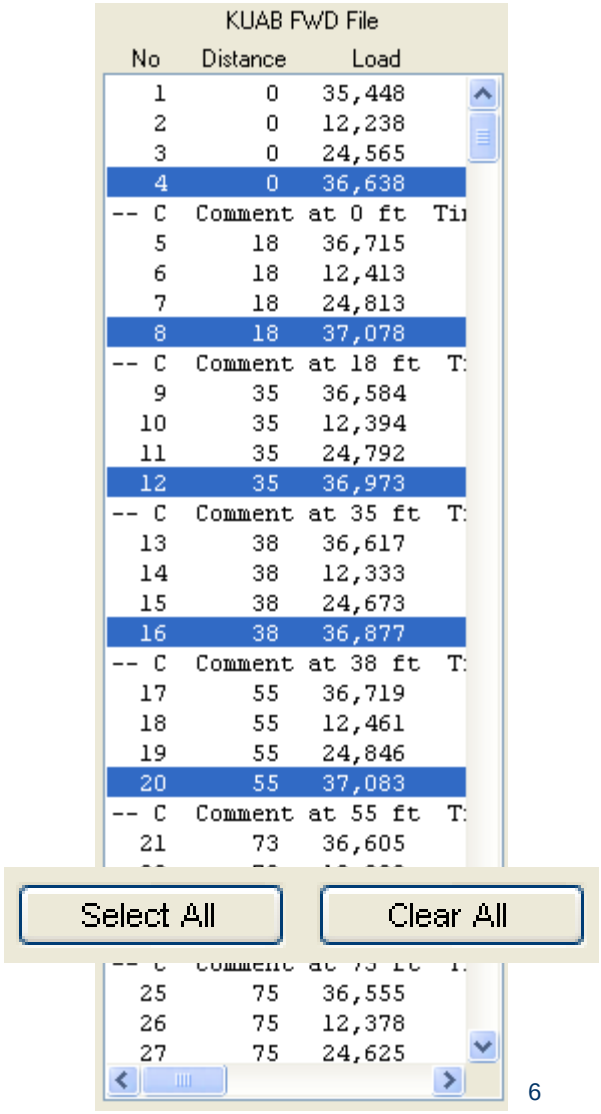

FAA Backcalculation - C:\Program Files\BAKFAA\HFC_011100_1230 Sample.fwd
Layer Number
Young's Modulus
Poisson's Ratio
Interface Parameter (0 to 1.0)
Thickness inches
Layer Changeable
1 200,000 0.35 1.00 5.00
2 212,985 0.35 1.00 8.00
3 125,145 0.35 1.00 12.00
4 21,628 0.35 1.00 95.00
5 60,000 0.35 1.00 0.00
6 0 0.00 0.00 0.00
7 0 0.00 0.00 0.00
8 0 0.00 0.00 0.00
9 0 0.00 0.00 0.00
10 0 0.00 0.00 0.00
Load FWD File
Load Structure
Save Structure
Backcalculate
Stop Backcalculate
Show Output
KUAB FWD File
No Distance Load
1 860 35,517
2 860 11,904
3 860 23,913
4 860 36,068
Comment at 860 ft :HFI
5 870 35,683
6 870 11,849
7 870 23,922
8 870 36,184
Comment at 870 ft :HFI
9 880 35,387
10 880 11,917
11 880 23,750
12 880 36,016
Comment at 880 ft :HFI
13 890 35,461
14 890 11,903
15 890 23,946
16 890 35,938
Comment at 890 ft :HFI
17 860 35,500
18 860 11,895
19 860 23,801
20 860 36,002
Comment at 860 ft :HFI
21 870 35,687
22 870 11,825
Sensor 1 2 3 4 5 6 7
Offset, in -11.81 0.00 11.81 23.62 35.43 47.24 59.06
Defl, mils 19.56 26.66 20.35 12.82 7.85 5.07 3.47
Calc, mils 16.57 30.11 16.57 12.12 9.24 7.09 5.47
Delete negative offset sensors
Evaluation Depth, inches
25.0001
40
30
20
10
Plate Radius, in
5.91
Plate Load, lb
36,068
Function RMS, mils
2.5551
Iteration Number
53 (Done)
Select Load and Run LEAF
Exit

# BAKFAA 2.0 Beta New Features



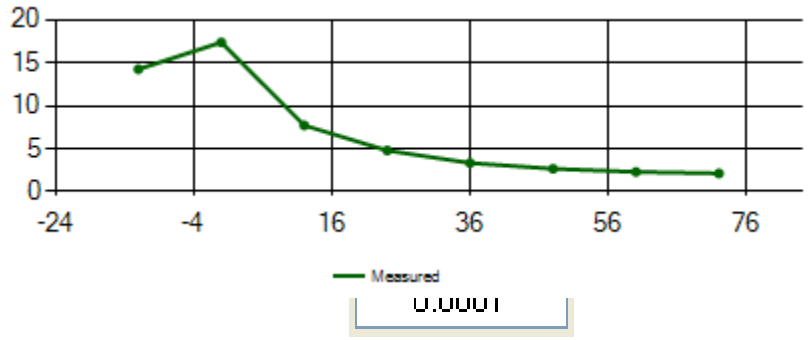
# BAKFAA 2.0 Beta New Features

- Toggle allows user to use English or Metric Units
- Button allows user to convert a loaded FWD/HWD file into the PDDX file format
- Selecting multiple drop locations prior to clicking the backcalculate button allows for batch processing
- Select All and Clear All buttons added for easy batch testing of an entire file

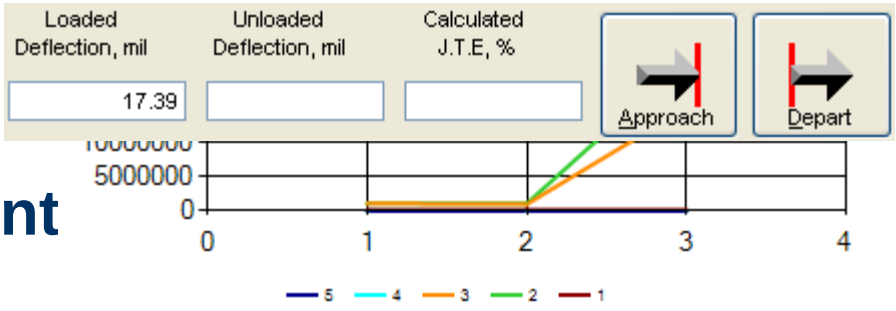


# BAKFAA 2.0 Beta New Features

- Help file has been added
- A user defined iteration tolerance affecting the termination criteria for the optimization algorithm
- Graph displays normally during backcalculation process but also shows a batch graph after calculations
- Users can now calculate joint transfer efficiency by approach or depart locations







# BAKFAA 2.0 Beta New Features

- **Redesigned, moving from VB6 to VB.NET**
- **Backcalculation results can now be output as an Excel File**
- **LEAF is compatible in both BAKFAA & FAARFIELD**
- **Extended list of supported file formats**

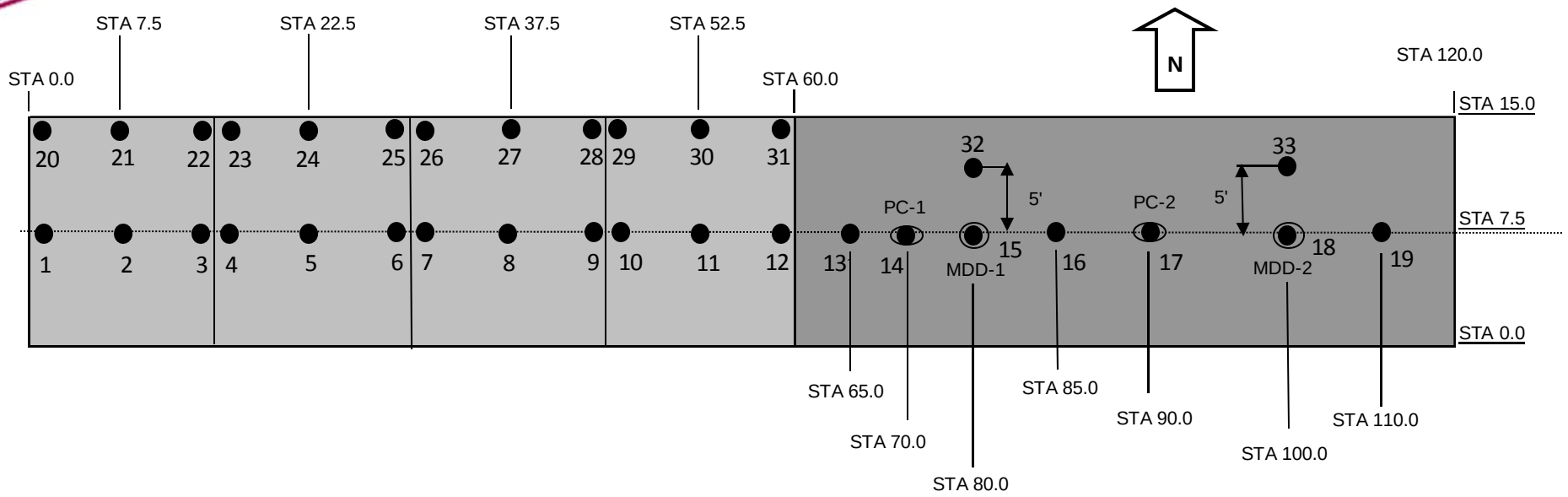
| Equipment Manufacturer | Proprietary File Structure | Associated file extensions |
|---|---|---|
| **Dynatest** | R80 | .fwd, .hwd |
| | F20,F25 | .fwd, .F20, .F25 |
| | FwdWin | .fwd, .txt |
| **KUAB** | KUAB | .fwd, .hwd |
| **JILS** | M3 | .fwd, .hwd, .dat |
| | M5 | .fwd, .hwd, .dat |
| **Carl Bro** | CarlBro | .txt, .fwd |
| **PaveTest** | PaveTest | .csv |
| **AASHTO** | PDDX | .ddx |

SRA INTERNATIONAL, INC.
Honesty and Service®

# F/HWD Round-Up Background

1. Create an indoor, controlled pavement structure for F/HWD testing purposes
2. Develop a testing plan for evaluating F/HWD vehicles
3. Evaluate specifications and methodologies of various F/HWD equipment
4. Examine what, if any differences are found between individual manufactures data and the effects that may have on data evaluation
5. Provide industry with the testing data for more exhaustive analysis

# F/HWD Round-Up Background




**RIGID PAVEMENT** **FLEXIBLE PAVEMENT**

● **Drop Location**

| FWD- Testing Load Levels | HWD- Testing Load Levels |
|---|---|
| 9,000 lbs | 12,000 lbs |
| 12,000 lbs | 24,000 lbs |
| 16,000 lbs | 36,000 lbs |

SRA INTERNATIONAL, INC.
Honesty and Service®

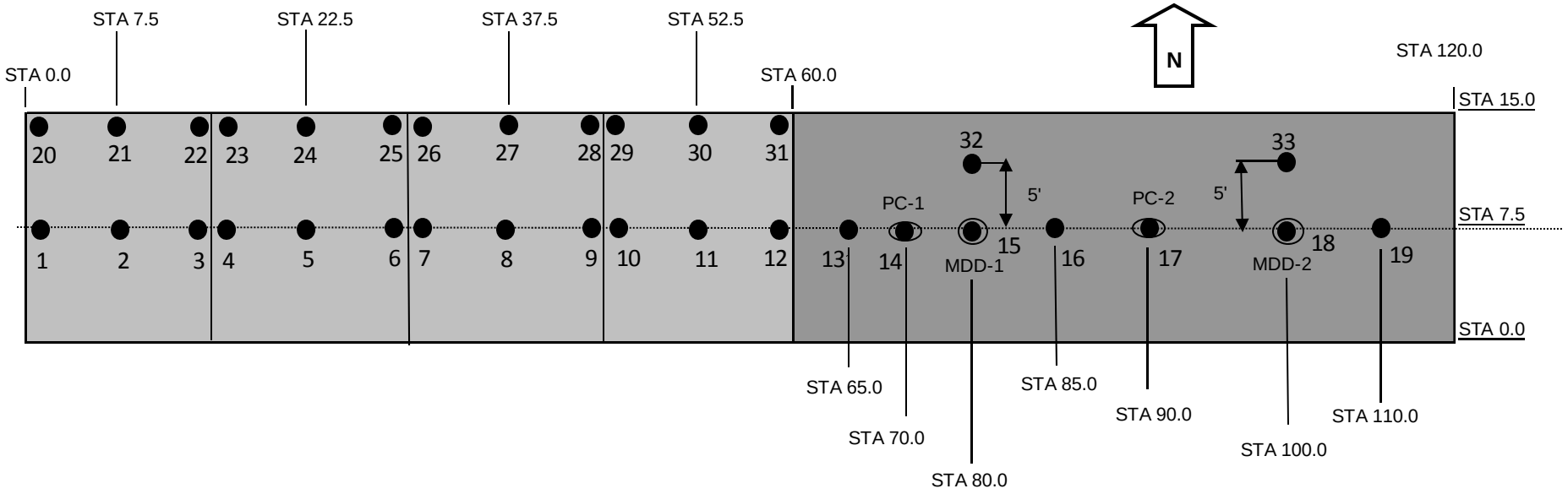
# Raw Data

- Nearly 1,200 individual files collected from the F/HWD equipment
- Countless deflections and time histories data collected for each drop location
- Nearly 900 individual files collected from the embedded sensors
- With 49 embedded sensors that equals nearly 44,000 unique data collected
- Unprocessed deflection and time history files were published first

# Excel Workbook Database

- **F/HWD equipment data sorted by participant and by drop**
- **Database data includes but is not limited to:**
  - Pavement Type Under Plate Load
  - Load
  - Deflection (at each sensor)
  - Time History
  - Pulse Width (at each sensor)
  - Peak Time (at each sensor)
  - Pavement and Air Temperature
  - Limited Embedded Sensor Responses

# Interactive Webpage Query System

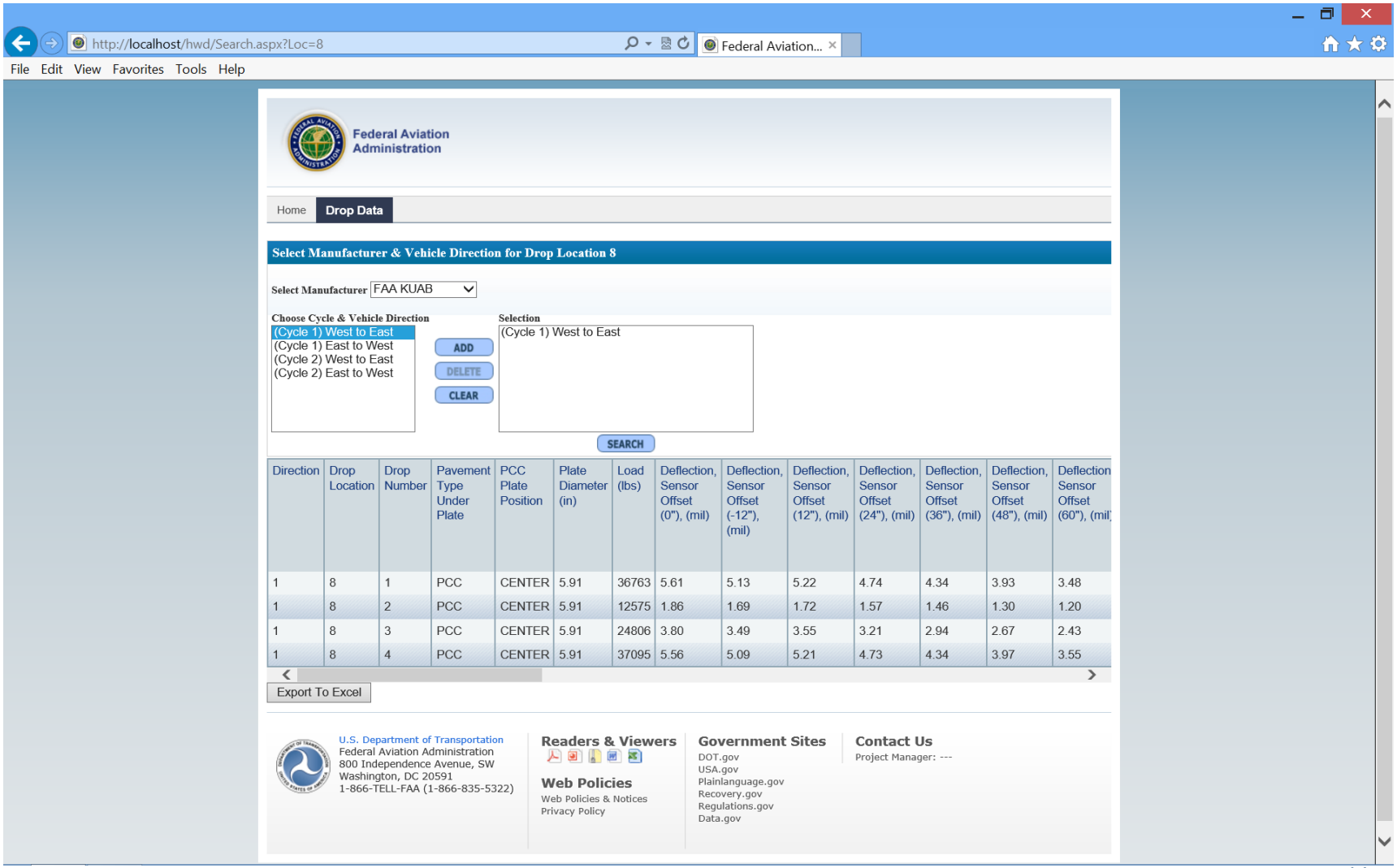



**RIGID PAVEMENT** **FLEXIBLE PAVEMENT**

● **Drop Location**

SRA INTERNATIONAL, INC.
Honesty and Service®

# Interactive Webpage Query System



SRA INTERNATIONAL, INC.
Honesty and Service®

# Future Work

- **BAKFAA**
  - User Group Meeting (Address Comments and Suggestions)
  - Consider integration of AI
- **F/HWD Round-Up**
  - Process and publish embedded sensor data
  - Provide software and instructions need to view embedded sensor data
  - Examine analysis opportunities (i.e. – compare dynamic loading responses and F/HWD responses)

# Questions???


- **Acknowledgements**
  - FAA
    - Dr. Satish Agrawal
    - Dr. Gordon Hayhoe
    - Jeff Gagnon
    - Al Larkin
  - SRA
    - Chuck Teubert
    - Jerry Connelly
    - Injun Song
    - Qiang Wang
    - Renaldo Aponte
  - SRA
    - Jason Tarby
    - Michael Lvov
    - Henry Fermin
    - Gaurav Verma
    - Durgesh Gupta