



Laser-Based Technology for Automated Rut Measurement in Accelerated Pavement Testing

Tom Byron

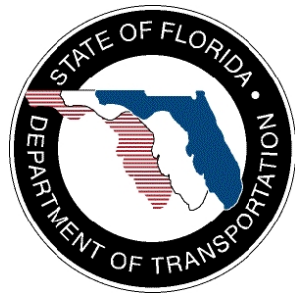
Salil Gokhale

Bouzid Choubane



Overview

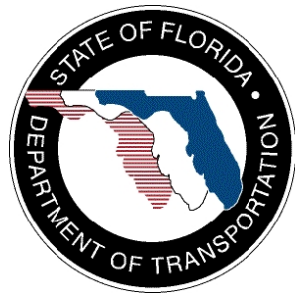
- Florida's APT program
- Pavement profile measurements
- Implementation of non-contact profiling in APT
- Data collection and analysis functions
- Automated rut measurements
- Other applications



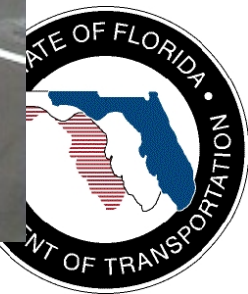
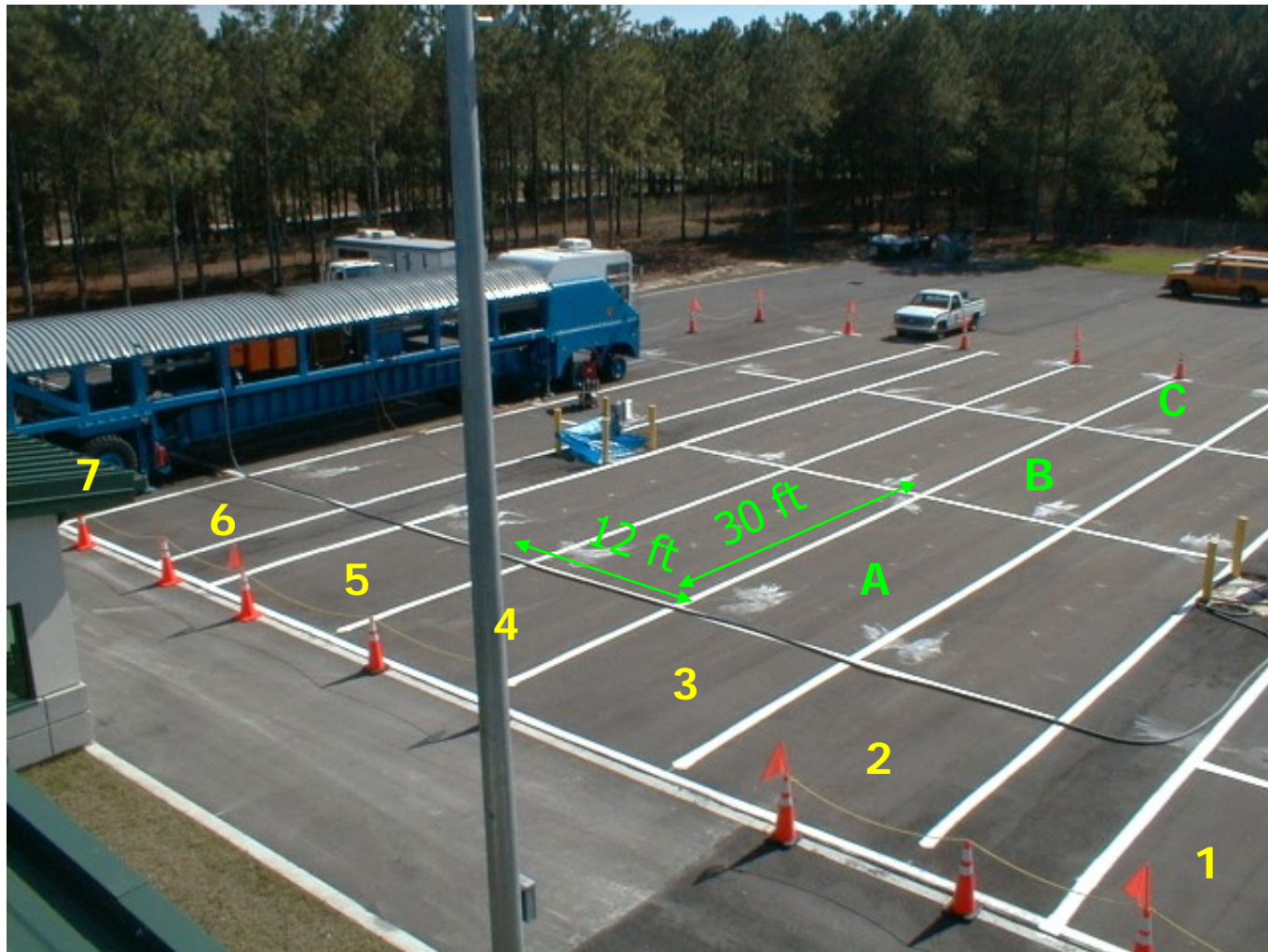


FDOT's APT Program

- Initiated in Year 2000
- To date:
 - 2 flexible pavement experiments
 - 1 rigid pavement experiment
 - 1 composite pavement experiment
 - 2 geotechnical experiments
 - 1 miscellaneous experiment – Raised pavement markers



APT Site



APT Site



Moisture Control Capability



Heavy Vehicle Simulator (HVS)

Diesel or Electric Power

Weight: 50+ t, Length: 23 m

Height: 4 m, Width: 3.7m

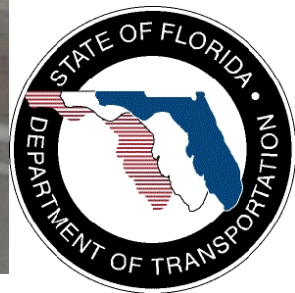
Loading: 31 – 200 kN

Wheel speed: 13 kph

Maximum Passes per day:

29,000 bi-directional

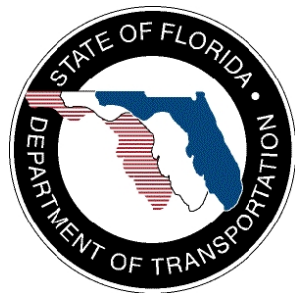
14,000 uni-directional



Additional Features



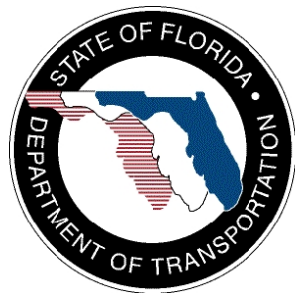
- Environmental Chamber (Radiant heater)
 - 50 mm styrofoam with aluminum siding
 - Most tests are conducted at a controlled temperature
- Single or dual tire
- Laser profiling system





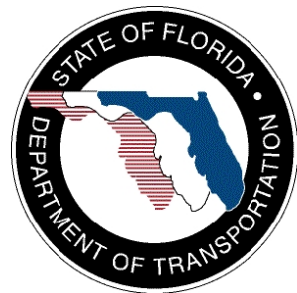
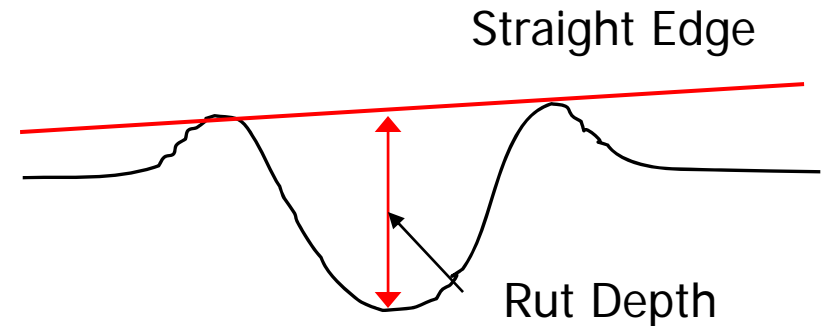
Pavement Profile Measurements

- In most APT experiments:
 - Characterizing test pavement surface
 - Measurement of permanent deformation
 - Accurate mapping of cracks



Measurement of Rut Depth

- Manual Methods
 - Straight edge
- Automated Methods
 - Non contact profilers
 - Various proprietary devices





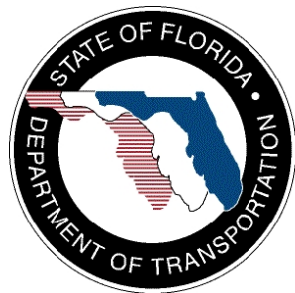
Manual Rut Measurements

- Advantages

- Widely accepted as base-line measurements
- Very easy to perform

- Disadvantages

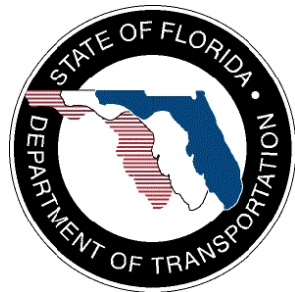
- Time consuming and labor intensive
- Limited data points, therefore difficult to obtain entire test surface profile
- More chances of measurement error





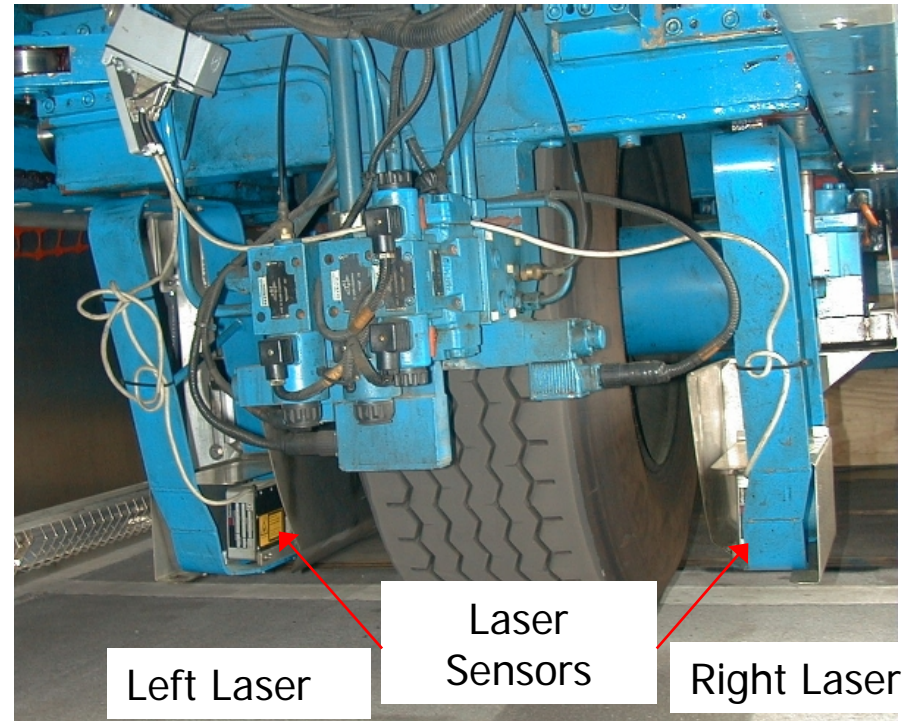
Automated Rut Measurements

- FDOT Laser Profiling System
 - Fully automated
 - Entire surface profile is obtained
 - One set of profiles is taken in less than 10 minutes
 - Highly accurate
 - Does not tie up personnel



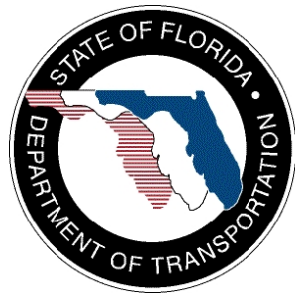
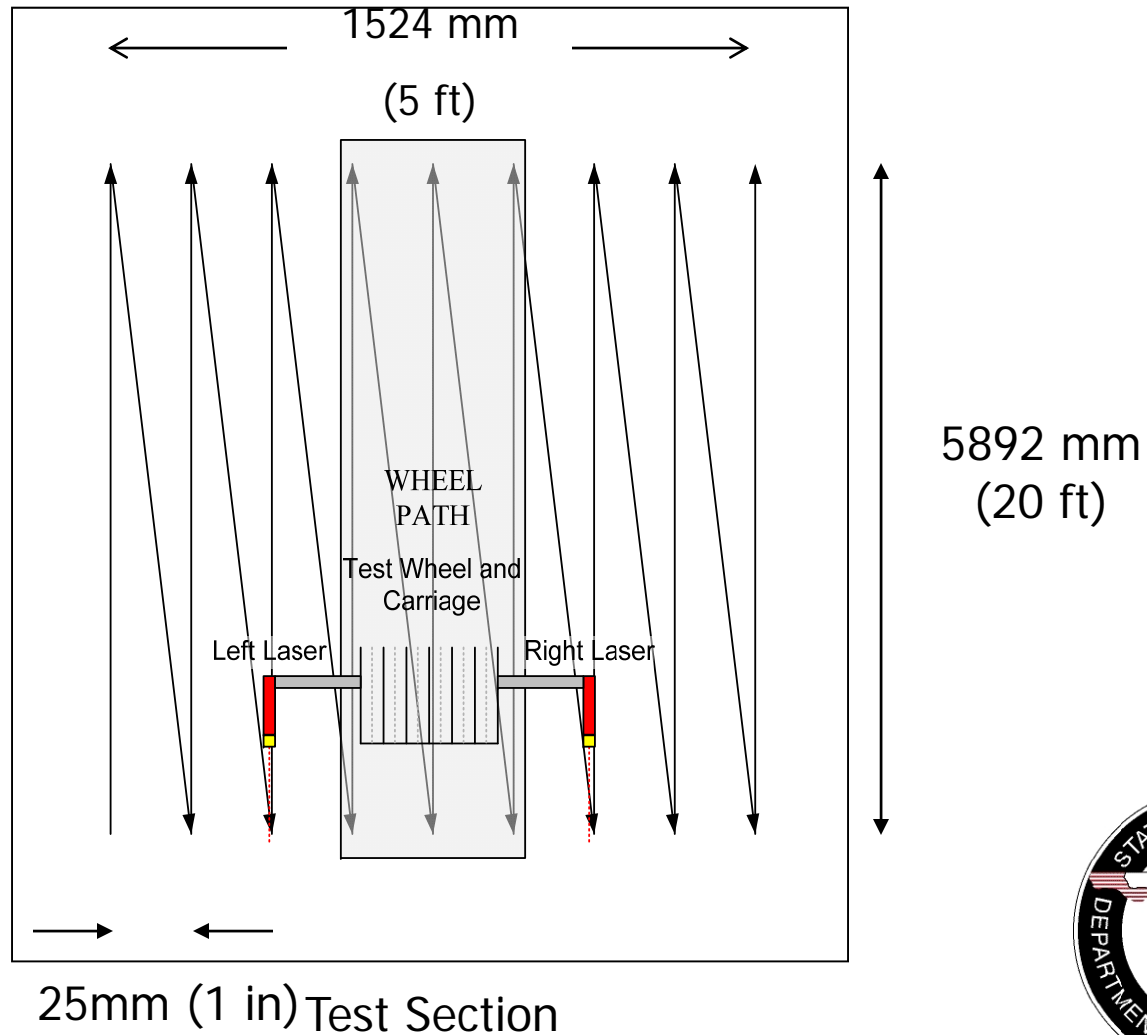
Laser Profiling System

- Two 16 kHz Lasers, mounted 762mm (30 in) apart
- Very accurate
- Wheel carriage travels at 4 kph during data collection
- Carriage is 'unloaded'



Pavement Profiles

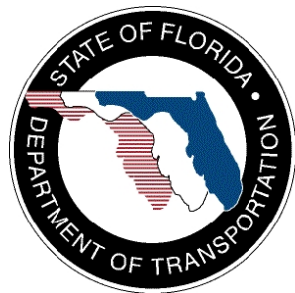
Data collection:
Wheel unloaded
Profile time = 10
minutes



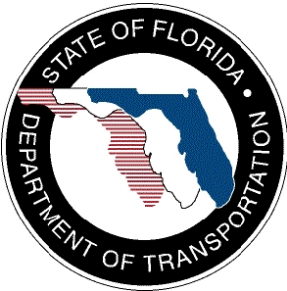
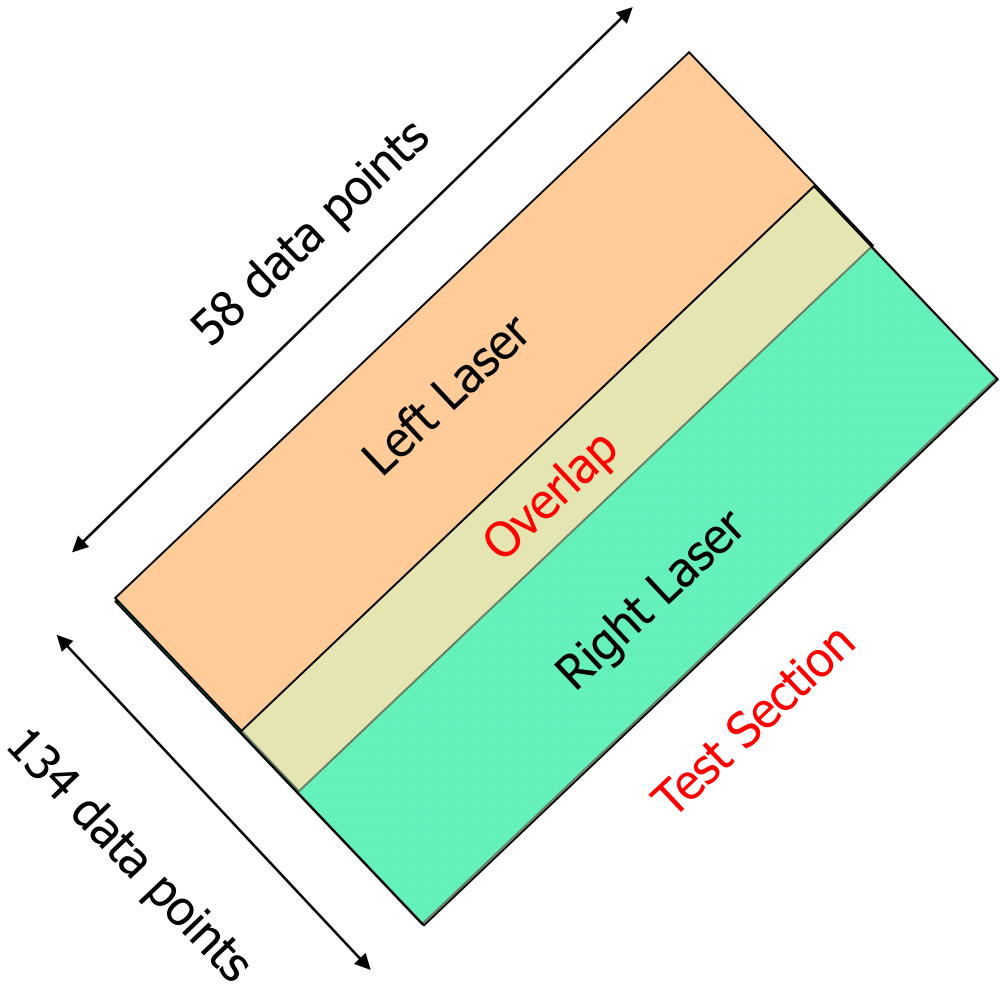


Data Collection

- 2 sets of data are acquired, one from each laser
- Data is averaged every 100 mm in the longitudinal direction
- Results in a 58 x 134 data array
- Data saved in ASCII format



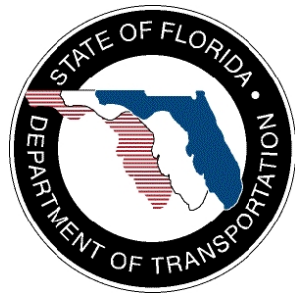
Data Acquisition





Data Analysis

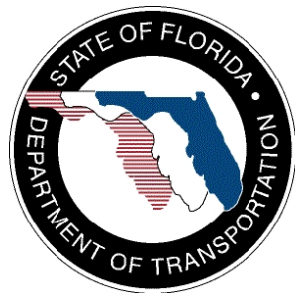
- Important Considerations
 - Ensure data collection procedure and data format are standardized
 - Collection of initial or 'untested' pavement surface profile is essential
 - Algorithm for data processing
 - Overlapping data is very important





FDOT's Rut Analysis Program

- Developed in-house
- MS-Excel, Visual Basic for Applications (VBA) based
- Very easy to use
- Complies, analyzes and stores data



Program Flow Chart

The screenshot displays a Microsoft Excel spreadsheet titled 'Profile Analysis7.xls' with a 'Flow Diagram' tab selected. The spreadsheet contains a program flow chart with the following steps:

- 1 User makes analysis/troubleshooting selections from the main form
- 2 Import_New_Data_Files
- 3 Application
- 4 One-by-one
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15 End of indiv
- 16
- 17
- 18
- 19
- 20
- 21
- 22
- 23
- 24
- 25
- 26
- 27
- 28
- 29
- 30
- 31 LeftLaserData(x,x,x)
- 32 RightLaserData(x,x,x)
- 33 RawLaserData(x,x,x)

An 'HWS Laser Profiler Analysis Tool' dialog box is overlaid on the spreadsheet, containing the following options:

- Rut Analysis Options**
 - Initial Profile Only
 - Differential Profile
 - Linear Corrected Profile
- Troubleshooting Options**
 - Save Raw Laser Files as .xls Files
 - Show Each Laser Data File As Worksheet
 - Show Adjusted Data - Individual Files
 - Show Averaged, Raw Data
 - Show Averaged, Adjusted Data
 - Show Cleaned Data
 - Show Averaged Cleaned Data
- Other Options**
 - Show Troubleshooting Options frame and Data Summary frame
 - Remove data based on range value between data points - Turned Off
 - Remove conduit interference from laser data (cleaned data) - Turned Off
 - Change number of transverse profiles in accel/decel zone - Default = 6
- Data Summary - ONLY**
 - Write Summary Worksheets - Only

Buttons: RUN (green), Reset (yellow), Cancel (white).

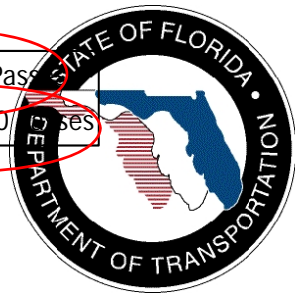
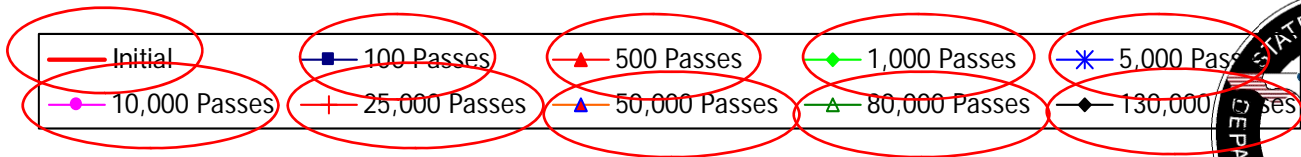
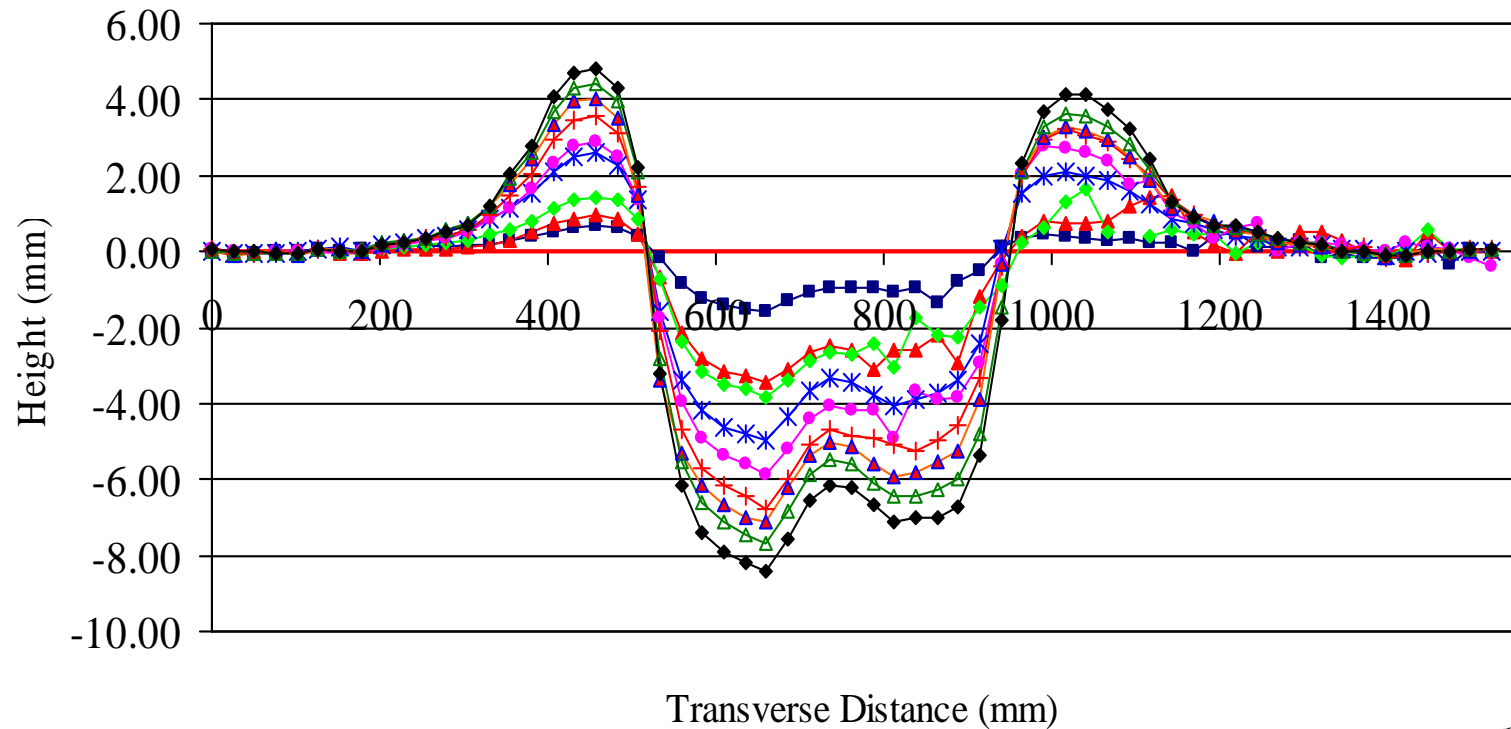
At the bottom of the dialog, there are three buttons: 'LeftLaserData(x,x,x)', 'RightLaserData(x,x,x)', and 'RawLaserData(x,x,x)'. An arrow points from the 'End of indiv' step in the flow chart to the 'LeftLaserData(x,x,x)' button.

The spreadsheet also contains text in cells G15 through G18: 'the data files', 'QC only', 'ot', and 'each file'.

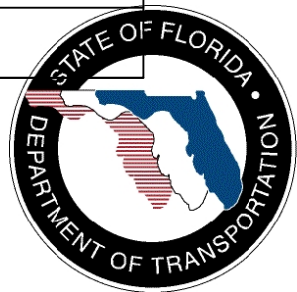
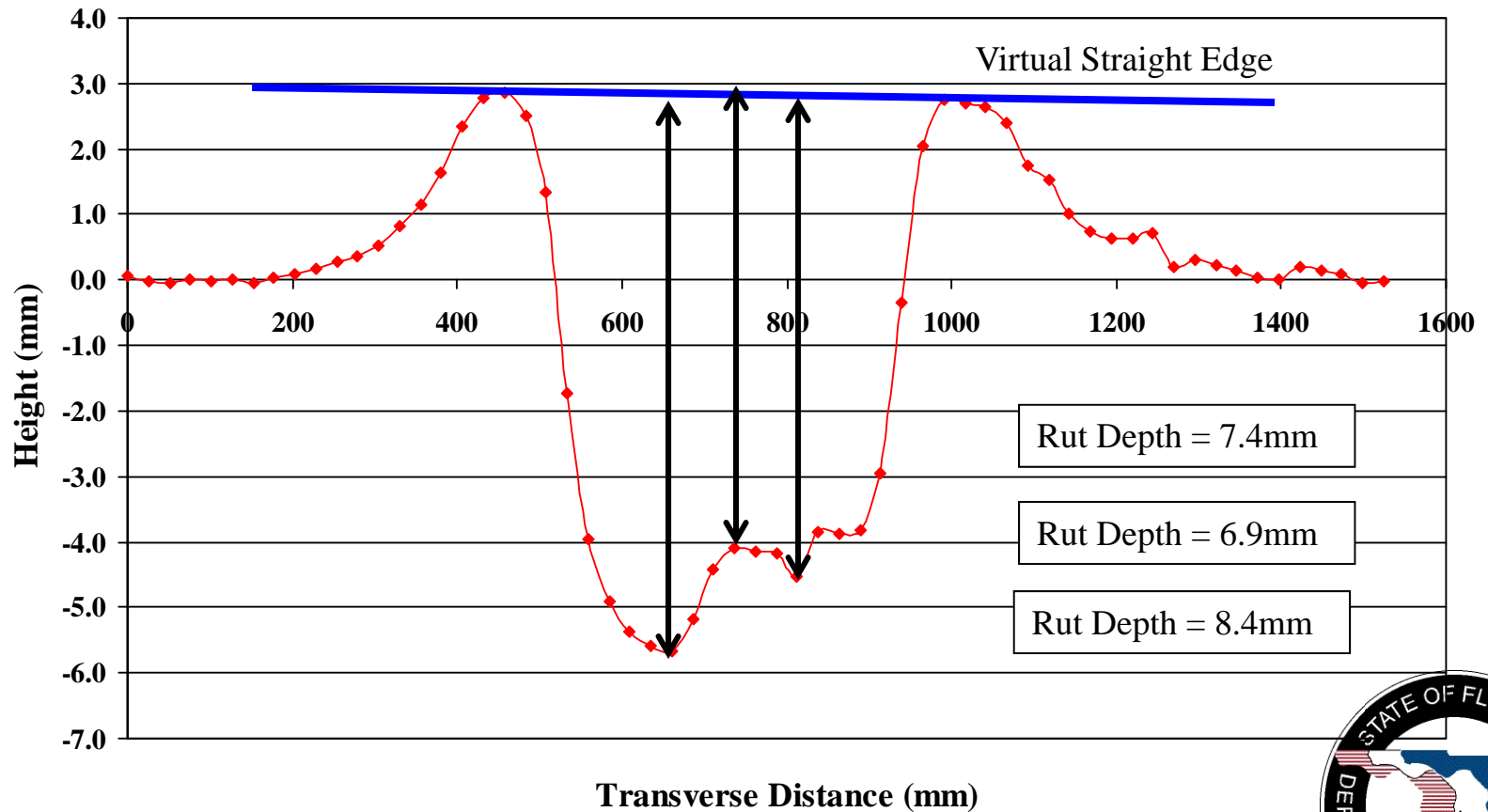
The bottom of the Excel window shows the 'Definitions' tab and the 'Flow Diagram' tab. The status bar at the bottom indicates 'Ready' and 'NUM'.



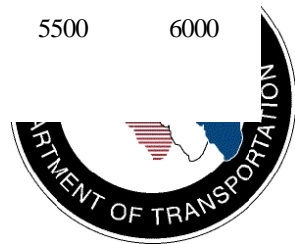
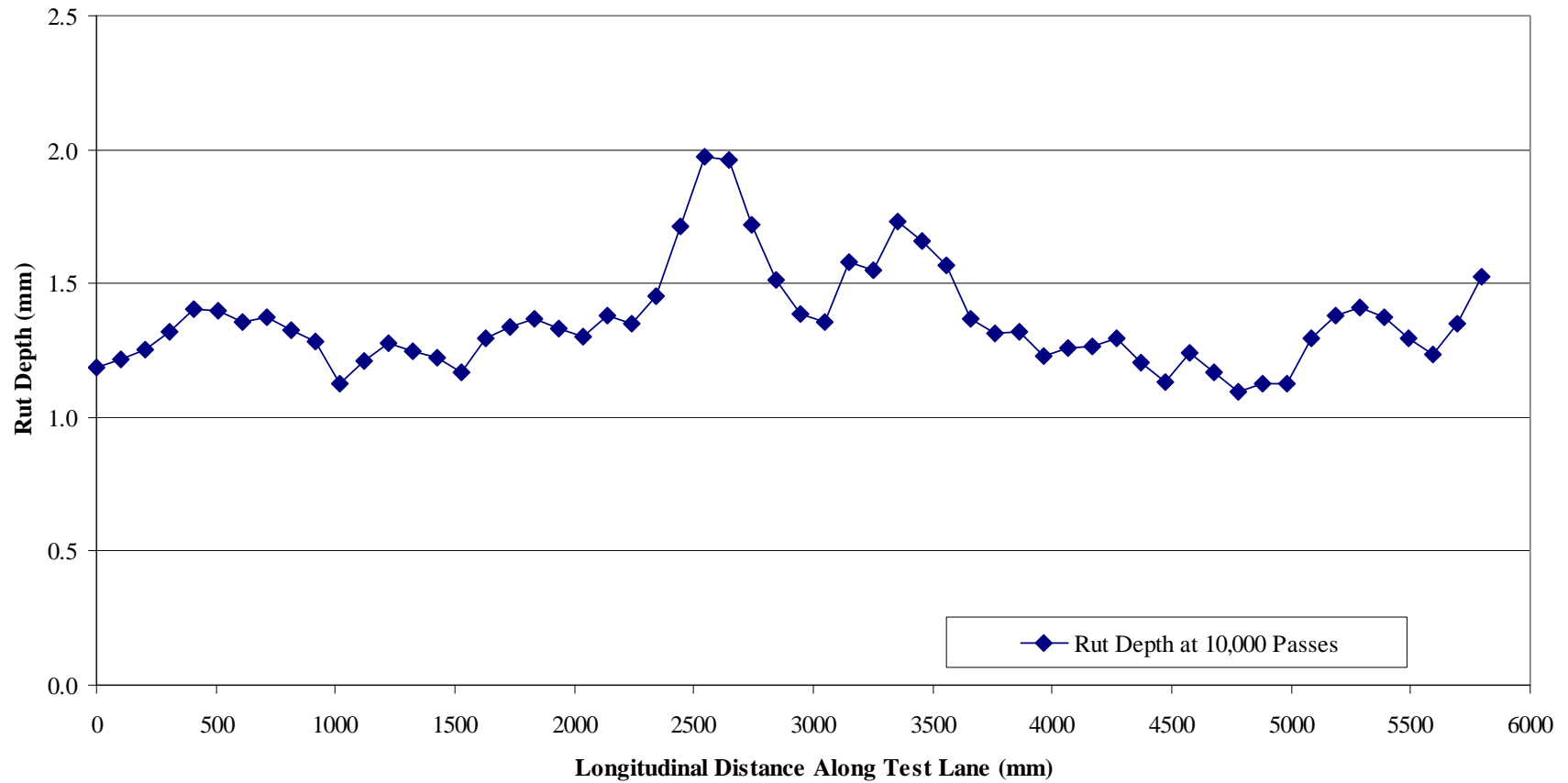
Typical Transverse Profile



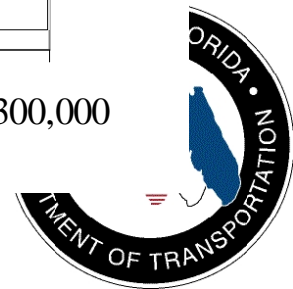
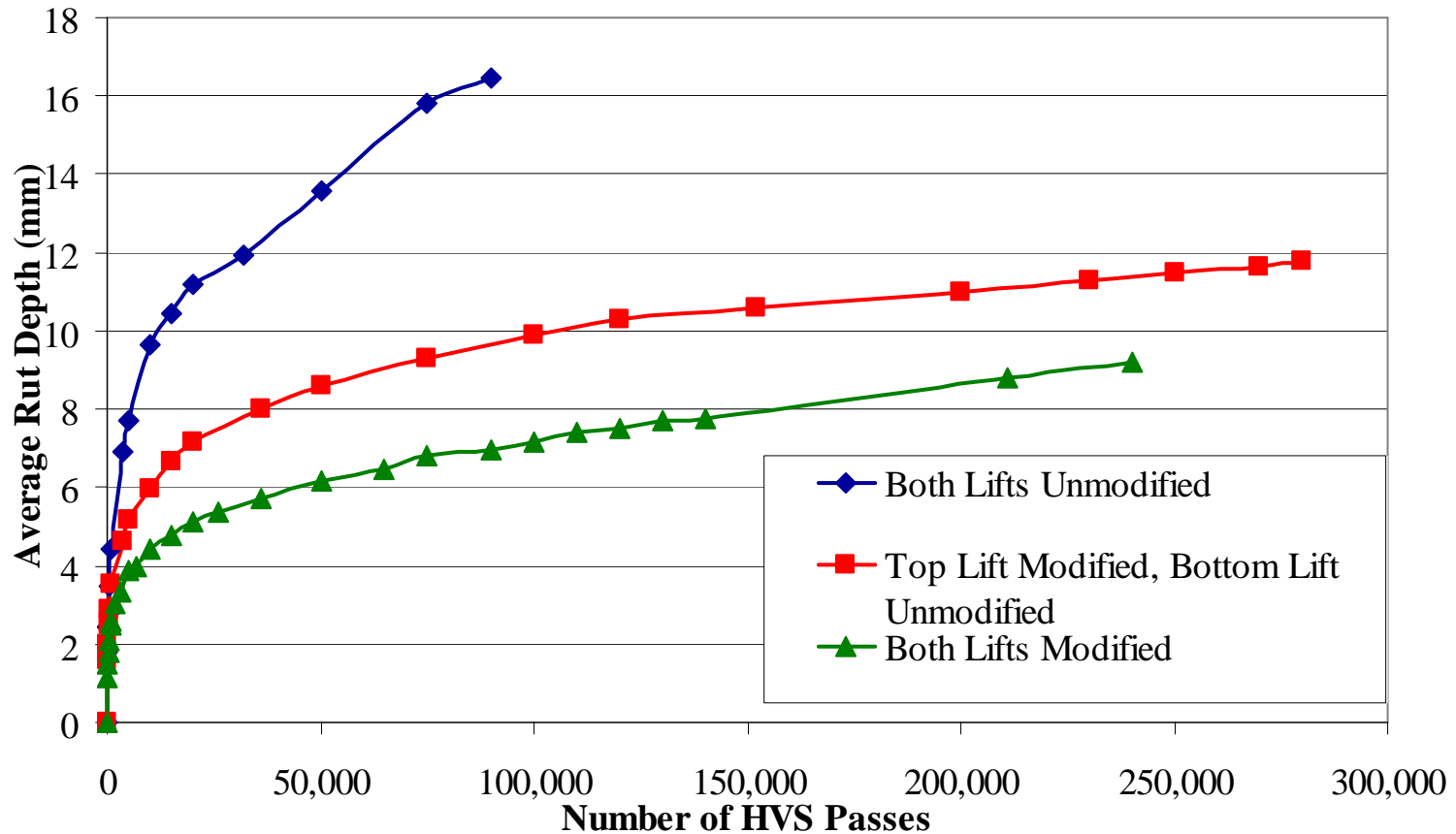
Calculation of Rut Depth



Longitudinal Variation of Rut Depth



Rut Measurements

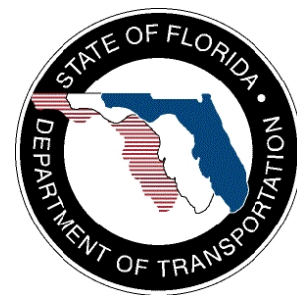
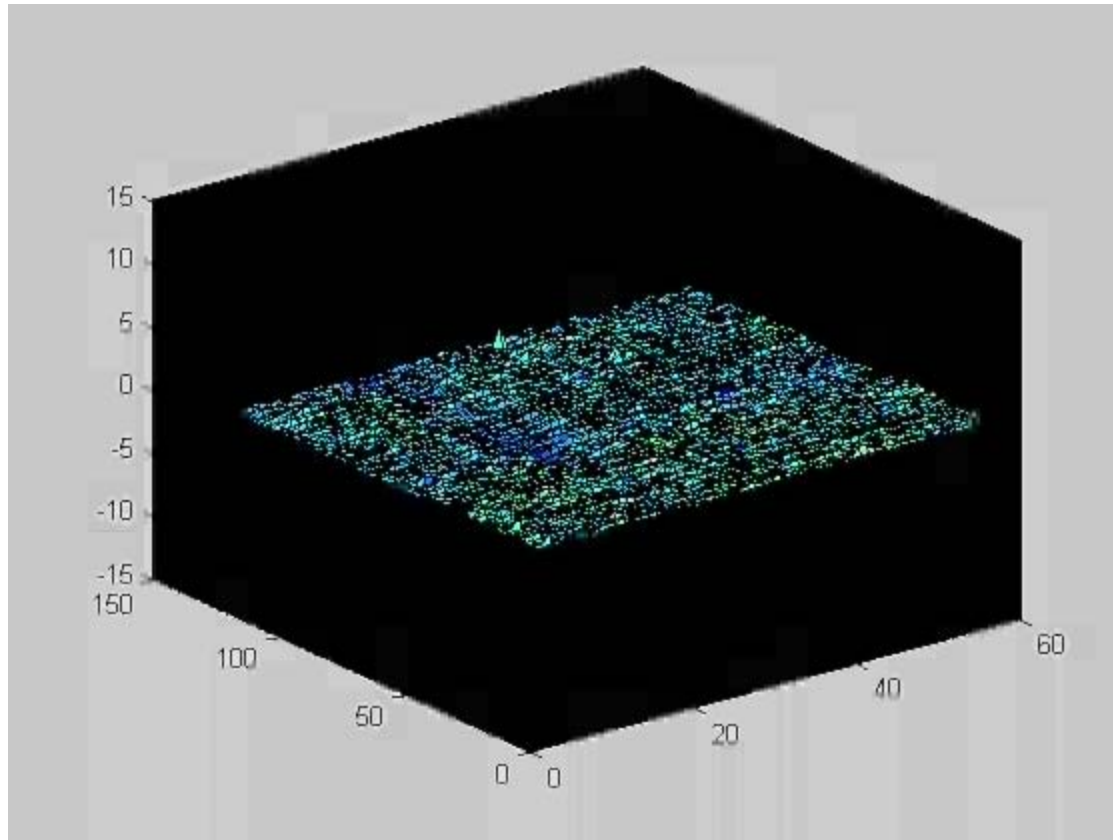




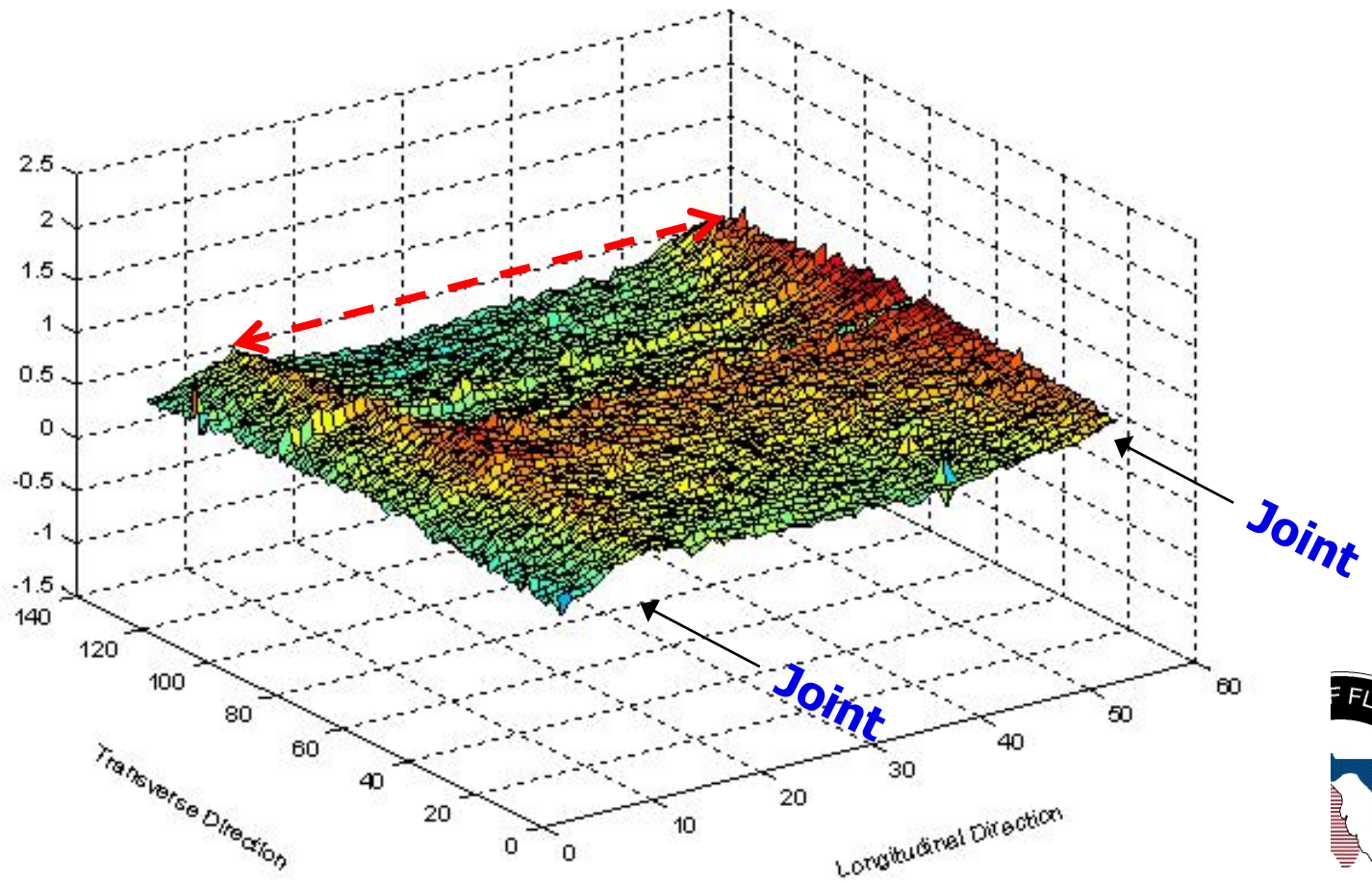
Laser Based Profiling System

Other Applications

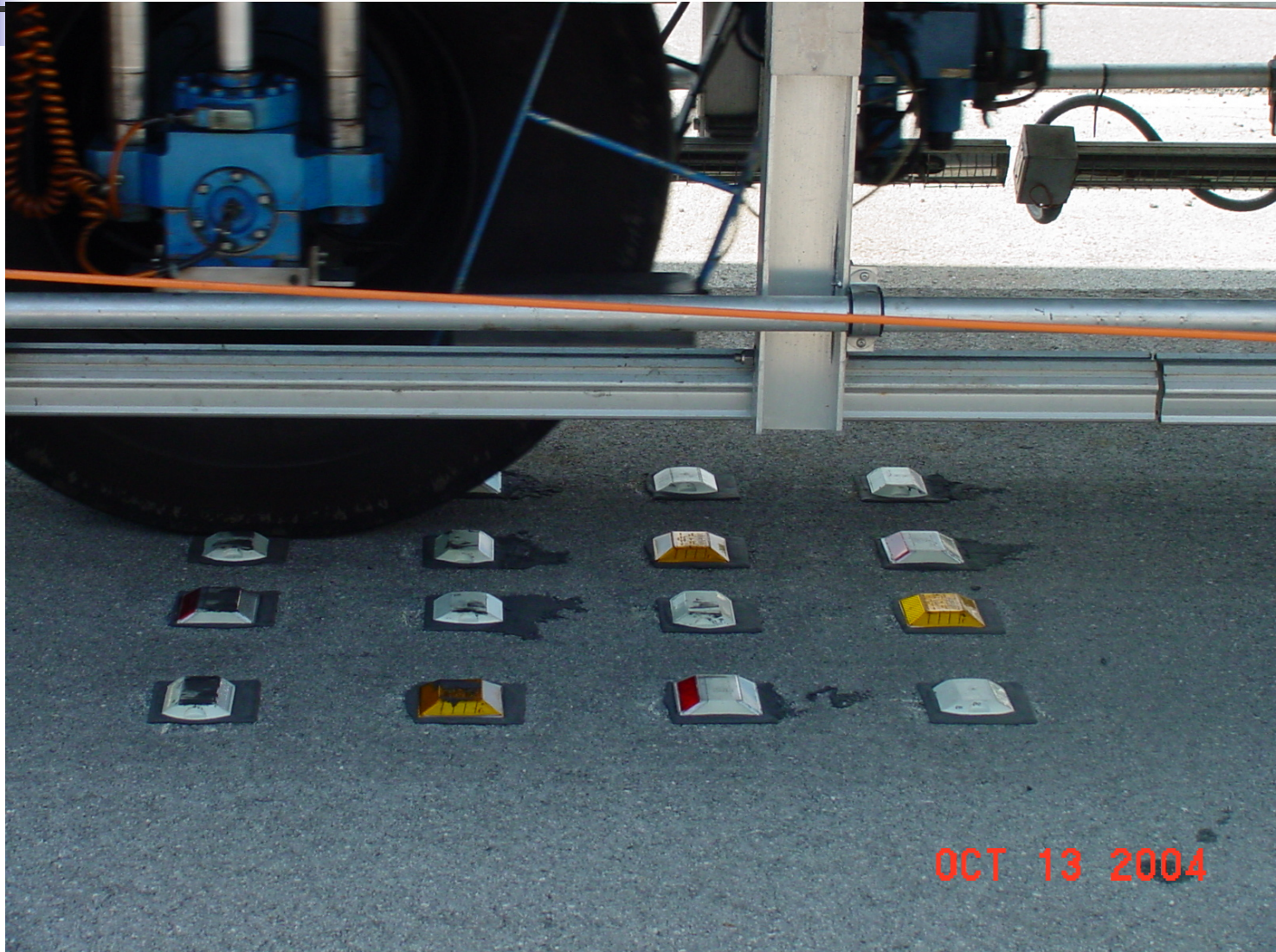
Flexible Pavements – Rut Development



Rigid Pavements – Slab Curling



Raised Pavement Markers



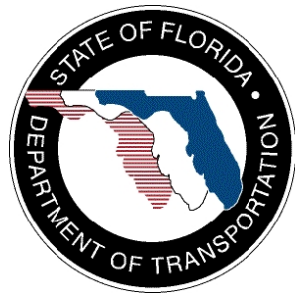
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FDOT's Experience

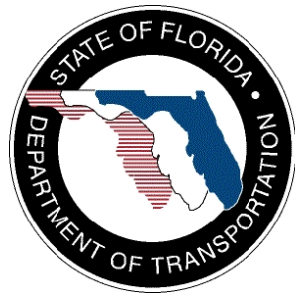
- Laser Based Profiling System
 - Extremely beneficial
 - Large savings in time and manpower resources
 - Entire surface profile is obtained
 - Data can be used for other analyses – Volume change analysis.





Presentation

- Rut Initiation Mechanisms In Asphalt Mixtures as Generated Under APT Loading
 - Recent and Significant Accelerated Pavement Testing Results, Session 708
 - Wednesday, January 12, 4.30 – 6.00pm
 - Shoreham



Questions?

