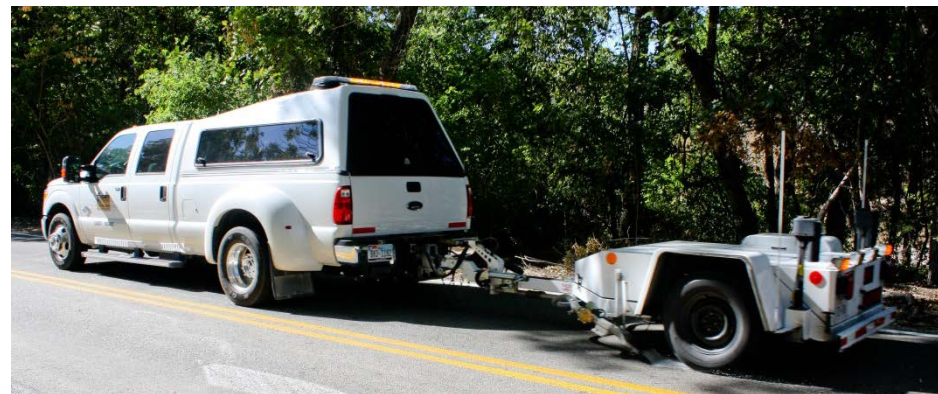


The following topics will be covered

1. Friction Testing
2. Texture Testing
3. Texture-Friction Relationship
 - Case Study, Louisiana DOTD
 - Implications for Network Condition Monitoring
4. Insights and Future Research

Friction Testing (What and Why?)

- Friction testing helps determine if
 - Adequate skid resistance exists
 - Or if corrective measures are warranted
- Friction is an important pavement parameter
 - One of the primary highway safety metrics
 - Inadequate pavement friction → higher rate of accidents
 - Can be used to evaluate Material types & Construction practices
- Value
 - Accident Reduction



Friction Testing (How and When?)

- Test Method: ASTM E274-97
 - Locked Wheel Method Using Full Scale Tire
 - Equipment of choice for DOTs
- Pavement friction changes over time
 - Typically increases the first two years after construction
 - Decreases as aggregates become more polished
- Many factors affect friction
 - Weather
 - Surface Texture
 - Surface Distresses
 - Surface Treatment



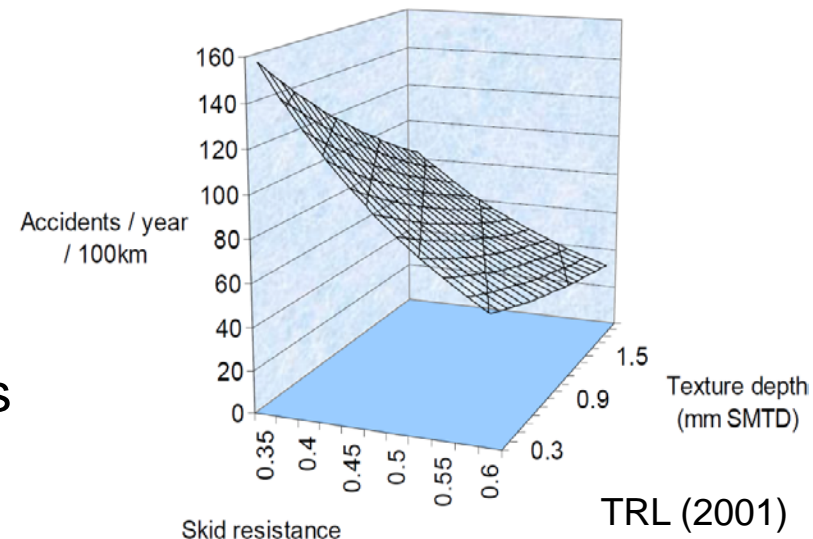
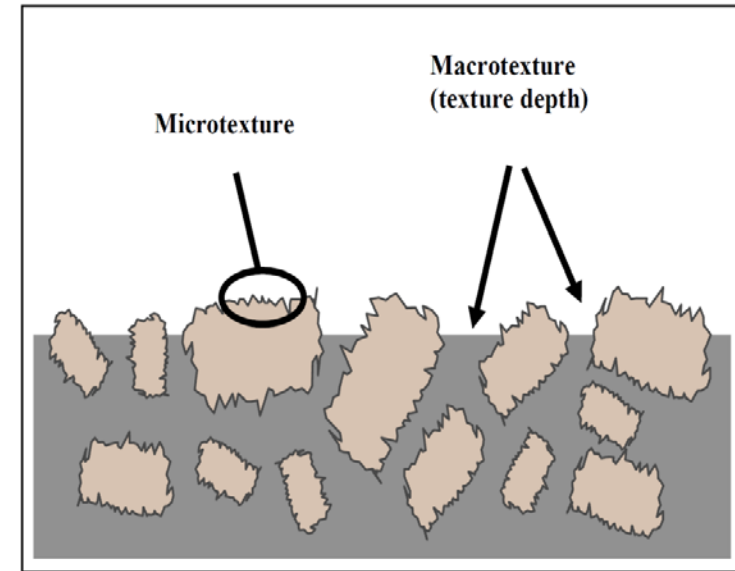
Friction Testing



Low Reliability, High Operations Cost and Safety Risk

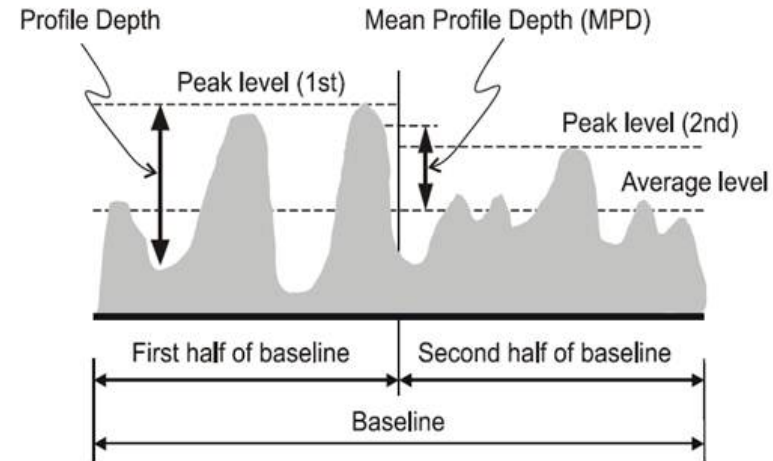
Texture Testing (What and Why?)

- Macro-Texture
 - A component of surface friction
 - Related to splash and spray
 - Determine corrective measures
- Texture is an important parameter
 - Contributes to Friction
- Value in Texture Testing
 - Contributes to safety evaluation in conjunction with friction data
 - Evaluation of noise
 - Identifying different surface types and patches for automated surveys



Texture Testing (How and When?)

- Test Method: ASTM E1845
 - Using a laser profiler
 - At highway speeds
 - mean profile depth (MPD)
- Texture changes over time
 - Micro-particles clogging surface
 - Traffic abrasion
 - Oxidation of asphalt surfaces
- Many factors affect macro-texture
 - Weather
 - Surface Aggregates and Mix Design
 - Surface Distresses
 - Surface Treatment



Texture Measurement

> TEXTURE (Option 2)
 The LCMS sensors calculate full lane width texture measured in 5 AASHTO brands

> POSITIONING – POS LV 220
 The POS LV tracks the position and orientation of the ARAN in real-time. This position and orientation solution and combines data from tactical-grade fiber optic gyros and accelerometers, a differential GPS, and a DMI.

> POSITIONING - GPS
 Every ARAN is equipped with a GPS and is integrated with other subsystems so that if the receiver cannot lock on enough satellites to determine its position, the ARAN DMI and the ARAN Inertial Reference System will fill in the gaps.

> PAVE3D DISTRESS
 With the ARAN's LCMS subsystem, 3D profile data is used for automated detection and full lane width image display.

> RIGHT-OF-WAY VIDEO
 The ARAN can be outfitted with as many as six HDTV cameras which captures right-of-way images allowing you to virtually view the road from the comfort and safety of your office.



> PAVE3D RUTTING
 The 3D Laser Measurement System uses dual scanning lasers to accurately measure the transverse profile of the road with 4000 points over 4 meters.

> GROUND PENETRATING RADAR
 An electromagnetic device used to detect changes in road structure, including material thickness, changes in material and changes in material condition.

> ROUGHNESS
 The Laser SDP is a longitudinal profile measurement system that provides road profile data capture and real-time roughness index calculation using a combination of high-speed lasers and accelerometers.

>TEXTURE (Option 1)
 Smart Texture utilizes high frequency lasers to measure the mean profile depth of road surface macrotecture.

> POSITIONING - DMI
 The Distance Measuring Instrument measures ARAN chainage and linear distance travelled. Every ARAN is equipped with a GPS and is integrated with other subsystems so that if the receiver cannot lock on enough satellites to determine its position, the ARAN DMI and the ARAN Inertial Reference System will fill in the gaps.

Texture Measurement



Area



Line

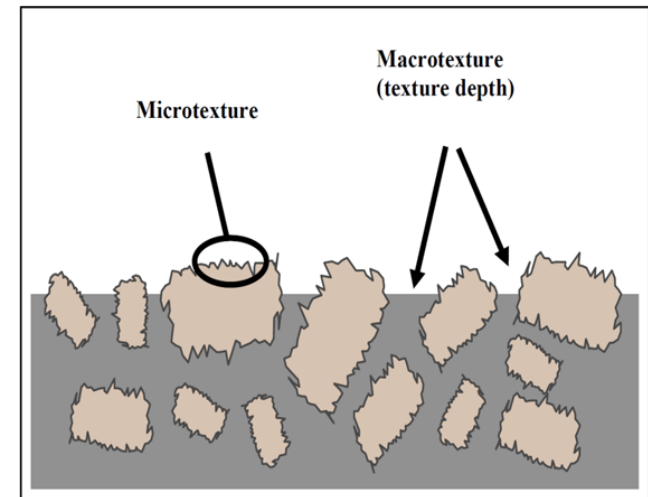
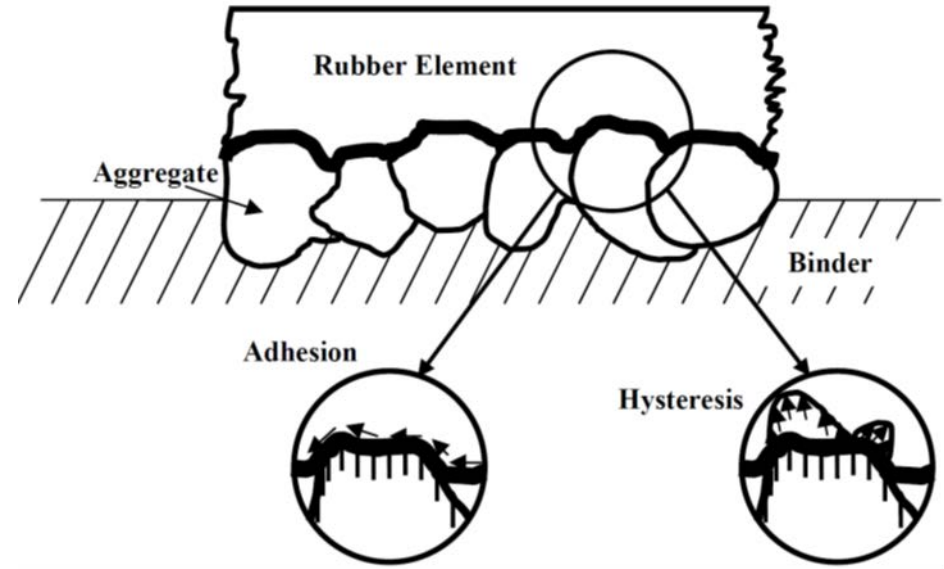
High Reliability, Lower Operations Cost and Safety Risk

Surface Properties Contributing to Friction

- Friction
 - Macro-Texture: Hysteresis
 - Micro-Texture: Adhesion

- Macro-Texture
 - Measured: Laser Profiler
 - Important at Higher Speeds

- Micro-Texture
 - Measured: Lab imaging, Lab SEM
 - Important at Low and High Speeds

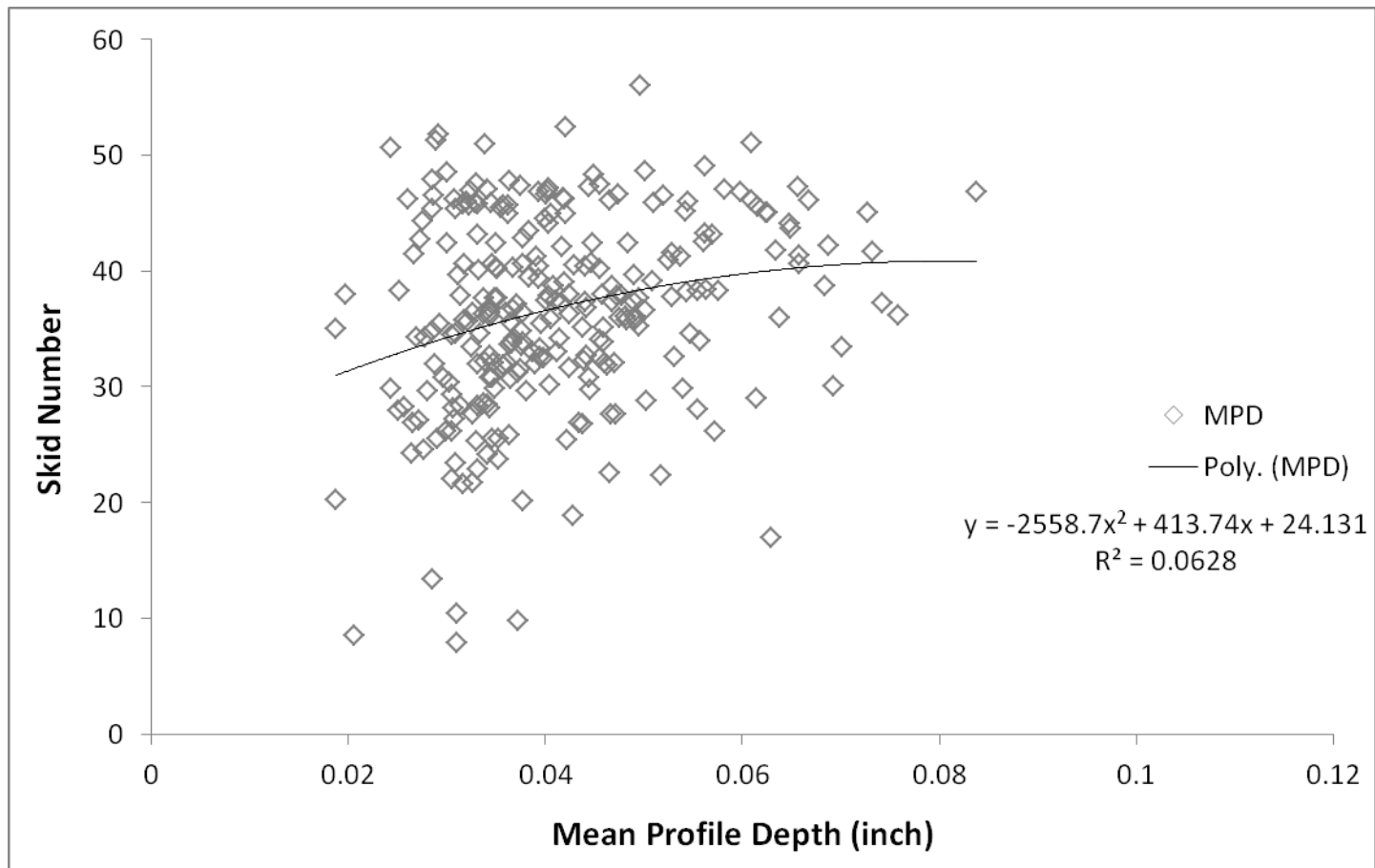


Texture-Friction Pilot Study

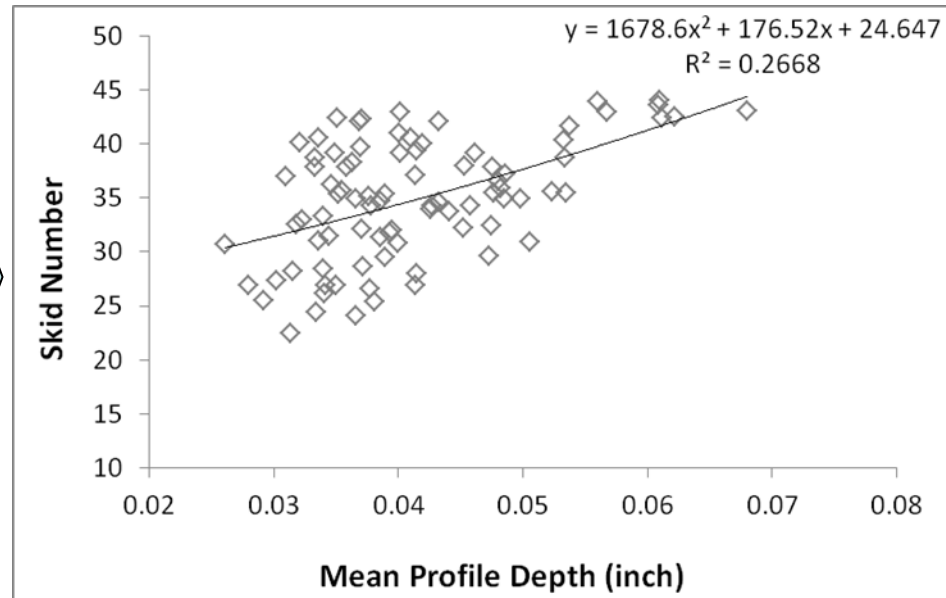
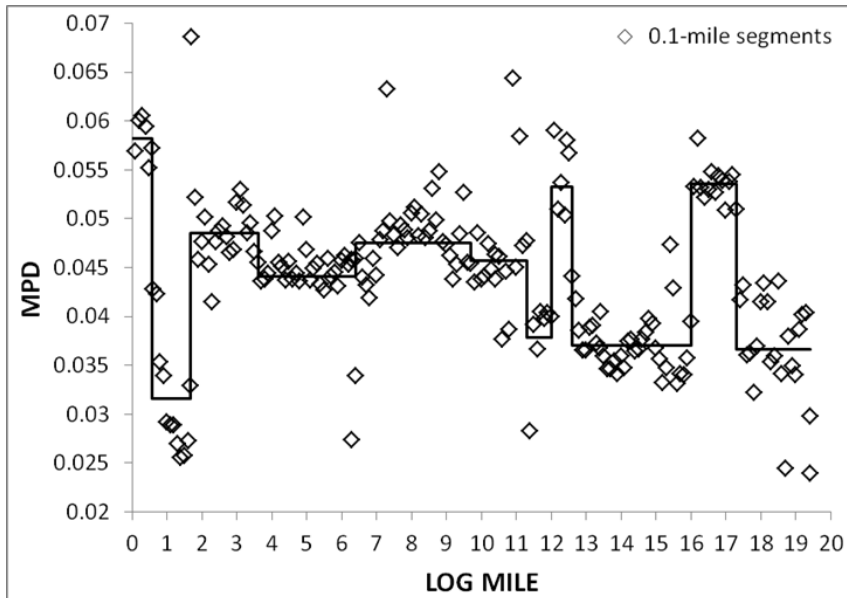
- Louisiana DOTD NHS network
- Relating Smooth Tire Skid Number to Macro-Texture
- Characteristic Length of Measurement
 - Every 0.5 Miles
 - Dynamic Segmentation
 - Average Along Each Section
- Friction Testing at Higher Speeds
- Texture-Friction Relationship
- Texture/Friction High and Low Thresholds

MPD vs. SN: Every 0.5 Miles

Example: Louisiana District 4, 2013

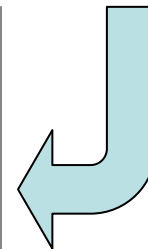
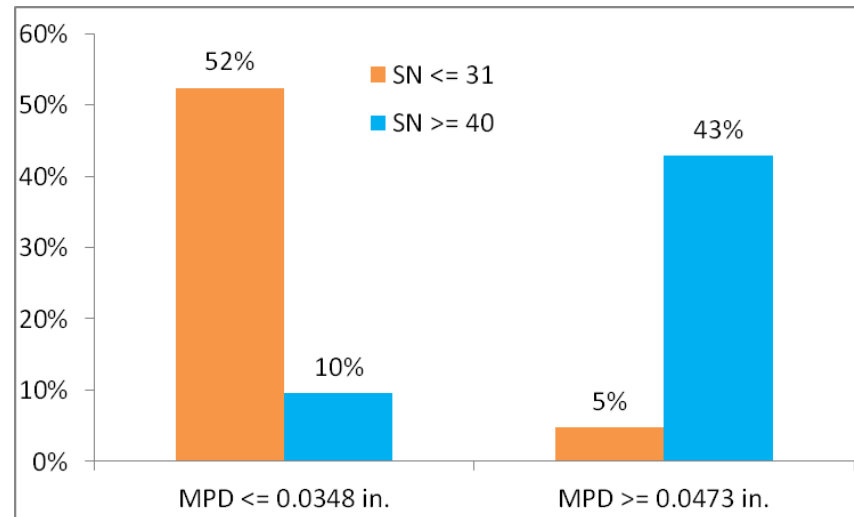


MPD vs. SN: Dynamic Segmentation



Lower Threshold:
First Quartile

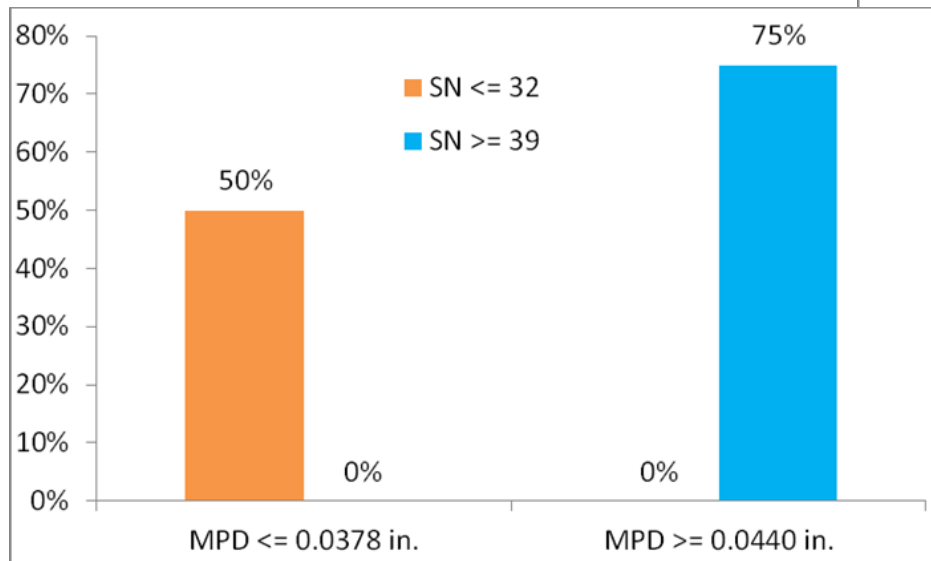
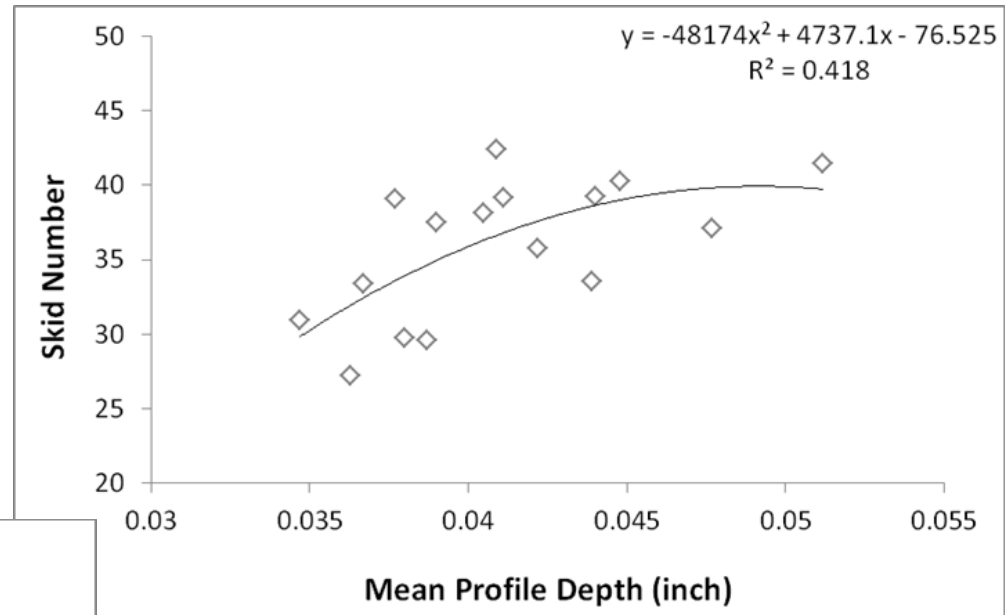
Higher Threshold:
Third Quartile



MPD vs. SN: Section by Section

Louisiana District 4: 2013

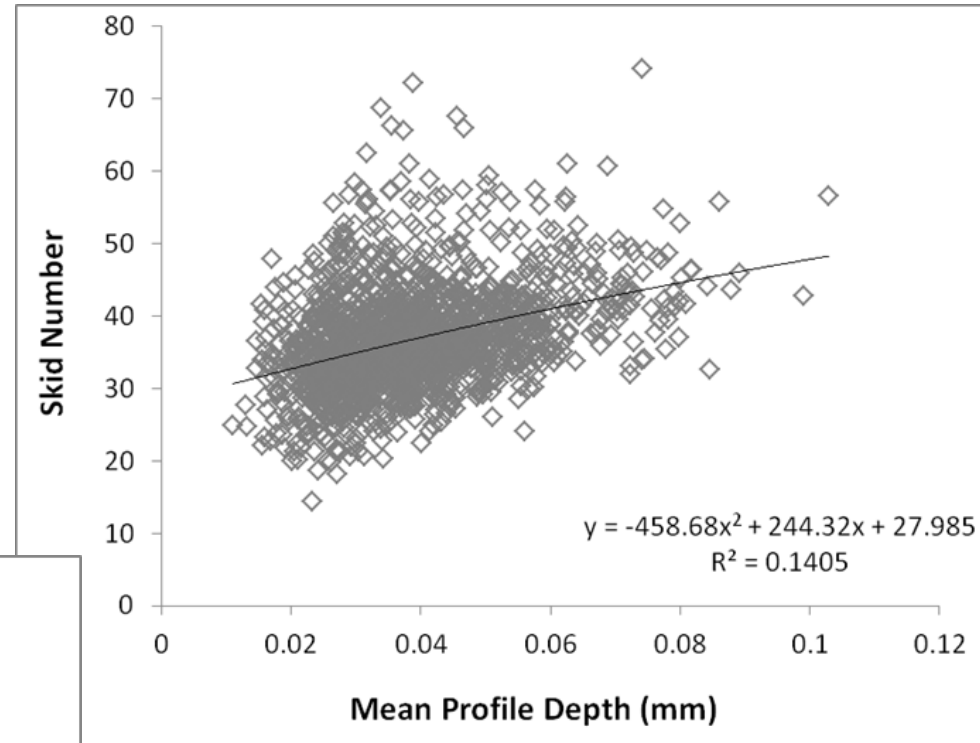
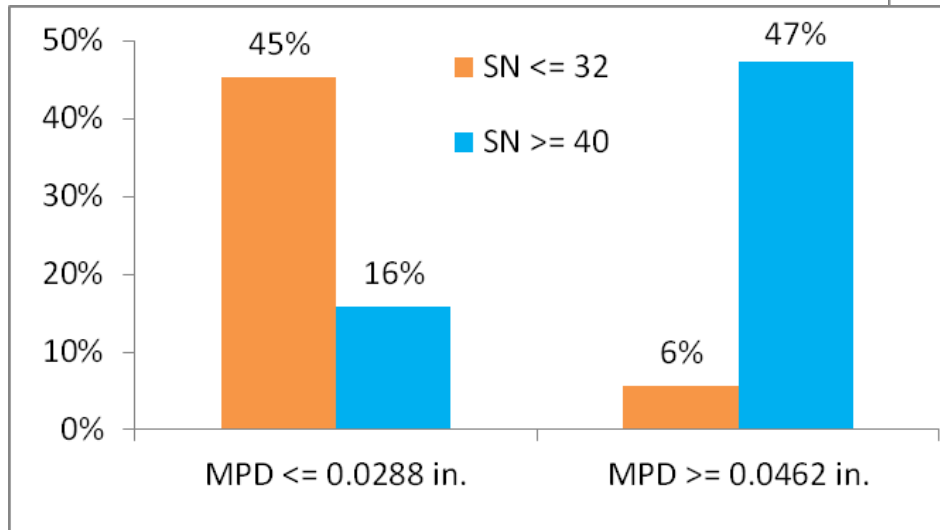
Averaging
=
Less Variability



Limited Number of Sections
=
Narrow Range of Micro-Texture

MPD vs. SN: Sections Longer Than 5 Miles

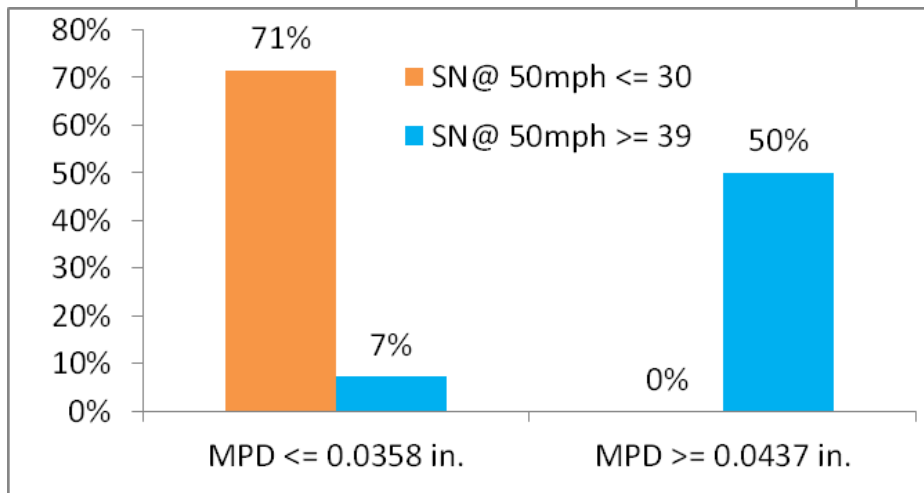
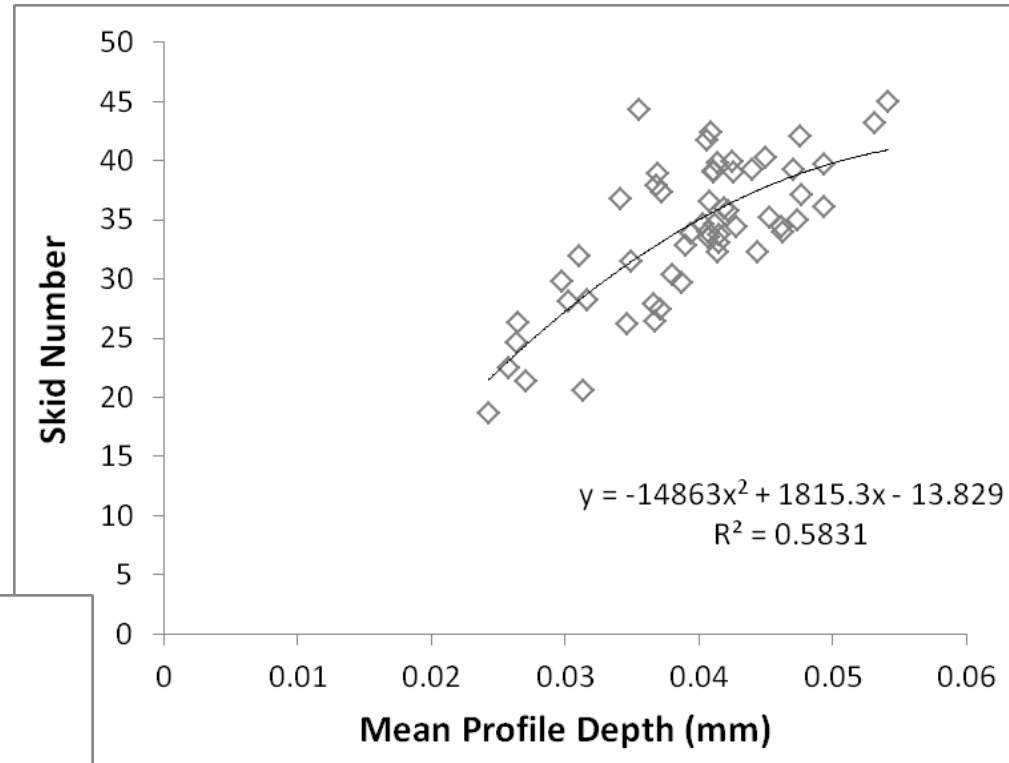
- Louisiana All Districts



Large Number of Pavements
 =
 Wide Range of Micro-Texture

MPD vs. SN: Higher Speeds

- Section Length
 - Longer than 5 miles
- Friction testing speeds
 - Higher than 50 mph



Insights from the Pilot Study

- Need Consistent Micro-Texture
 - Aggregate Source and Age
 - Mix Properties
 - Surface Treatments
- Texture Depth Impacts Friction at Higher Speeds
- Need to Investigate Change Rate
- Texture Depth Can Guide Friction Testing Locations

Directions From Here

- Continue Collection of Friction and Texture Data

- Further Research Efforts
 - Isolate the Effect of Micro-Texture
 - One Aggregate Source
 - Same Surface Age (level of abrasion)
 - Identify another Macro-Texture Metric
 - Full Lane Width Texture?
 - Determine Micro-Texture Component
 - Lab Imaging Techniques
 - Lab SEM

Macro-Texture versus Skid Resistance?

Nima Kargah-Ostadi

nkargah-ostadi@fugro.com

www.fugroroadware.com

