**Objectives:**
Can You Measure Rail “Friction” using “Simple”, Optical Fiber Doppler Sensors? Yes...or No?

- **NO...**
  - If you mean Measurement of Absolute, Universal or Instantaneous “Friction” or “Traction”.
  - Answer applies to all sensors and technologies.
- **YES!**
  - If you Define “Friction” reasonably for Different “Scales”.
  - If you Seek a “Functional” Index or “Effective Friction” for a Specific Task. (e.g., Push Tribometer, Force L/V Site, etc.)
  - If you assess the measured “Index” or “Friction” parameter over enough distance, time or measurements.

Extended Analyses of '07 TCTI On-Board Data
- Prevailing complication in prior Analyses ('08-'08) is the Vibration Noise Obscuring the Dynamic Data
- Nature of Ladar Data Formats Require Agile, Filter Functions compatible with Excel. Not available till Spring '09
- Filtering allows separation of basic Traction signature from ancillary Noise, Acceleration & Vibrations

**RESULT 1:** Correlation of Push Tribometer Friction Measurements with On-Board Experimental Results: Slip Speed
- Correlation NOT obtained with Slip Speed unless Friction is Saturated, i.e. out of the Friction Demand Region.
- Correlation NOT obtained with Creepage* except on the basis of Fixed Track Speed

**RESULT 2:** Lidar Detection of TOR Modifier – Grease (6-12 Feet of Track Lube)
- YES the on-board Ladar can Detect TOR Modifiers
- Robust Detection of TOR Modifiers:
  - Depends on Sufficient Track Distance
  - Magnitude of Change in Traction

**RESULT 3:** Curves & Special Calibrations
- Averaging Left and Right Wheel Signals allows Tractive Performance Assessments in Curves
- Systems may be Configured and Calibrated for Special Train Configurations e.g., Geometry Cars!

**WHY?? - Rail Friction Modeling: Polynomial Chaos Analyses Results for just Two uncertainties**

**Review:** Slip – Friction On-Board Instrumentation Operational Support Courtesy TTCI, Year 3, 2007
- TTCI FAST Loop tests 10/15/07 – 10/18/07, Pueblo, Colorado
- System Deployed in NS3000 Cab
- Optics on-board on TTCI Locomotive NS3000, 40.54” wheel Binder Plate
- Idle Wheel tests NS3000 pulled by BNSF Locomotive
- Optical Locations subject to Displacement and Fixture Pointing Errors
- Steady State Conditions in Test Section(s) function of Human Throttle Factor

**Rail Friction Modeling: Polynomial Chaos**

- Real Friction Measurements with Onboard System Deployed in NS3000 Cab
- Progressive Lube Exposure

- Coefficient of Slip vs Lube Condition

- Rail/Ground Reference Wheel Beam Locomotive Slip Optics, Right Side, Outside Rail

- lattice of correlation
- wheels at speeds: 50 75 100 120 mph

- data adjusted to “match” at point of inflection

- correlation matrix
- no correlation

- correlation between wheel slip, rail/ground velocity, wheel speed

- correlation between wheel slip, rail/low speed, tangent track

- Creepage = Coefficient of Slip # Speed

**Simple Optical Fiber Doppler Sensors for Measurements of Rail Friction**

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