AN APPROACH TO DEVELOPING A REFERENCE PROFILER

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RPUG Meeting
October 28, 2008

Overview

Vehicle Terrain Performance Lab Research Mission

Improve vehicle performance by studying interactions between vehicles and terrain

Supported by: FHWA Project
"Improving the Quality of Pavement Profiler Measurement"

U.S. Department of Transportation
Federal Highway Administration

Overview

Vehicles

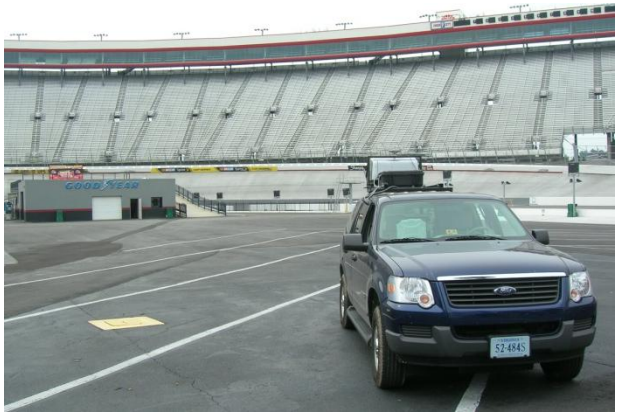
- Passenger cars, commercial off-road, military vehicles, motorcycles
- Chassis components (e.g., tires, suspension)

Terrain

- **Pavement Health Monitoring (Today)**
- Vehicular Simulation- racetracks, proving grounds

Performance

- Ride
- Handling
- Mobility
- Durability

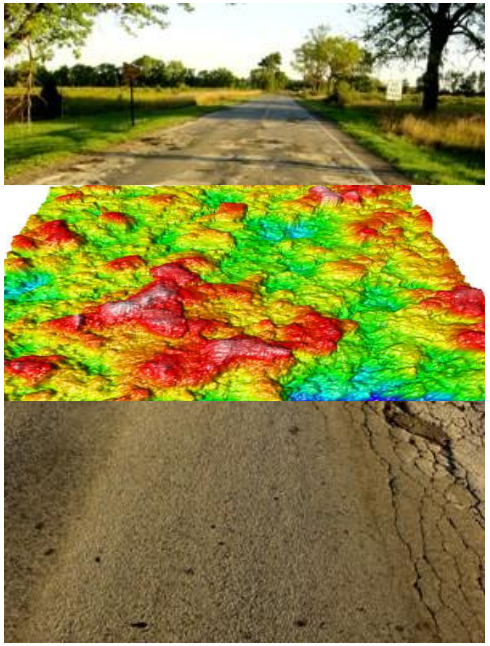


Project Motivation

Establish uniform method for profiler certification

Objectives

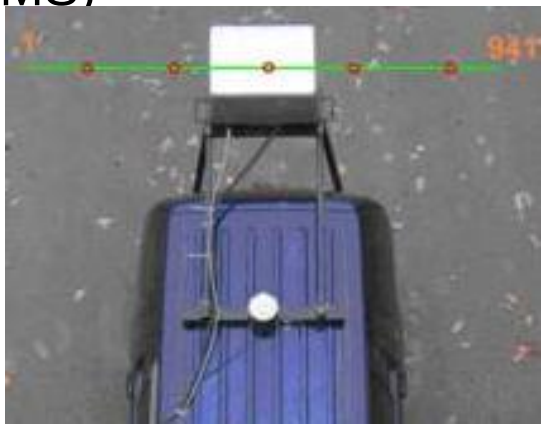
- Resolution (record wavebands of interest)
- Repeatability
- Accuracy
  - Profile
  - Longitudinal Distance



Reference Profiler Status

Developed and Verified

- Vehicle Terrain Measurement System (VTMS)
- Capabilities
  - 1 mm precision for short (sub km) distances
  - 10 mm precision for longer (km +) distances



Currently Developing Two System Improvements

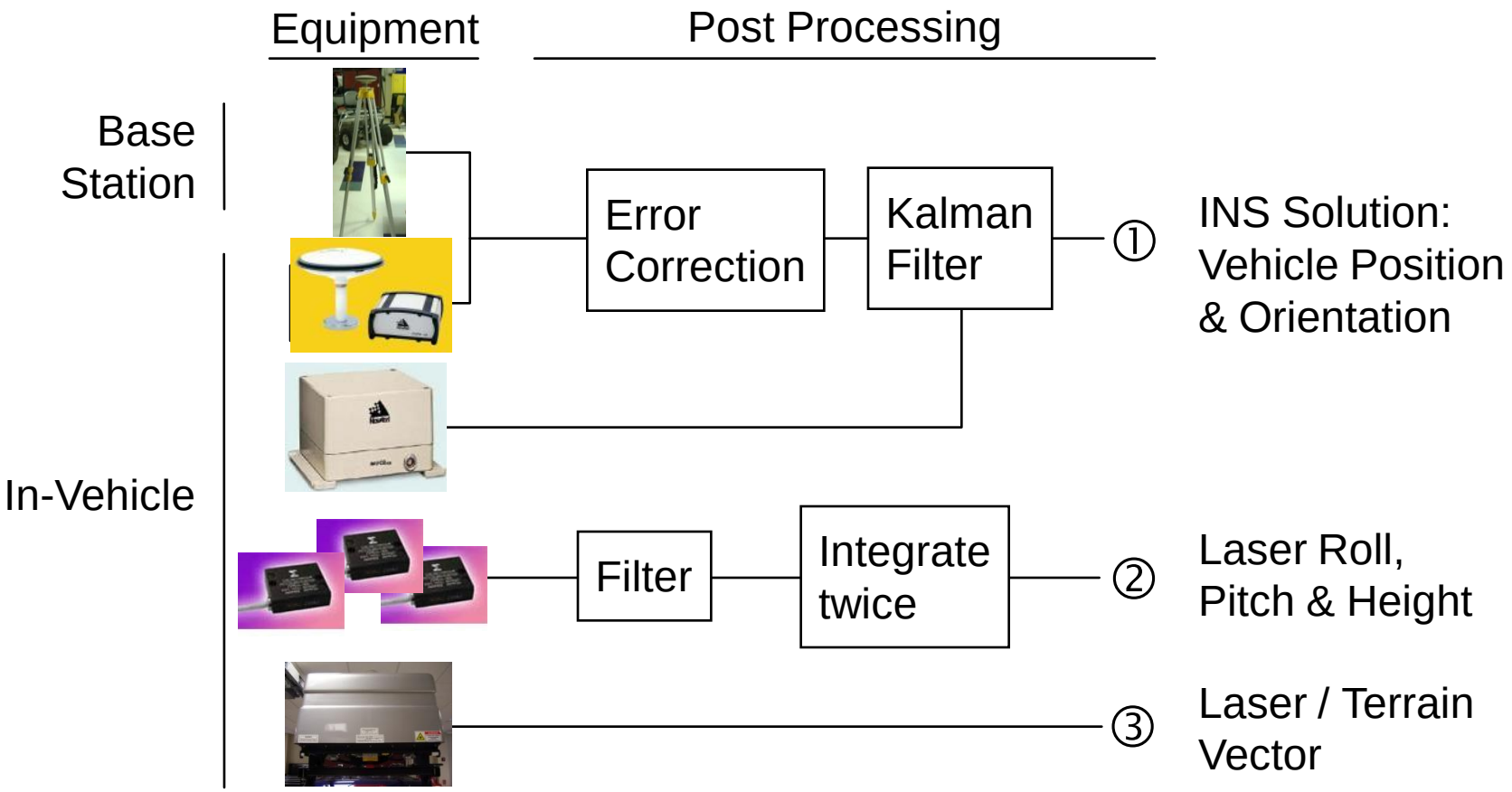
- Tire Bridging/Envelopment Algorithms
  - To be submitted to the *International Journal of Vehicle Modeling and Testing*
- Absolute System Calibration Techniques (Today's Focus)
  - To be submitted to the *Journal of Testing and Evaluation*

Developed and Verified

Vehicle Terrain Measurement System

- Scanning Laser
  - Provides relative height measurement
- Inertial Navigation System
  - Establishes global coordinate system
  - Attenuates low frequency body motion (<10 Hz)
- Accelerometers
  - Attenuate high frequency body motion (>10 Hz)

Developed and Verified



All Data Combined in Post-Processing

So now that we have a high-fidelity 3D terrain profiler, how can it be effectively used for Pavement Health Monitoring?

3D Terrain Profiles

Problems

- Produces copious amounts of data
- Undefined performance metrics for 3D

Benefits

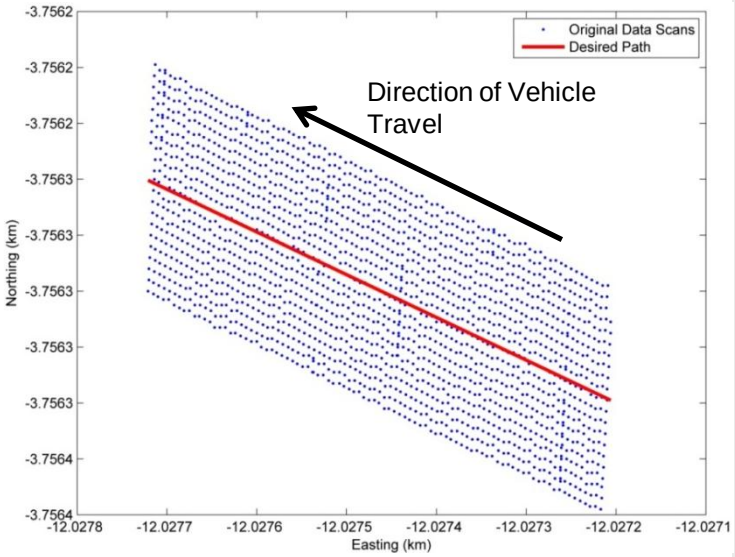
- Knowledge of entire contact patch
- Localized disturbance recognition
- High Fidelity

Collapsing 3D Terrain Data

Problem: How to generate 2D profiles using benefits of 3D Data?

Solution: Intelligently collapse 3D data to 2D profiles

- User defines path of travel
- Consult elevation information from neighboring points
- Choose statistical reduction method



Absolute System Calibration

What issues affect Overall System Performance?

- Relative reference-ground distance measurement
  - Evaluate laser measurement system
- Body motion mitigation procedure
  - Sprung-mass motion and laser motion convoluted
  - Common Mode Rejection

Laser measurement system

Inertial Navigation System

Absolute System Calibration

What can be done to evaluate how these issues are addressed?

- Evaluate laser measurement system
  - Sharp edged (high bandwidth) event
  - Changing reflectivity
- Sprung-mass motion and laser motion convoluted
  - Accuracy of inertial navigation system
  - Accuracy of accelerometers

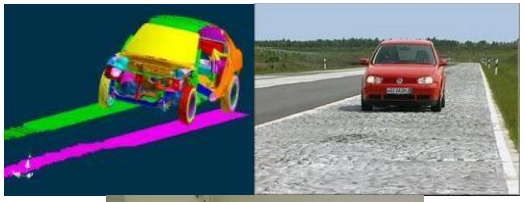
Solution: Excitation Event and Calibration Surface

- Excite vehicle to primary-ride and wheel-hop frequencies
- Evaluate performance on machined surface

Absolute System Calibration

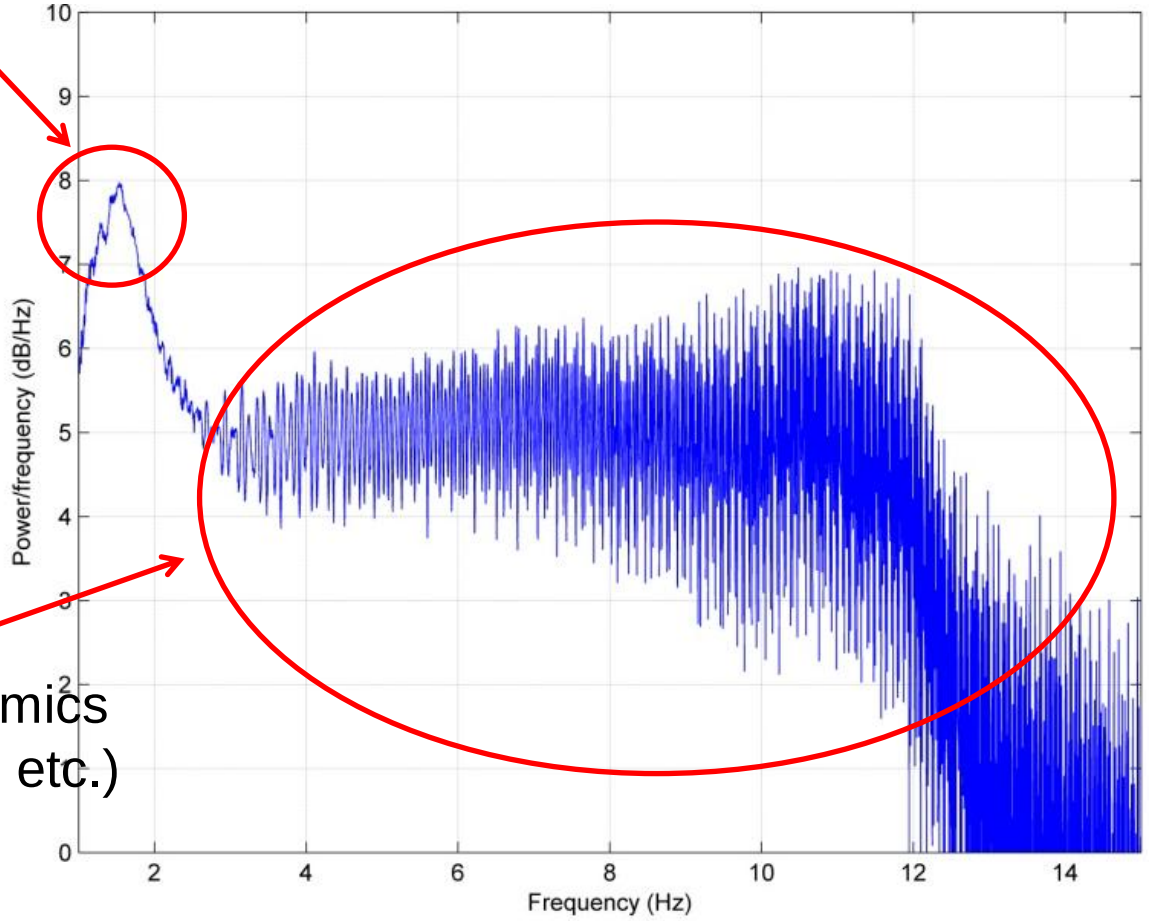
Excitation to Resonant Frequencies

- Excite vehicle at resonant frequencies with shaker rig (8 post for the NASCAR fans out there)
- Plot PSD of velocity
- Use PSD to find primary ride and wheel-hop frequencies



Absolute System Calibration

Primary Ride Frequency (1.5 Hz)

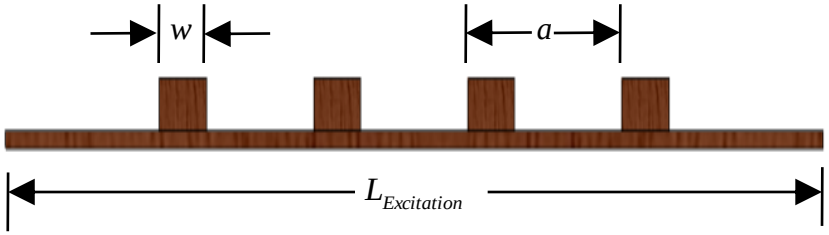


Nonlinear dynamics
(from dampers, etc.)

Absolute System Calibration

Excitation Event Design

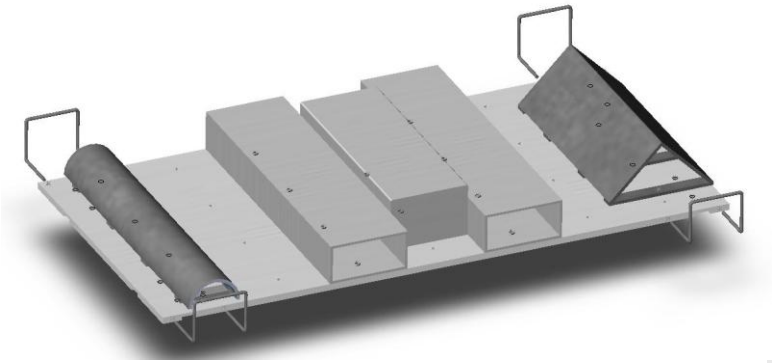
- Geometry driven by resonant frequencies
- Inexpensive and light



Submitted to the SPIE

Calibration Surface

- Machined for High Accuracy
- Sharp Edged transitions for laser verification
- Easily Transported
- Interchangeable Cleats



Conclusions

Vehicle Terrain Measurement System

- Produces high-fidelity 3D Terrain Measurements
  - Knowledge of entire contact patch
  - Mitigate the effects of localized disturbances

Absolute Calibration

- Excitation Event
  - Excite vehicle to resonant frequencies
- Calibration Surface
  - Machined for high accuracy
  - Absolute Reference