Relating Pavement Macrotexture Patterns to Tire-Pavement Interaction Noise Levels

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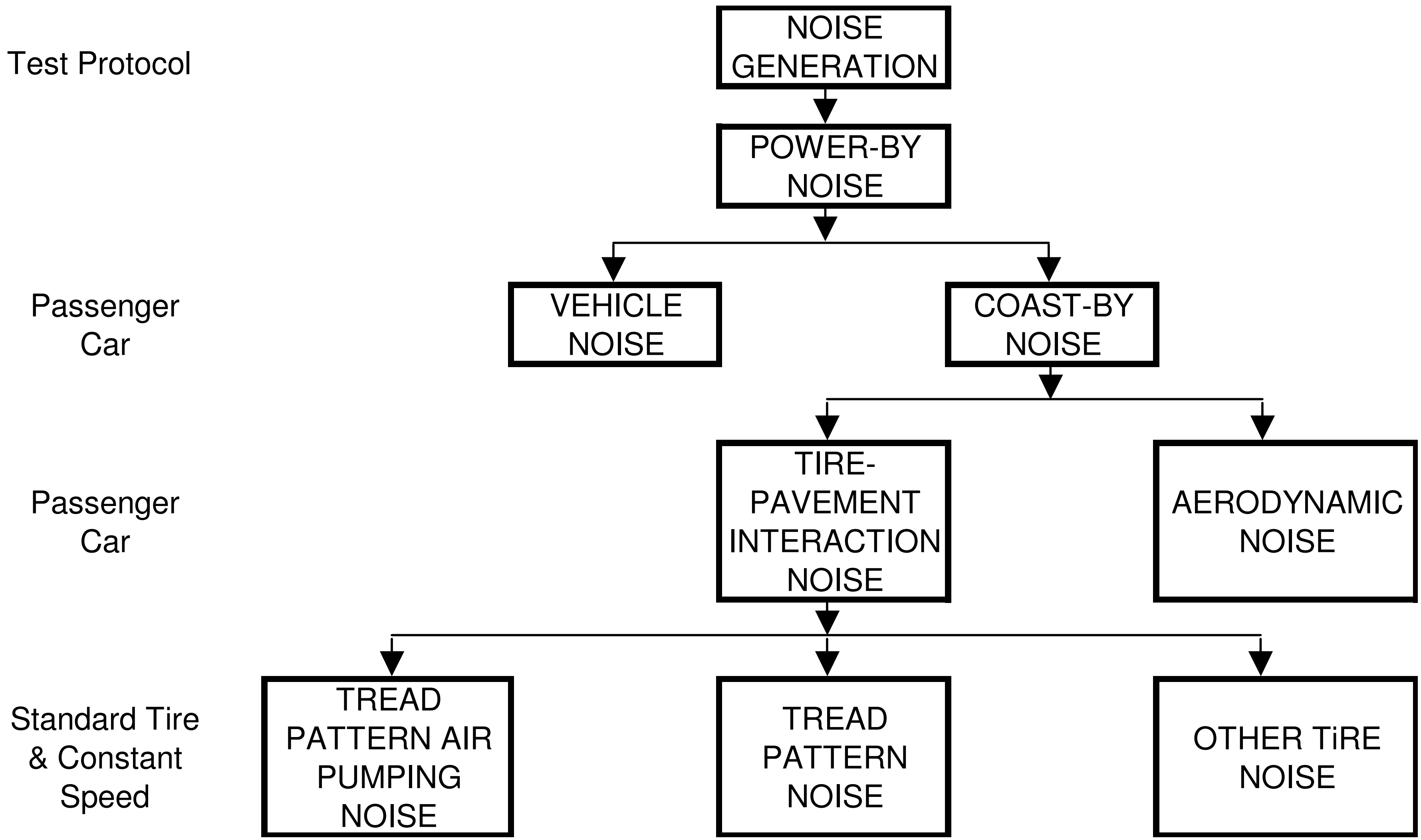
NOISE GENERATION FACTORS



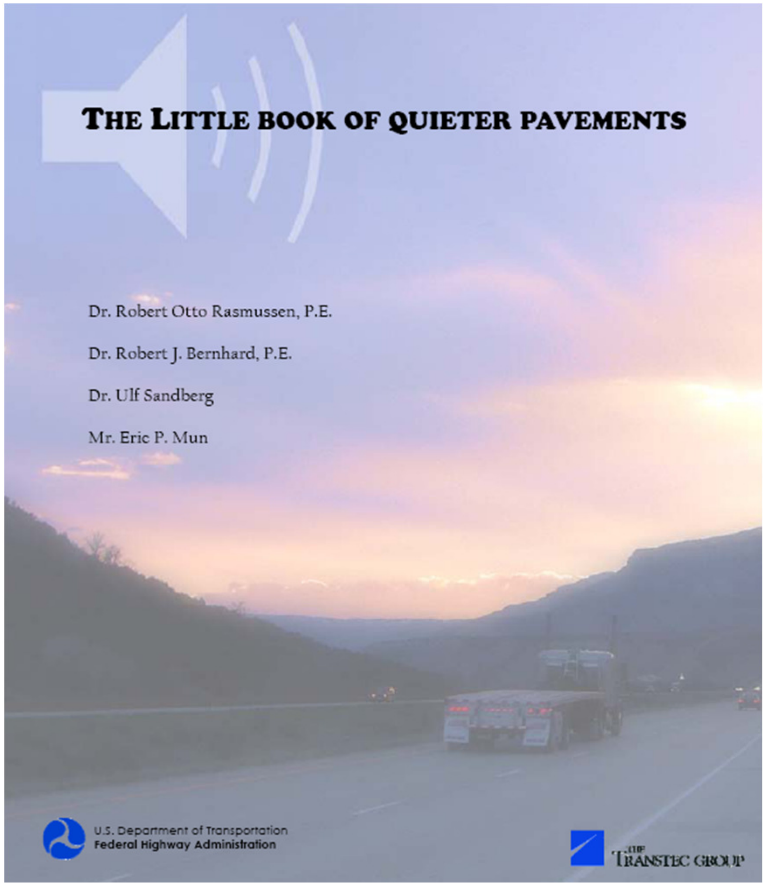
FHWA ***T***raffic ***N***oise ***M***odel

A scientifically founded and experimentally calibrated acoustic computation methodology:

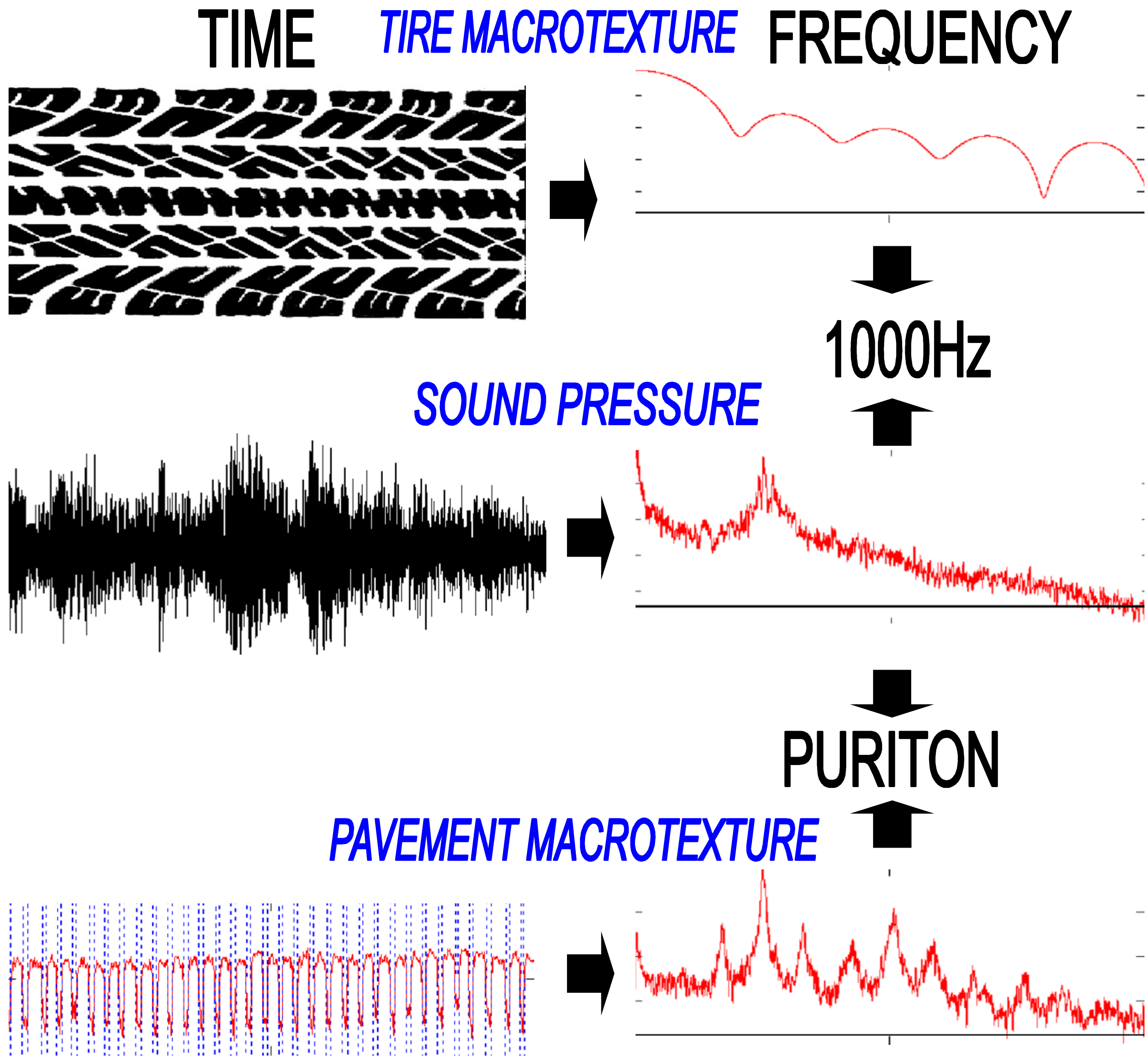
- Modeling of five standard vehicle types, including automobiles, medium trucks, heavy trucks, buses, and motorcycles, as well as user-defined vehicles.
- Modeling of both constant-flow and interrupted-flow traffic using a 1994/1995 field-measured database.
- Modeling of the effects of different pavement types, as well as the effects of graded roadways.
- Sound level computations based on a one-third octave-band database and algorithms.
- Graphically interactive noise barrier design and optimization.
- Attenuation over/through rows of buildings and dense vegetation.
- Multiple diffraction analysis.
- Parallel barrier analysis.
- Contour analysis, including sound level contours, barrier insertion loss contours, and sound-level difference contours.

Tire-***P***avement ***I***nteraction ***N***oise

- TPIN has many components described qualitatively in the little book of quieter pavements.
- Previous research consider pavement- and tire- textures characteristics.
- Noise generation has many components: tread impact, air pumping, acoustical horn, stick slip, tire-structural vibrations and resonances.



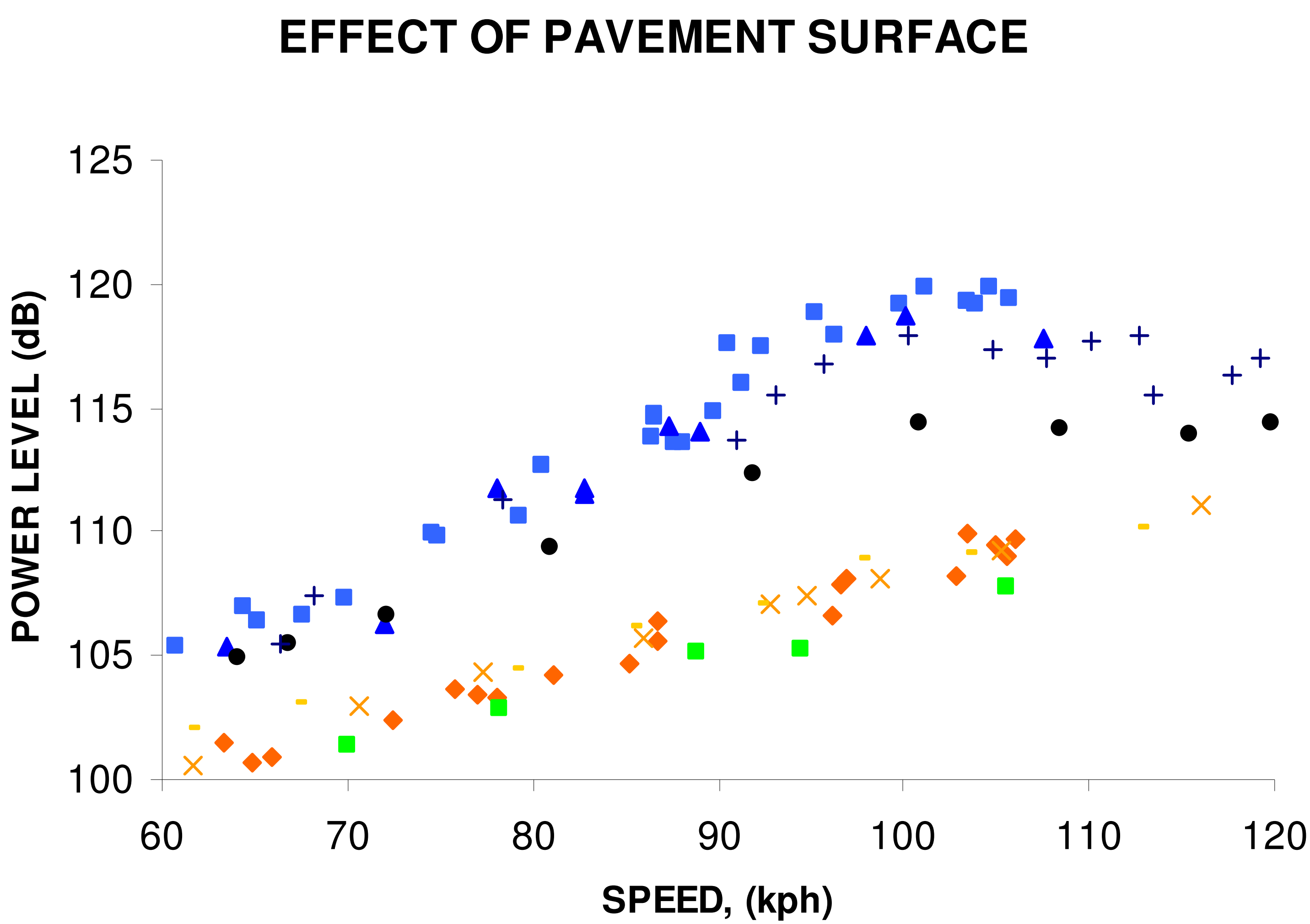
Tire-Pavement Noise Interaction



POROSITY

STRUCTURAL CHARACTERISTICS (STIFFNESS)

Tire-Pavement Interaction Noise



A. Objectives

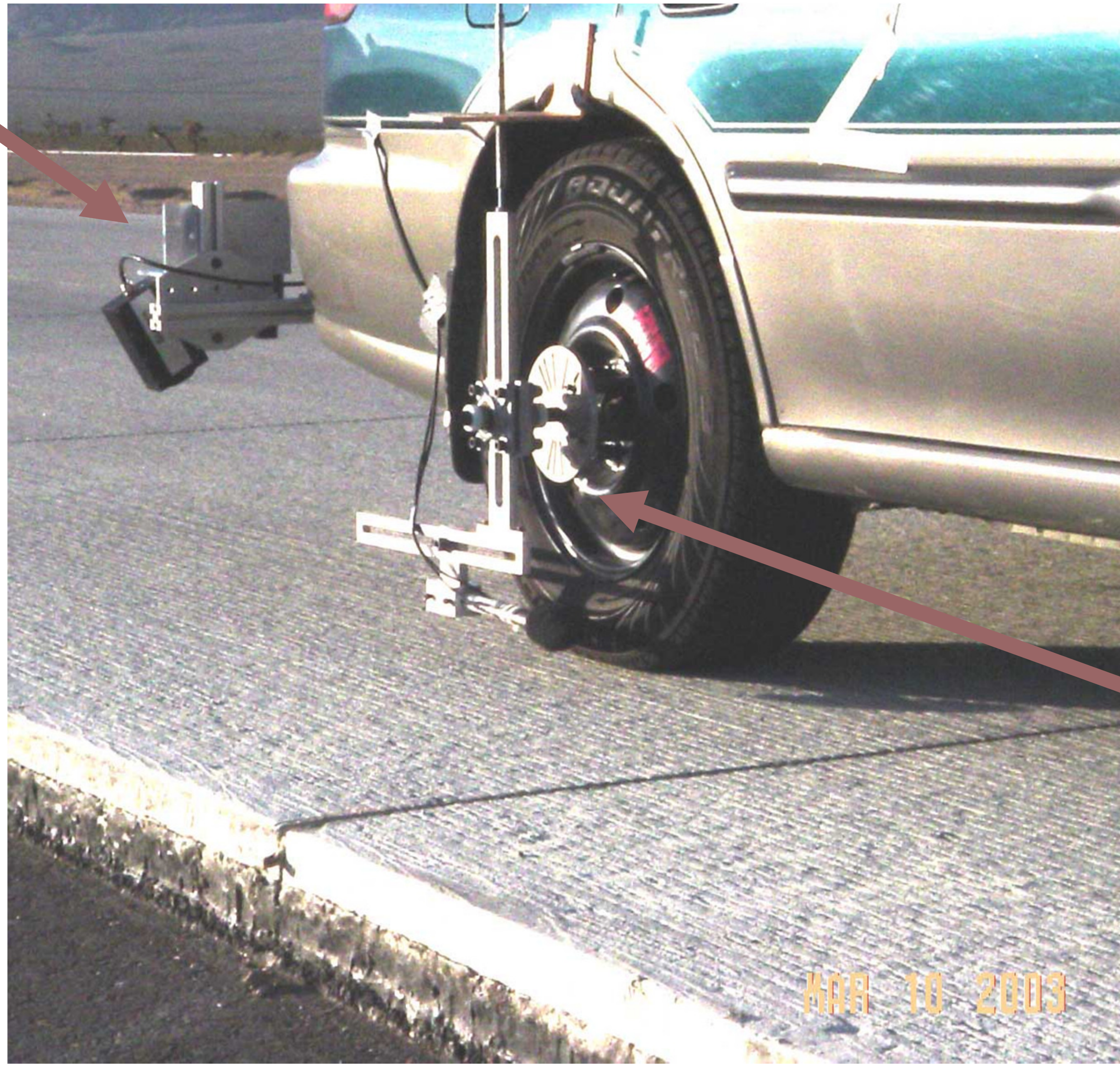
- Relate pavement surface macrotexture characteristics to tire-pavement interaction noise
- Use non-linear non-stationary signal decomposition to characterize pavement surface macrotexture (1-D and 2-D) and tire-pavement interaction noise
- Using synchronized measurements, perform correlation analysis for local variations
- Define adaptive non-linear non-stationary procedure as an alternative to third octave analysis used in OBSI method

B. Hypothesis

- Non-linear frequency modulations are lost in the third-octave analysis approach
- Transient variations in the spatial domain are lost in the third octave analysis approach
- Scalar differences between macrotexture and tire-pavement interaction noise (TPIN) are lost in the linear parameters mean-profile depth and third-octave sound intensity
- The frequency and power modulations of macrotexture and TPIN are directly related
- Continuous sound intensity can be estimated using continuous macrotexture

C. Synchronization:
CALTRANS Project 1998

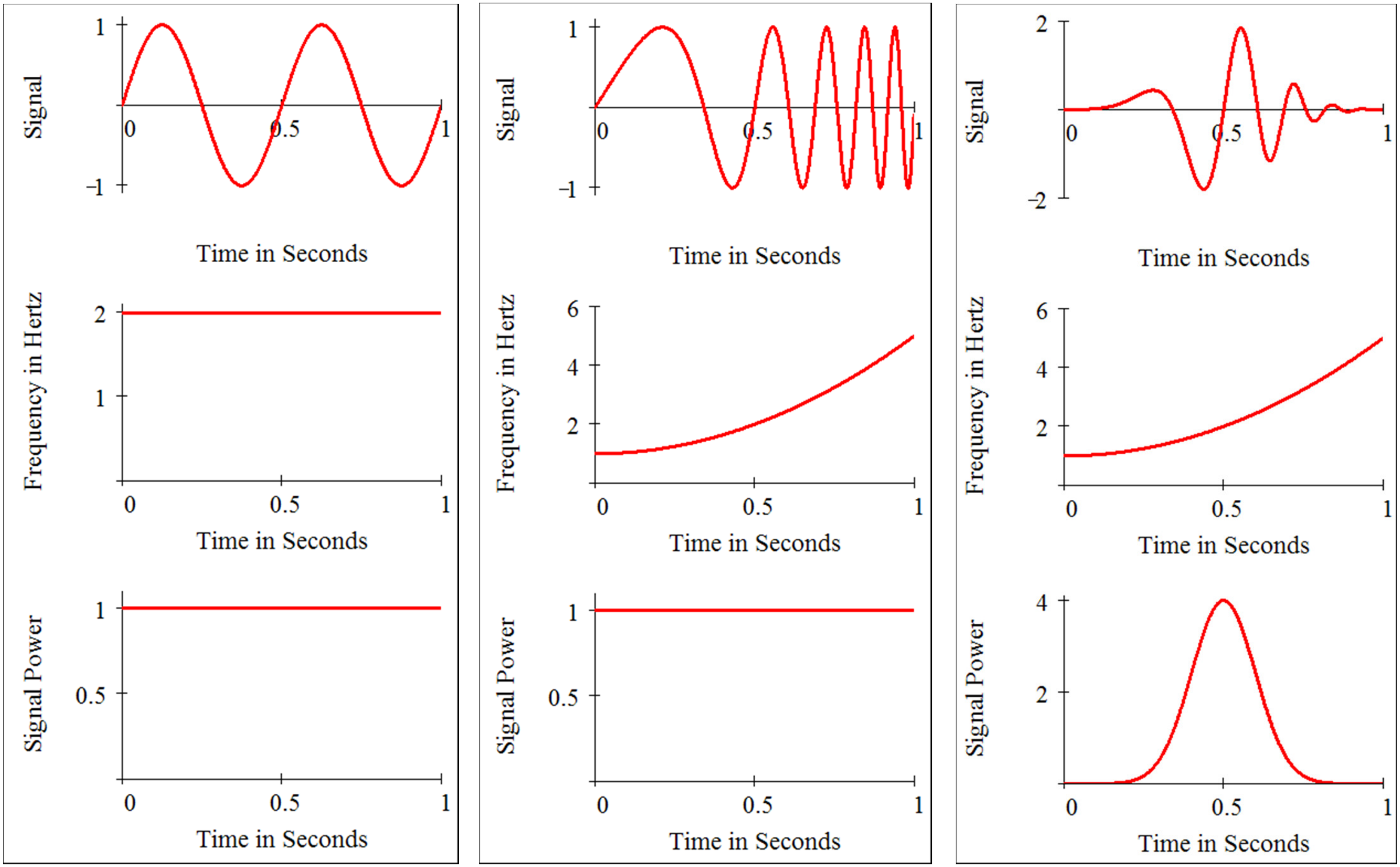
ROSAN



OBSI

D. Signal Processing

Linear/Stationary | Non-Linear/Stationary | Non-Linear/Non-Stationary

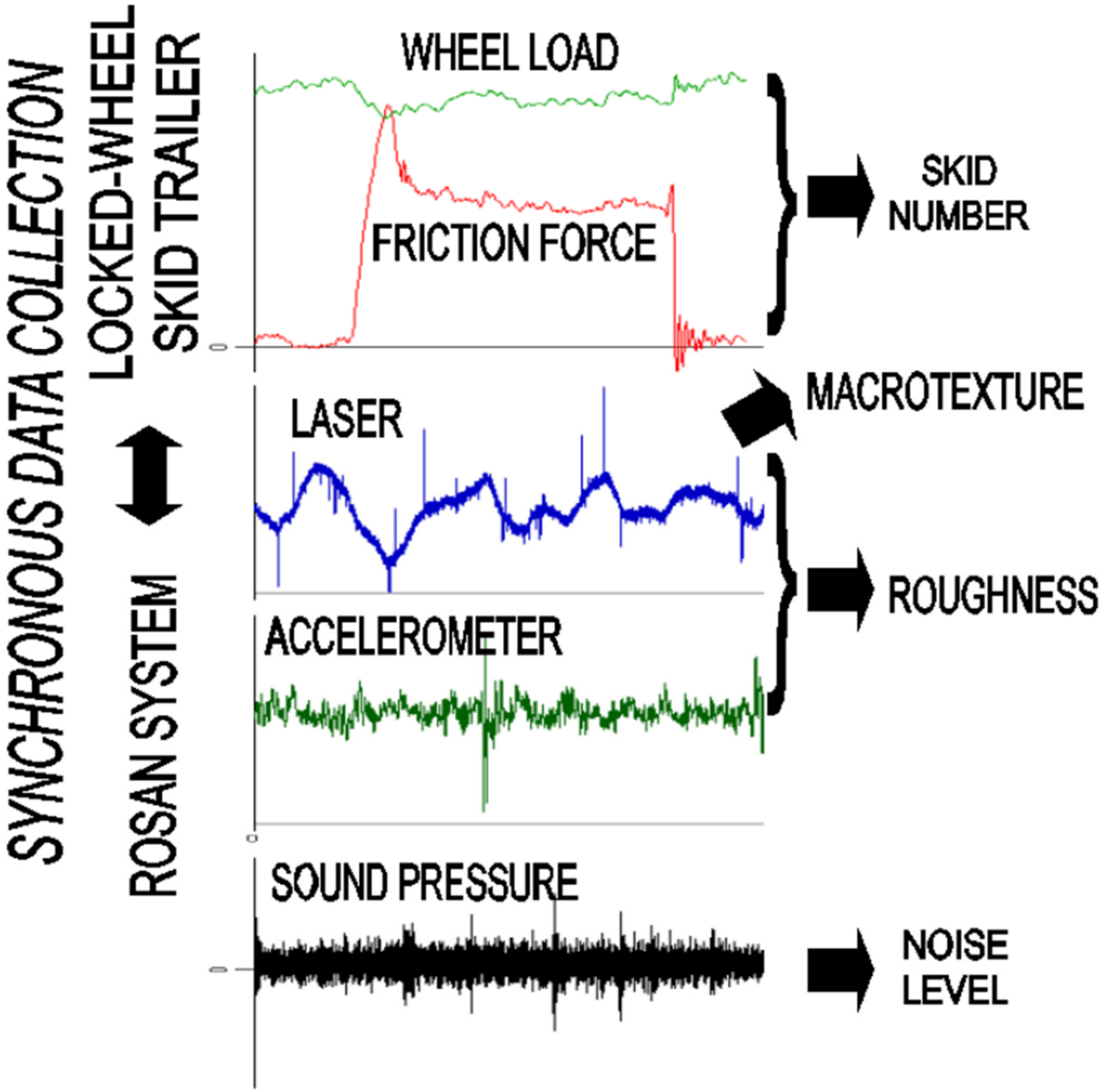


Fourier | Wavelet | EMD

E. Current status

- Literature Search Completed
- Data Reduction Approach Defined
- Performed Preliminary Field Experiment in Fall of 2009
- Defined Data Needs
- Identified Potential Sub-Contractors for Limited Data Collection with Control Protocol
- Requested/Received Cost Estimates – Evaluation Currently in-progress

F. Data



SYNCHRONOUS DATA COLLECTION
LOCKED-WHEEL SKID TRAILER
ROSAN SYSTEM
WHEEL LOAD
FRICTION FORCE
SKID NUMBER
MACROTEXTURE
LASER
ACCELEROMETER
ROUGHNESS
SOUND PRESSURE
NOISE LEVEL

ROSAN
DMI DATA

At one speed ONLY: 60 mph

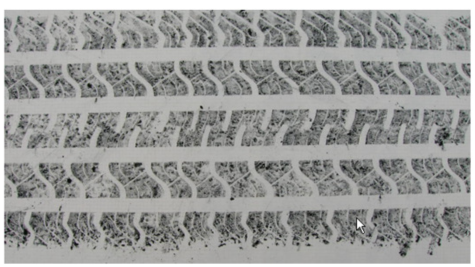
Rear

Vehicle with OBSI and ROSAN systems.

Front

OBSI System

3 1
4 2

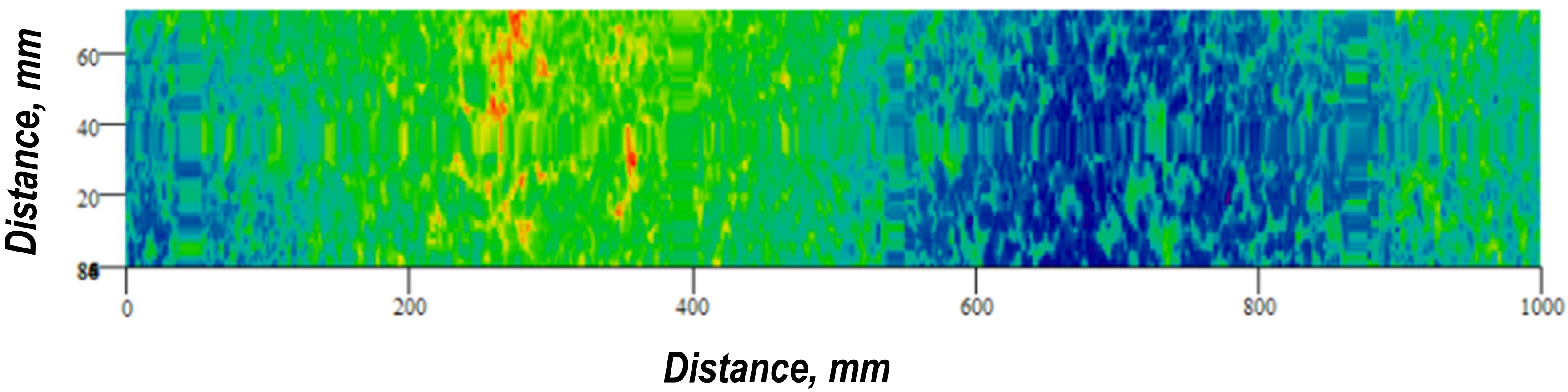


SRTT Tire Print

OBSI –SRTT
MICROPHONE DATA

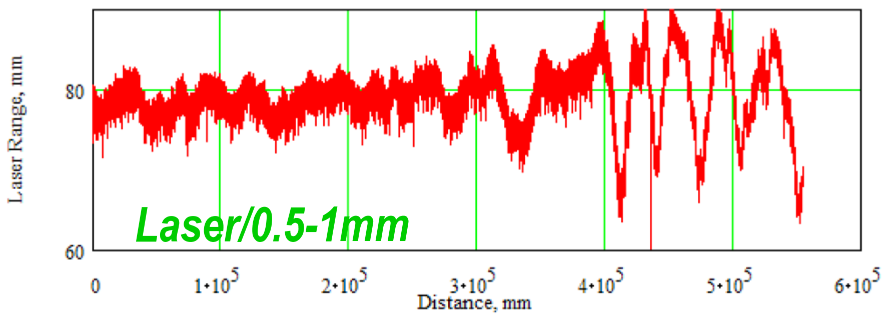
ROSAN
LASER DATA

At 12 mph



ULIP
ROLINE LASER DATA

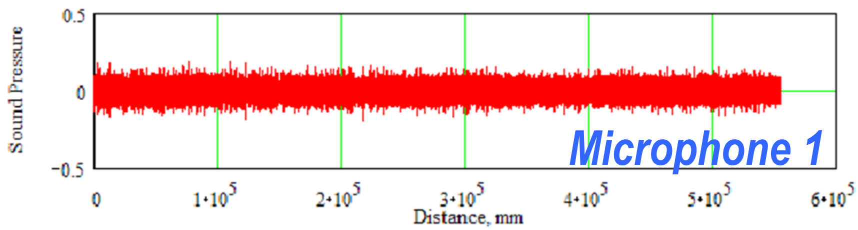
ROSAN
LASER DATA

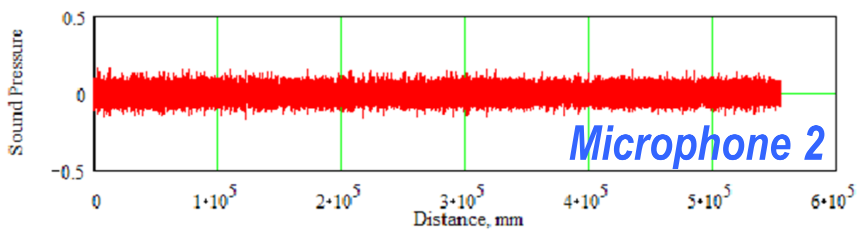


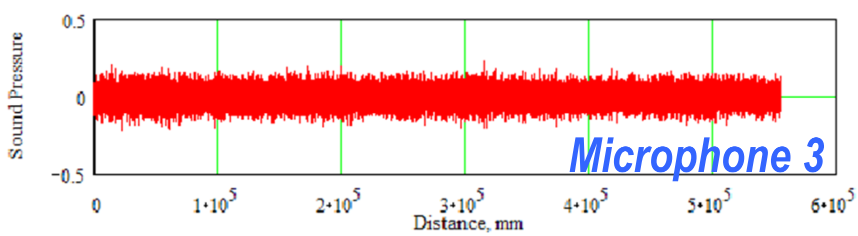
LASER
- Wavelength-Distance Maps
- Intrinsic Mode Functions

60 mph

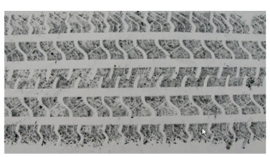
OBSI –SRTT
MICROPHONE DATA

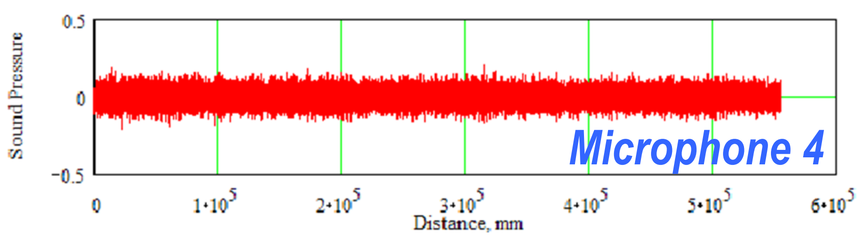






SRTT Tire Print

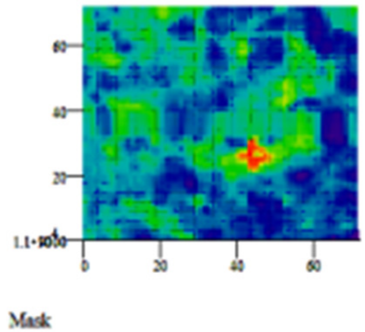




MICROPHONE
- Wavelength-Distance Maps
- Intrinsic Mode Functions

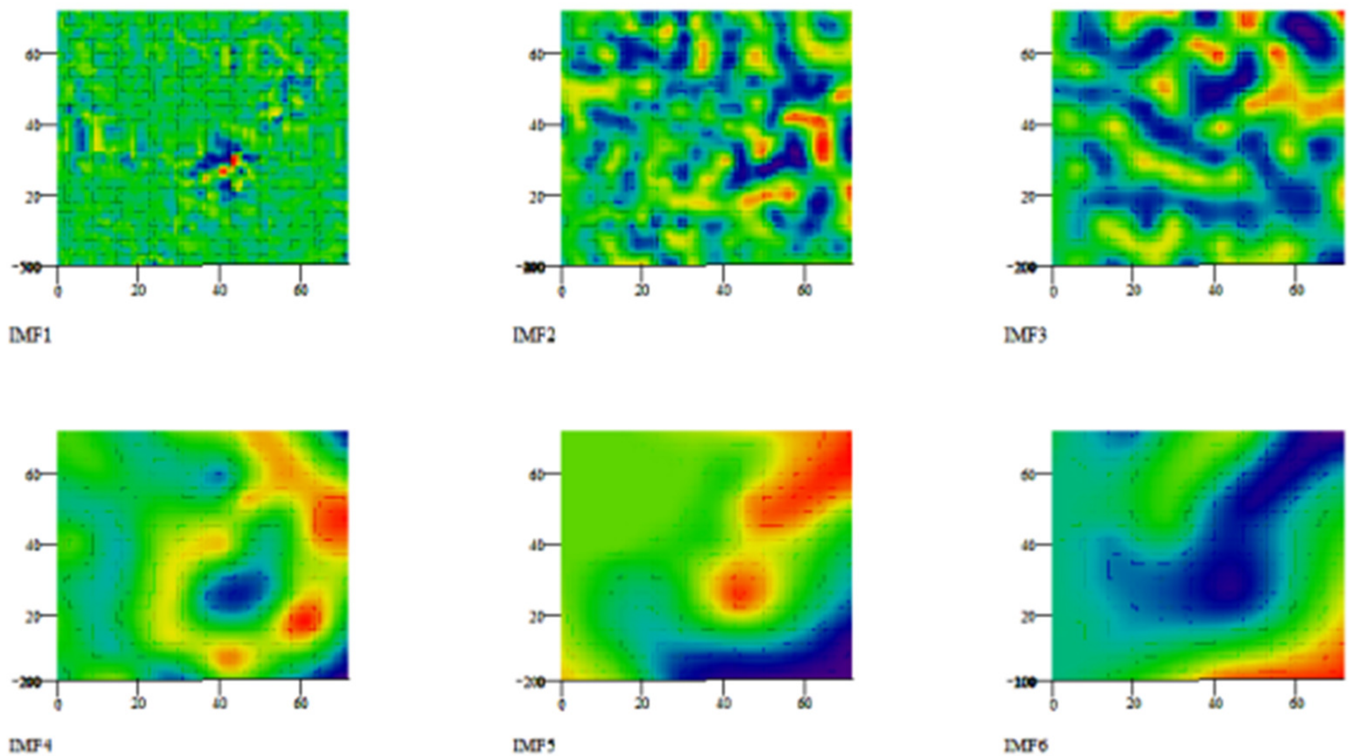
TIRE-PRINT
- Wavelength-Distance Maps
- Intrinsic Mode Functions

ULIP ROLINE LASER DATA



ROLINE LASER
- Wavelength-Distance Maps
- Intrinsic Mode Functions

ULIP ROLINE LASER INTRINSIC MODE FUNCTIONS



LASER
- *Wavelength-Distance Maps*
- *Intrinsic Mode Functions*

MICROPHONE
- *Wavelength-Distance Maps*
- *Intrinsic Mode Functions*

TIRE-PRINT
- *Wavelength-Distance Maps*
- *Intrinsic Mode Functions*

ROLINE LASER
- *Wavelength-Distance Maps*
- *Intrinsic Mode Functions*

DATA ANALYSIS
- *Cross-Correlation of Intrinsic Mode Functions*
- *Cross-Spectrum of Wavelength-Distance Maps*

TEXTURE – NOISE MODEL
Based on Wavelength Patterns

G. Final Thought

- TPIN – Noise Components are complex non-linear, non-stationary waves
- 1-D and 2-D SURFACE Macrotexture are the primary geometric aspect. Microtexture, Megatexture, Porosity, and Structural Response are secondary.
- Proposed model looks at ACCURATE LOCAL patterns in both pavement surface macrotexture and Noise records at the sensor level, not the PROCESSED PARAMETER level, Sound intensity and mean texture depth.