2012 RPUG Conference

24th Annual Road Profile Users' Group Meeting

Tire-Pavement Noise

Presented by: John Wirth (TxDOT)

At RPUG Conference 9/25/2012

Tire / Pavement Noise

- Noise 101
- On Board Sound Intensity (OBSI) technology
- TxDOT's experience with OBSI measurement

Noise 101

Noise:

Any sound that is undesired or interferes with one's hearing of something

FHWA-IF-07
July 2007

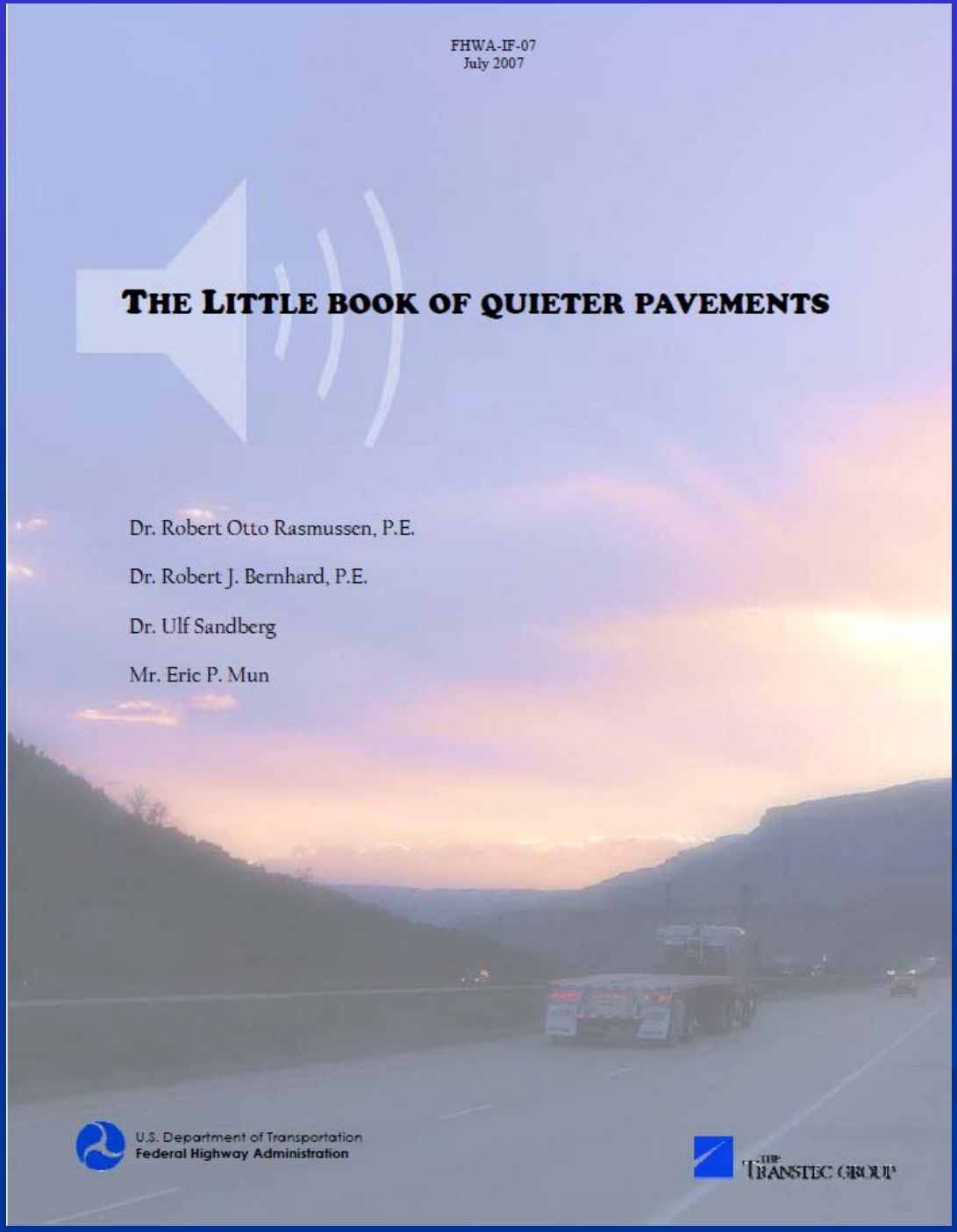
THE LITTLE BOOK OF QUIETER PAVEMENTS

Dr. Robert Otto Rasmussen, P.E.

Dr. Robert J. Bernhard, P.E.

Dr. Ulf Sandberg

Mr. Eric P. Mun



U.S. Department of Transportation
Federal Highway Administration

The Transtec Group

Noise Definitions

- **Noise** - Any sound believed to be objectionable.
- **Decibel (dB)** - A scientific measure of the volume of a sound
- **Traffic Noise** - Noise generated by a traffic stream.
- **Tire-Pavement Noise** - the sound generated by the interaction of the tire with the pavement surface as it traverses a specific length of pavement.

Sound intensity level:

Is a logarithmic measure of the sound intensity (measured in W/m^2), in comparison to a reference level.

The decibel is a ***ratio of two sound intensities***, *not* an *amount* of sound intensity. It is ***a relationship***…a ***comparison*** made between two sound intensities.

Combining dB levels of sounds with equal intensities

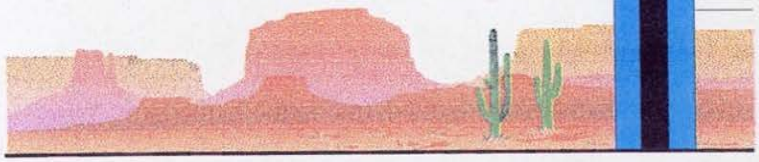
Adding two sounds of equal intensity (equal dB levels) will increase the overall dB level by 3dB.

e.g. 60dB + 60dB ≠ ~~120dB~~

60dB + 60dB = 63dB

Common Indoor and Outdoor Noise Levels

Common Outdoor Noises	Sound Level (dBA)	Common Indoor Noises
	140	Threshold of pain
	130	
	120	
Jet Flyover at 1000 feet	110	**Rock Band** at 15 feet
Gas Lawn Mower at 3 feet	100	
Diesel Truck at 50 feet	90	**Food Blender** at 3 feet
Urban Daytime	80	Garbage Disposal at 3 feet
Gas Lawn Mower at 100 feet	70	Vacuum Cleaner at 10 feet
Heavy Traffic at 300 feet	60	Normal speech at 3 feet
Typical Urban Daytime	50	Dishwasher next room
Urban Nighttime	40	Library
	30	Bedroom at night
Rural Nighttime	20	
	10	
	0	Threshold of hearing



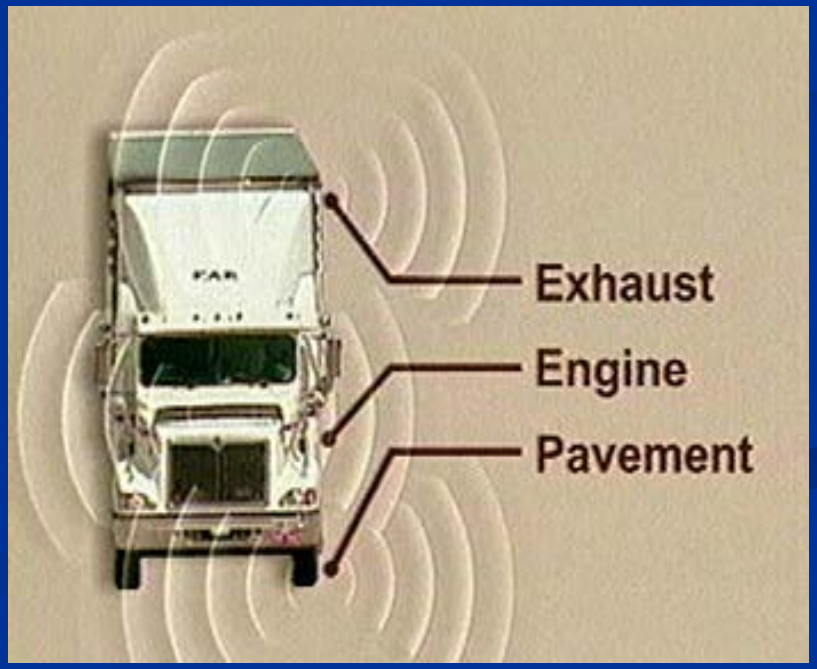
Note: ***Sound is preceived differently by every individual***

Sound Amplitude - Loudness

Change in Sound Level (Δ dB)	Change in Loudness
1 to 3 dB	Just perceptible change
5 dB	Noticeable change
10 dB	Twice or (1/2) as loud
20 dB	Four times or (1/4) as loud

True only for the same sound!

Noise Generation



Traffic Noise

- **Propulsion** – Noise includes sounds generated by the engine, exhaust, intake, and other power train components.
- **Aerodynamic** – Noise is caused by trubulence around a vehicle as it passes through the air.
- **Tire/Pavement** – Noise is that which is generated as the tire rolls along the pavement

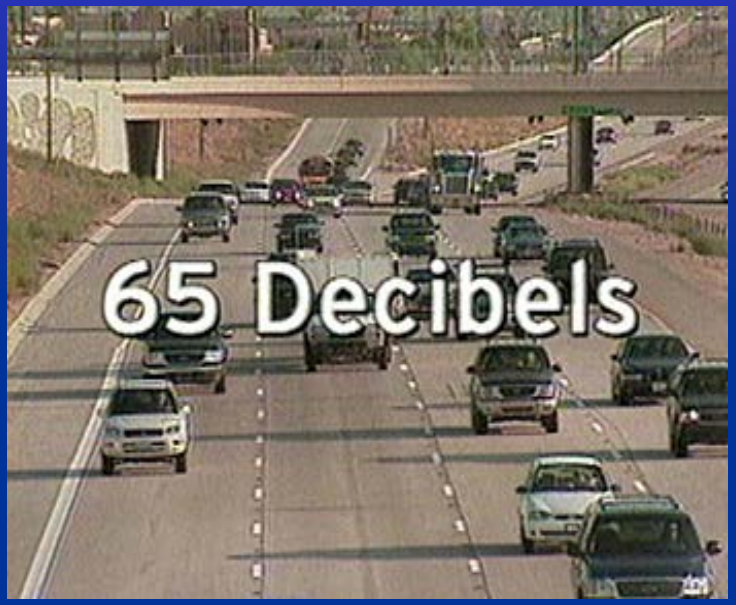
Other Contributing Factors

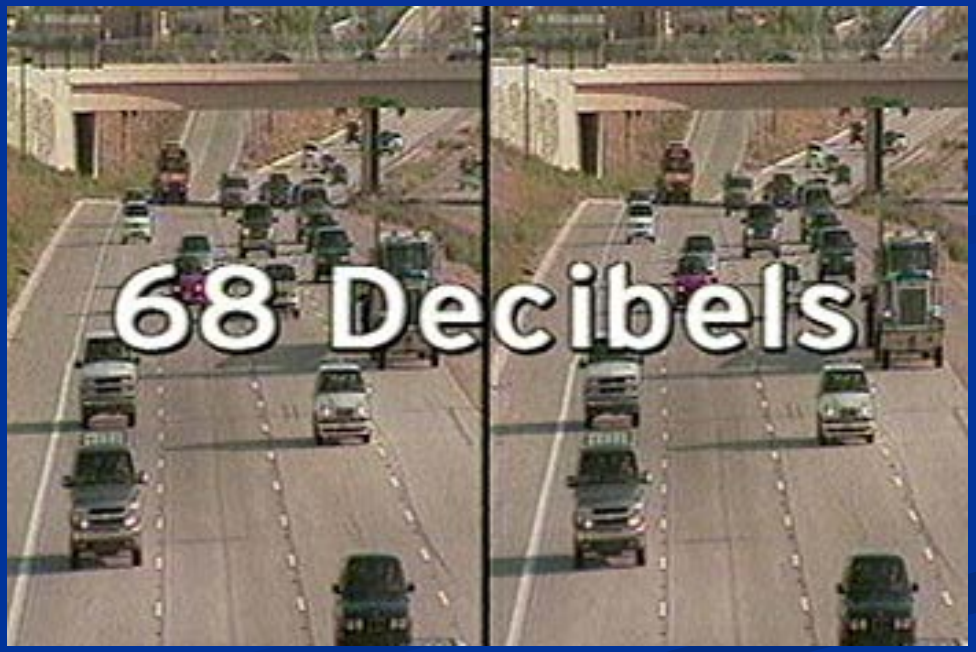
- Traffic Mix
- Speed/ braking/ acceleration
- Roadway features

Factors – Traffic Mix

- Cars are quieter than trucks.
- Height of the noise source is a factor.
- A small truck is about 6 dBA louder than a car.
- A large truck can be 11 dBA louder than a car.

Doubling Traffic adds 3dBA





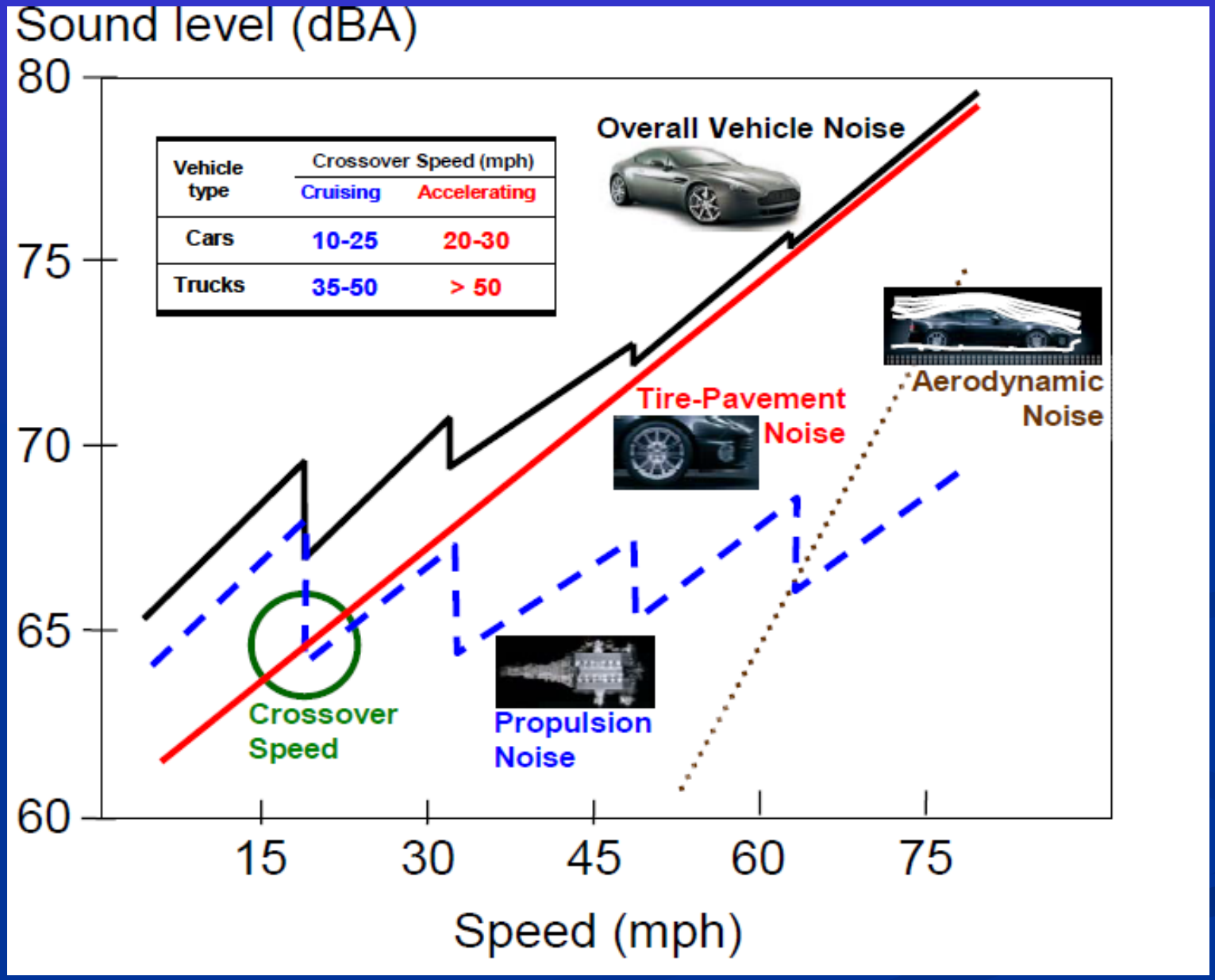
Double the traffic

Factors - Speed

- An increase of 10 mph will result in an increase in sound level of approximately 2 to 3 dBA.
- When Congress allowed states to raise the speed limit, highways got noisier.
  - A car at 65 mph is 3 dB louder than a car at 55 mph.

Factors - Acceleration

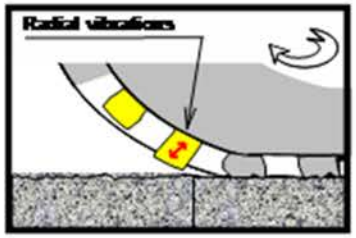
- Engine braking can add to overall traffic noise.
- Noise produced during acceleration can be as much as 5-10 dB greater than cruising speed.
- Steep inclines, ramps and other areas will increase engine power.

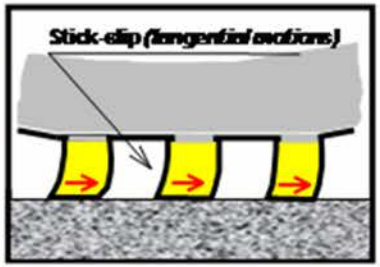

Sound level (dBA)
80
75
70
65
60
15
30
45
60
75
Speed (mph)
Vehicle type
Crossover Speed (mph)
Cruising
Accelerating
Cars
10-25
20-30
Trucks
35-50
> 50
Overall Vehicle Noise
Tire-Pavement Noise
Aerodynamic Noise
Propulsion Noise
Crossover Speed

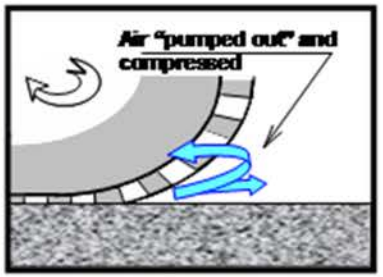
Noise -Tires

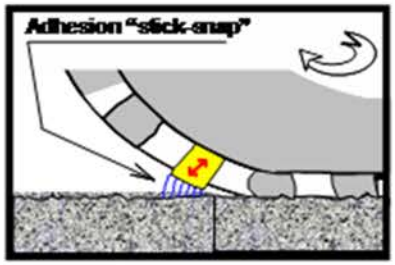
- Tire-Pavement noise and other surface characteristics, are dependent on the tire too
- Numerous properties of the tire will affect noise, safety, etc.
- With respect to noise, the tire industry does seek out quieter tires but for those inside the vehicle, not those on the side of the road.

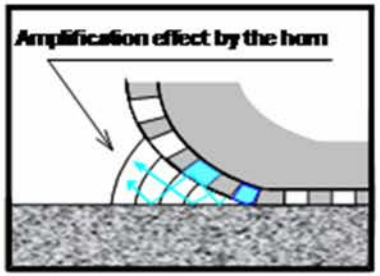
Tire-Pavement Noise

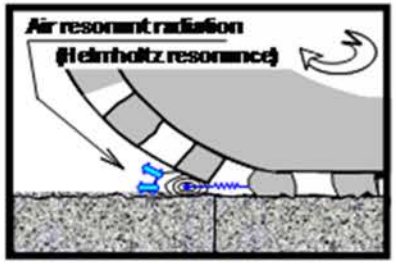


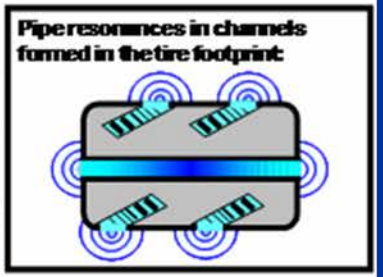


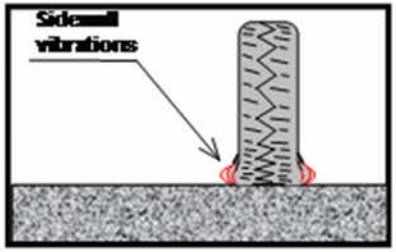


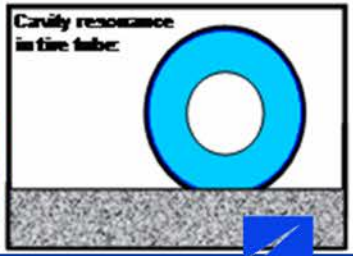












How can Noise Be Controlled

- At the Source
  - Vehicle & Tire Emissions
- Through Distance
  - 3 dBA Reduction for Each Doubling of Distance
  - 25ft=70dBA, 50ft=67dBA, 100 ft=64
- Through Obstructions
  - Berms, Walls, And Combination of both

Quieter Pavements

Bad

Good

THE TRANSTEC GROUP

Sound Measurement Types

On Board Sound Intensity (OBSI) technology

What is OBSI?

On-Board Sound Intensity

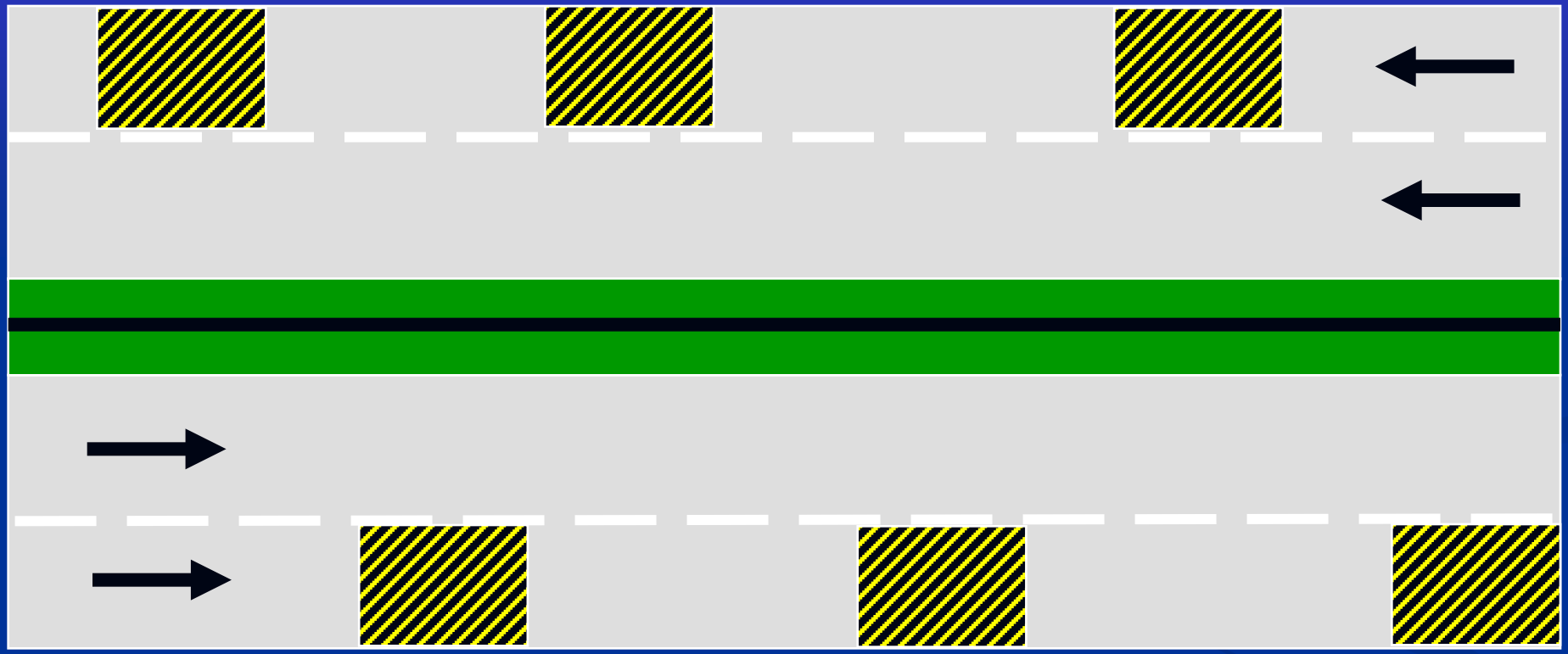
Standard Method of Test for OBSI:

AASHTO Designation: TP 76-10

Measurement of Tire/Pavement Noise Using the On-Board Sound Intensity (OBSI) Method

Newest Version in Process: TP 76-13

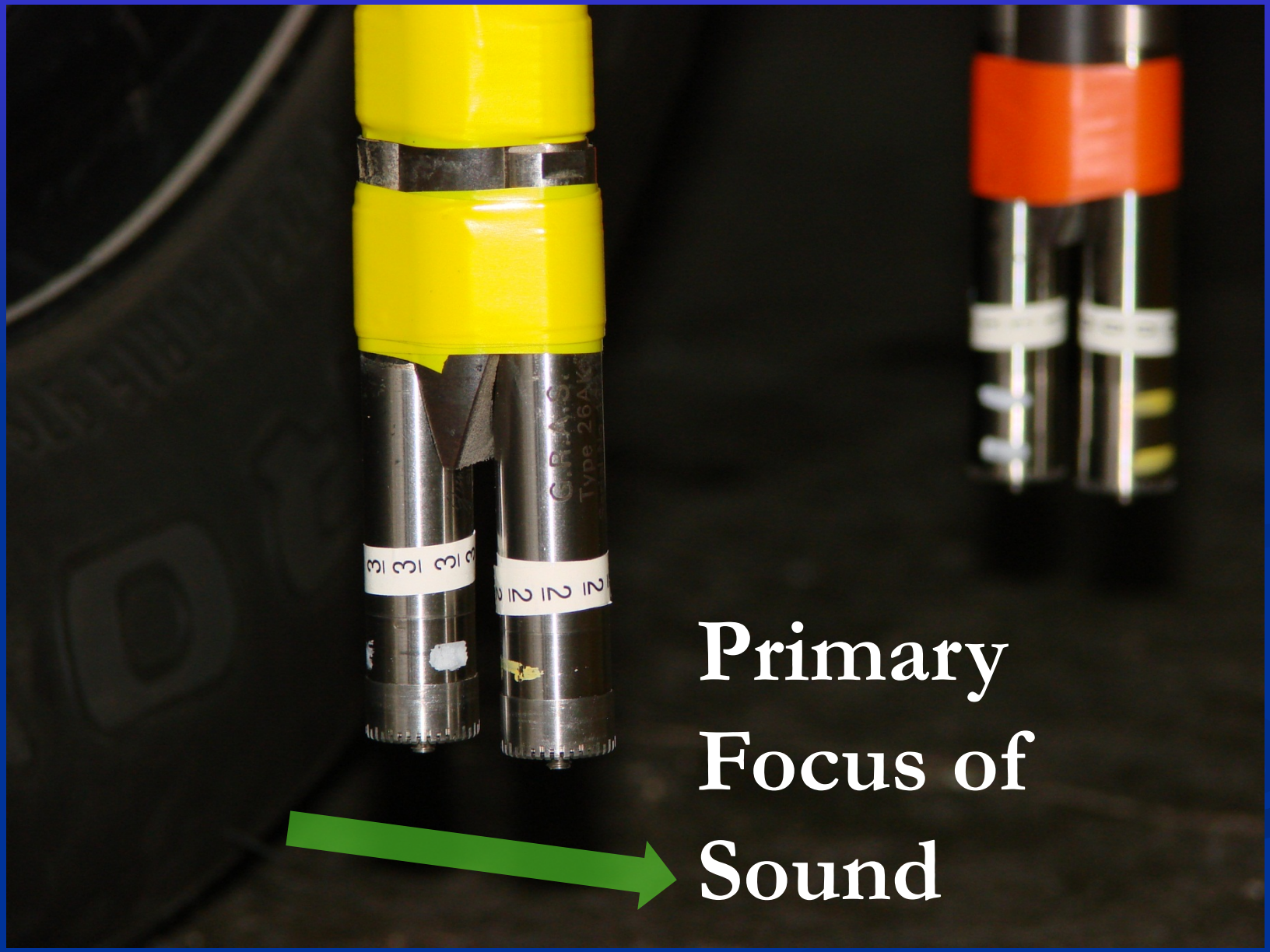
One Noise Test Section with 6 OBSI Test Sites



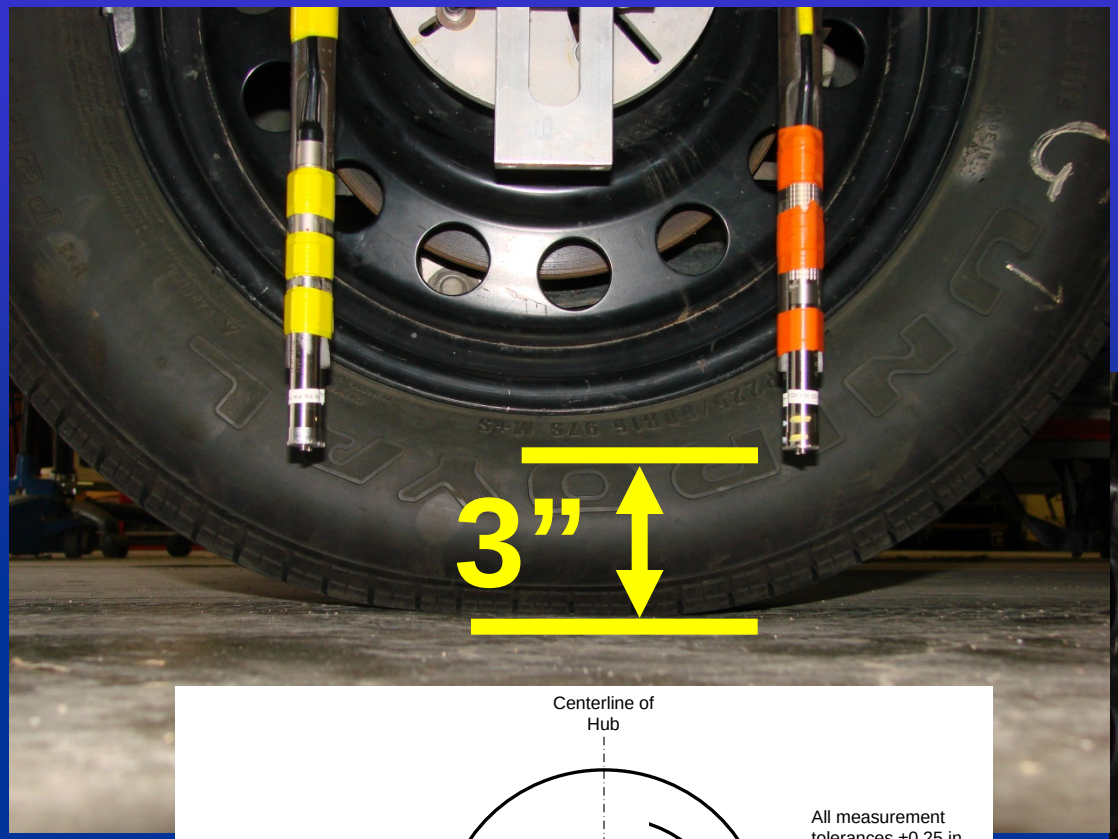
OBSI Site 440’

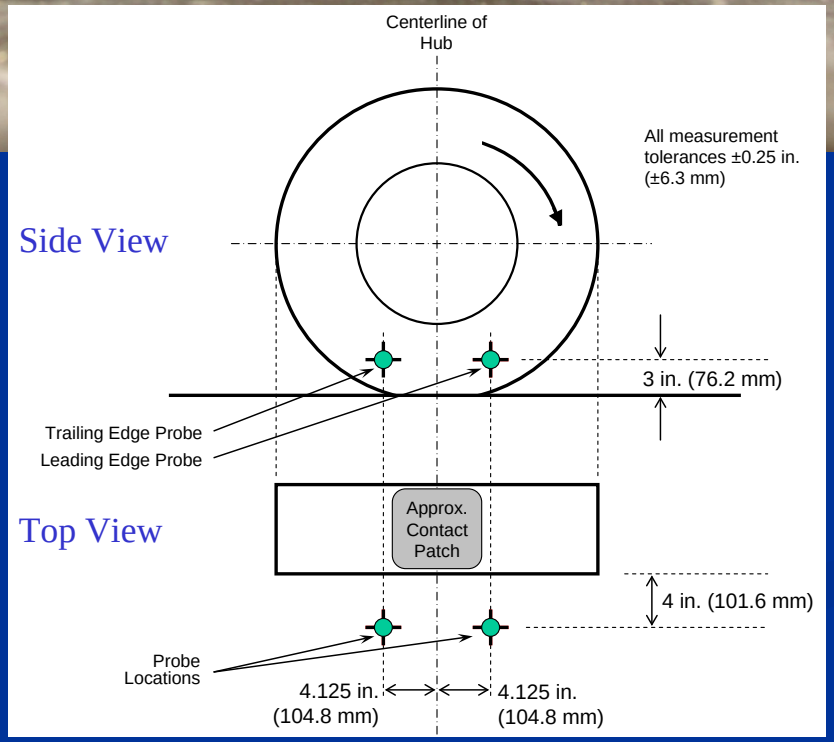
Single Probe OBSI

Dual Probe OBSI


Primary
Focus of
Sound

Dual Probe OBSI





TxDOT's experience with OBSI measurement

TxDOT OBSI Objectives

Research Program

- **Goals**
  - Construction/Pavement (CST)
    - Improved Designs
      - Safety/Durability (+) ...and Quieter
    - Measurement Protocol ...OBSI
  - Environmental (ENV)
    - Avoid Impacts = Avoid Noise Barriers
    - Measurement Protocol ...SPB and OBSI
      - SPB compared to TNM “Average”
      - Seek FHWA approved adjustment in TNM
- **Status: Collecting Data**
  - Two OBSI systems (TxDOT and CTR)
    - According to AASHTO TP 76-13 Standard

Data Collection Objectives and Work Plan

- **Objectives**
  - **Process development**
    - Characterize Texas pavements
    - Factors
    - Trends
    - Noise ‘Families’
  - **Information support (CST- M&P)**
    - Design guidelines
    - Project-level support
    - Facts / information exchange
  - **Policy support (ENV)**
    - Policy decision support
    - Facts / information exchange

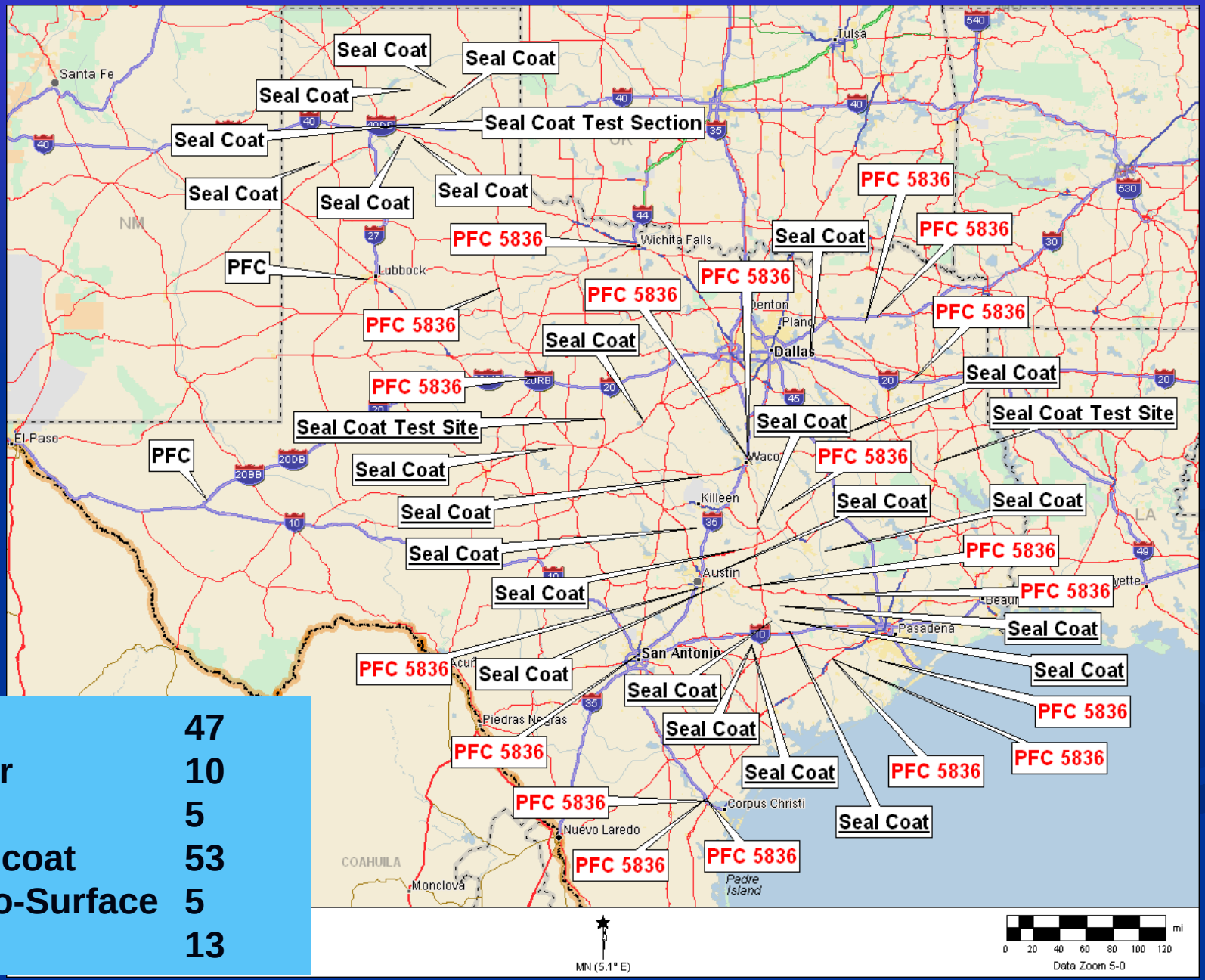
Tire / Pavement Noise

- **Work Plan**
  - Stay current with OBSI trends and research
  - Follow AASHTO Standards to ensure data collected is comparable to data collected by others.
  - Analyze data collected, try to understand data types
  - Participate in state and national OBSI discussions
  - Collection coordination (TxDOT/CTR)
  - Database management

Tire / Pavement Noise

- **Work Plan – continued**
  - **Test Sections tested to date by 'Family'**
    - PFC **47**
    - Other **10**
    - SMA **5**
    - Seal coat **53**
    - Micro-Surface **5**
    - PCC **13**
  - **Additional Test Sections planned**

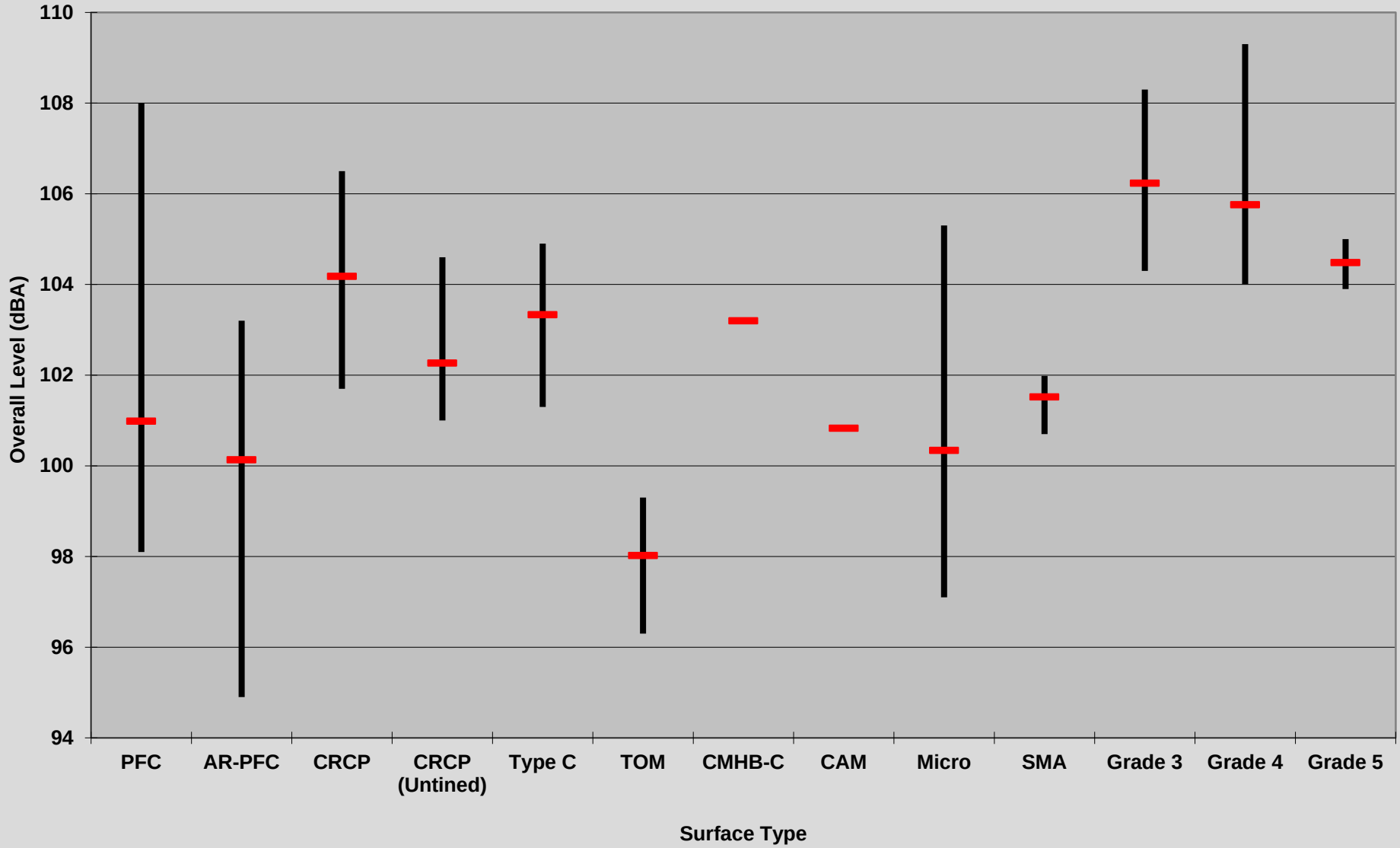
TxDOT & CTR OBSI Test Sections



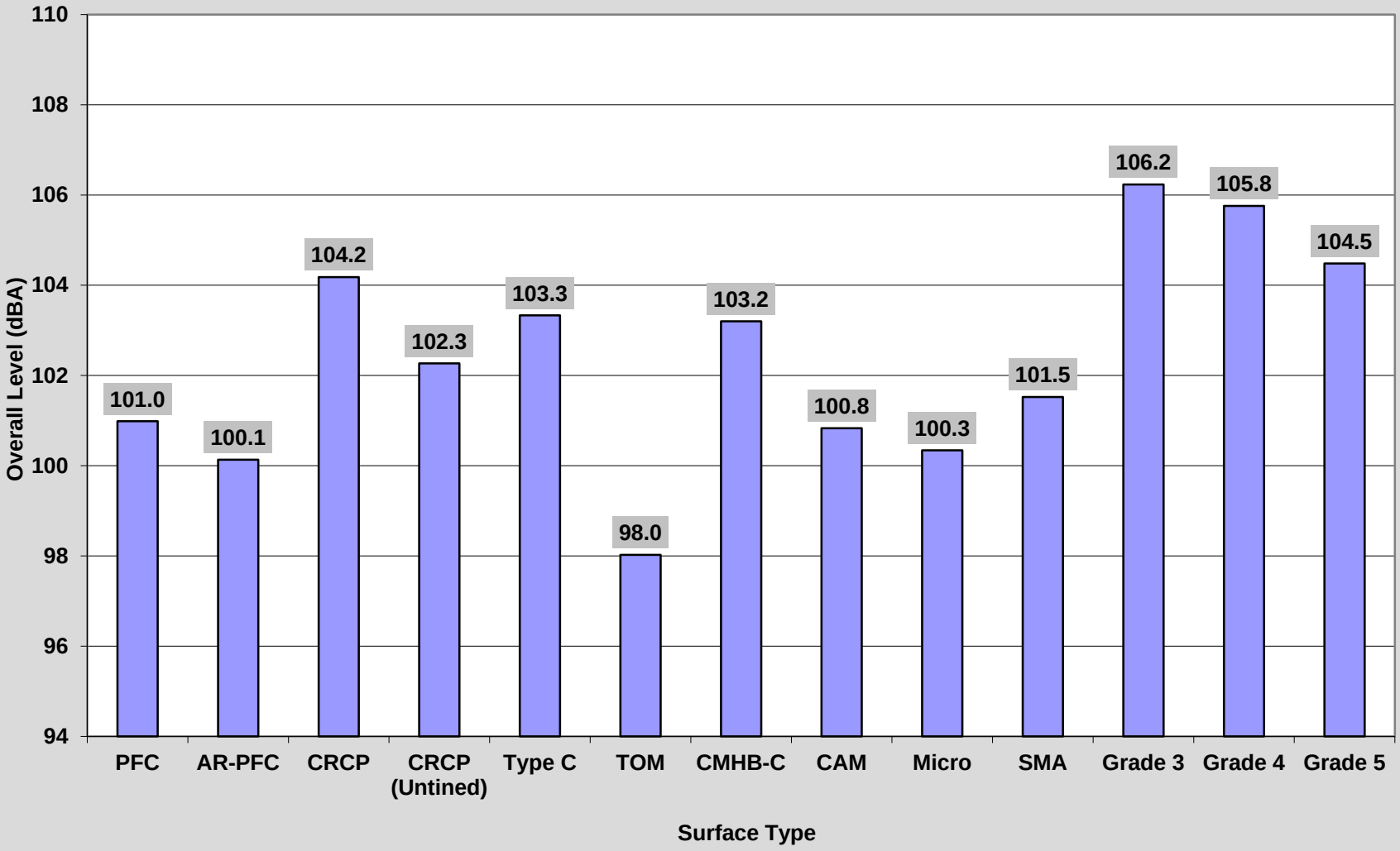
- PFC	47
- Other	10
- SMA	5
- Seal coat	53
- Micro-Surface	5
- PCC	13

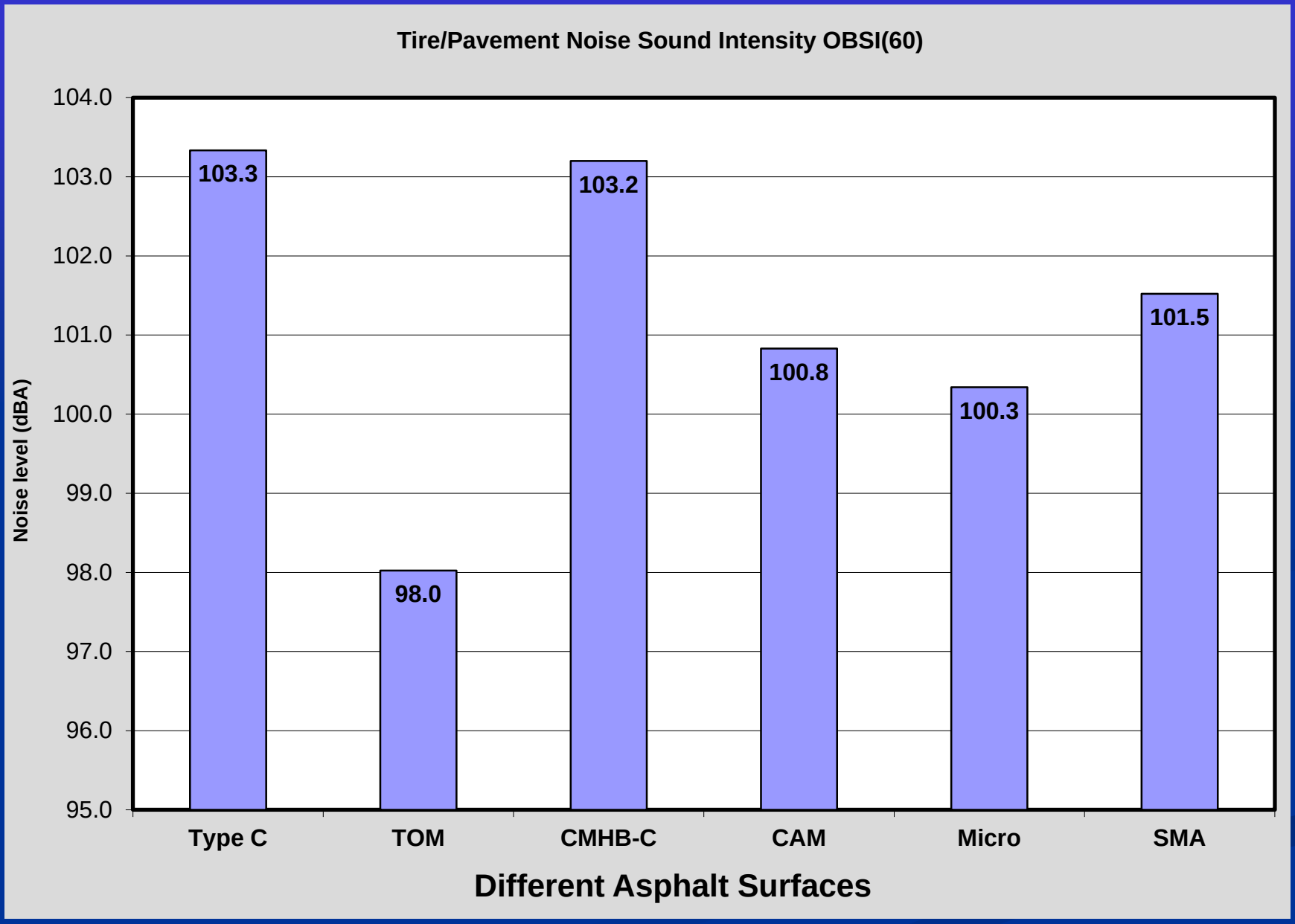
TxDOT OBSI Data

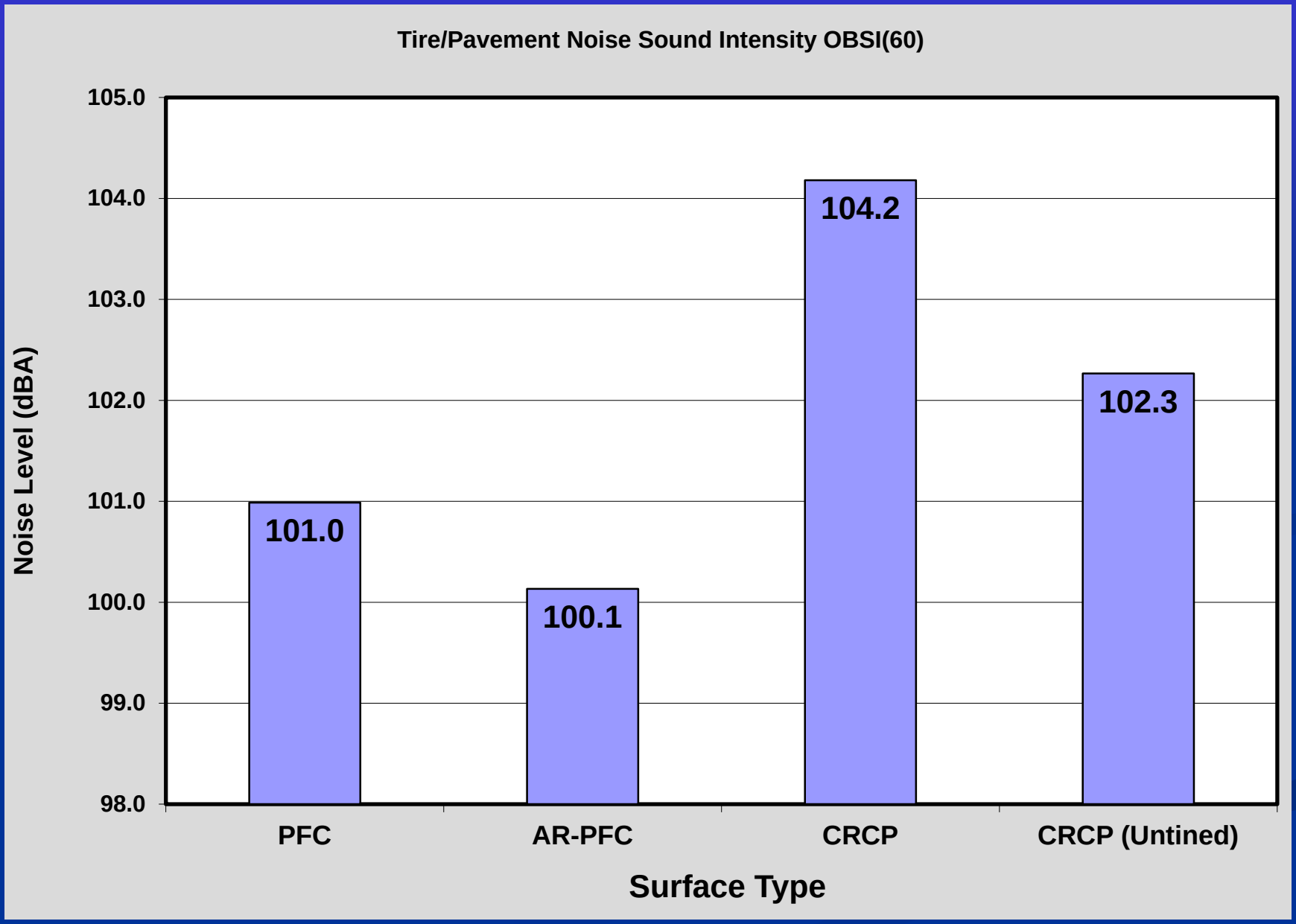
Tire/Pavement Noise Sound Intensity OBSI(60)
Range and Average of Pavement Test Sections - TxDOT & CTR

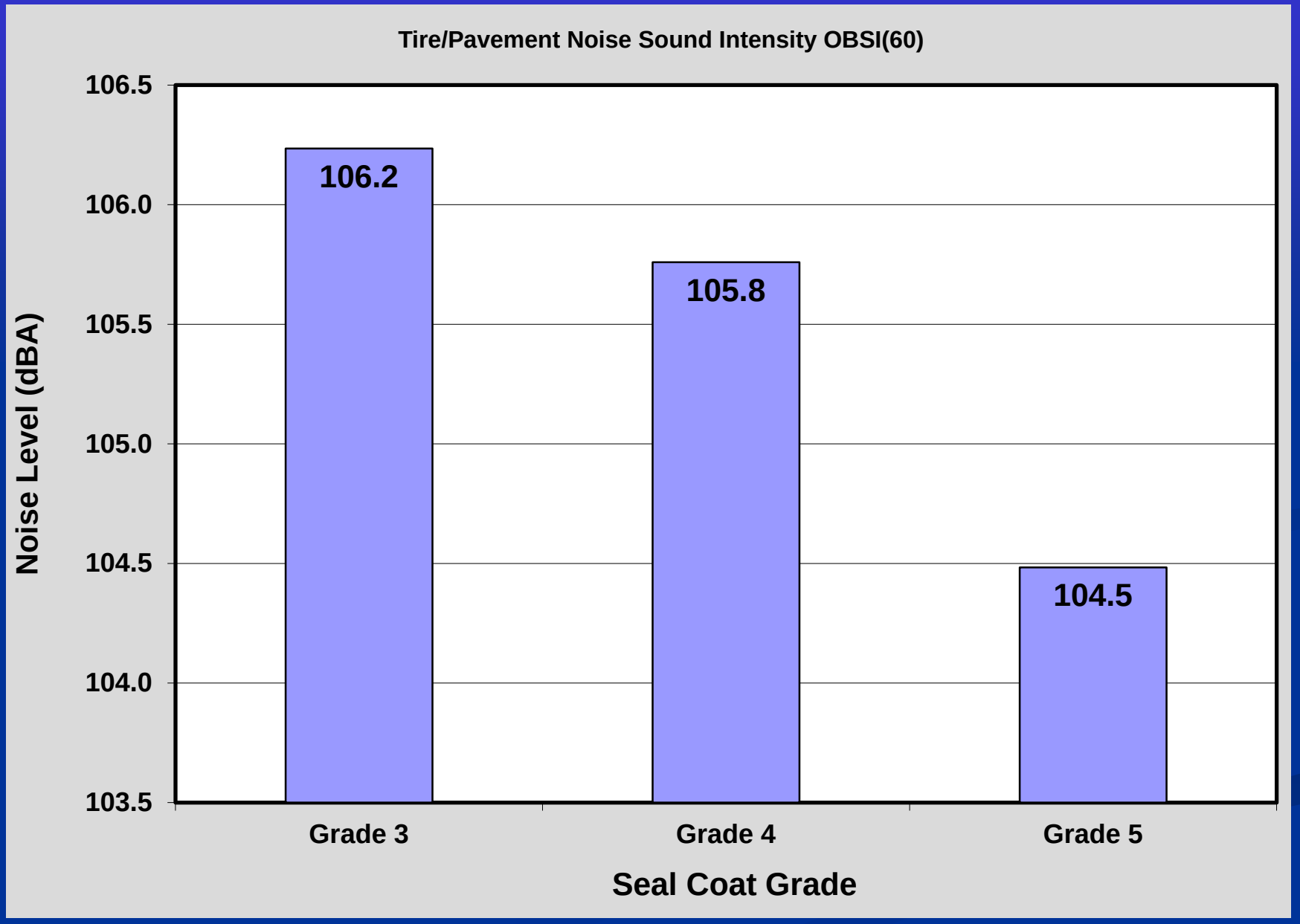


Tire/Pavement Noise Sound Intensity OBSI(60)
Average of Pavement Test Sections - TxDOT & CTR




Tire/Pavement Noise Sound Intensity OBSI(60)
Noise level (dBA)
104.0
103.0
102.0
101.0
100.0
99.0
98.0
97.0
96.0
95.0
103.3
98.0
103.2
100.8
100.3
101.5
Type C
TOM
CMHB-C
CAM
Micro
SMA
Different Asphalt Surfaces


Tire/Pavement Noise Sound Intensity OBSI(60)
Noise Level (dBA)
105.0
104.0
103.0
102.0
101.0
100.0
99.0
98.0
101.0
100.1
104.2
102.3
PFC
AR-PFC
CRCP
CRCP (Untined)
Surface Type


Tire/Pavement Noise Sound Intensity OBSI(60)
Noise Level (dBA)
106.5
106.0
105.5
105.0
104.5
104.0
103.5
106.2
105.8
104.5
Grade 3
Grade 4
Grade 5
Seal Coat Grade

Thin Overlay Mix

Thin Overlay:
96.3 dBA
OBSI (60)

PFC Surface

98.7 dBA OBSI (60)

Regular Dense Mix

Dense Graded: 104.9 dBA OBSI (60)

Seal Coat Grade 3 Lightweight

Seal Coat Grade 3:
107.6 dBA OBSI (60)

Concrete Tining Surfaces

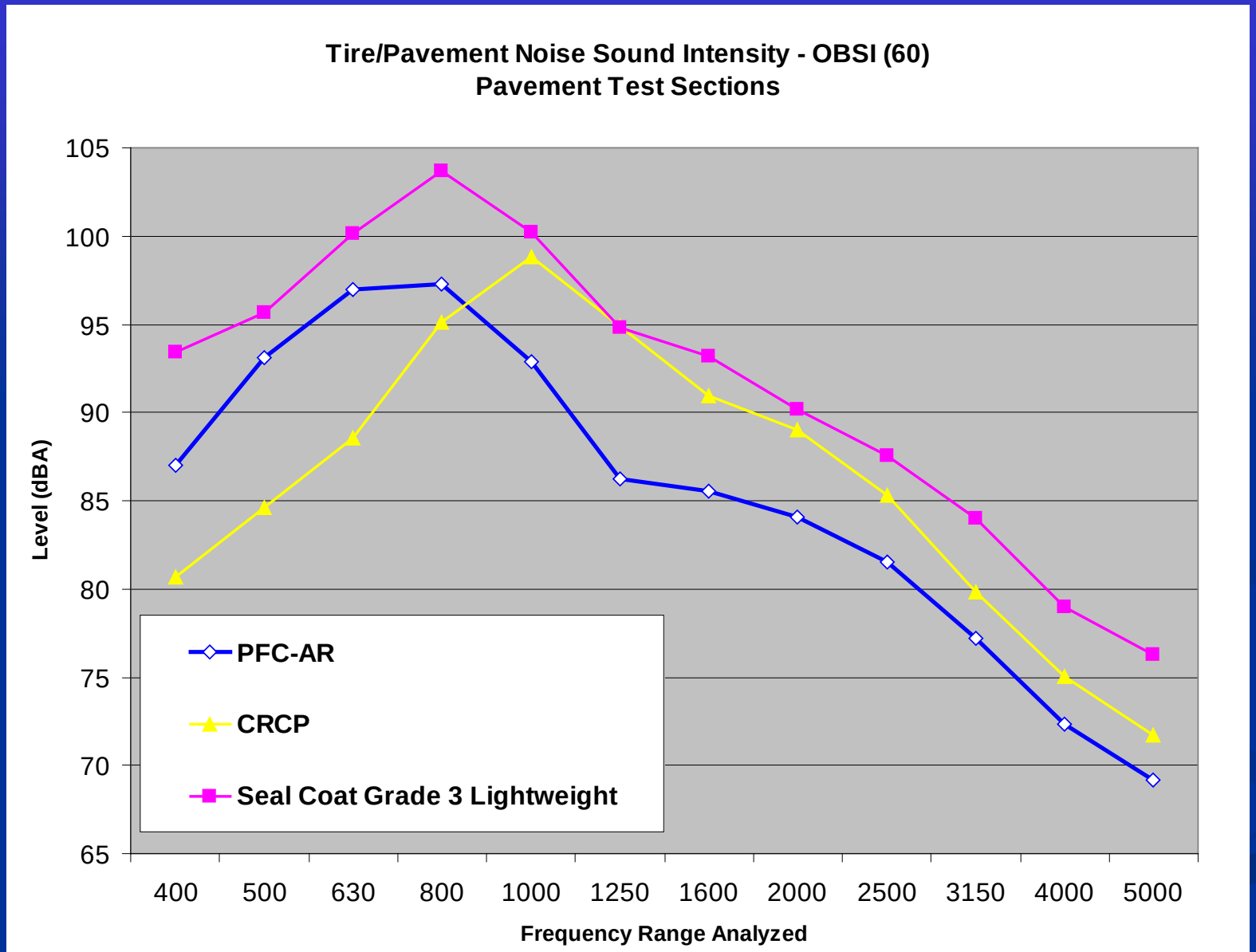
Longitudinal

Uniform Transverse

Random Transverse

Concrete Tining Surfaces

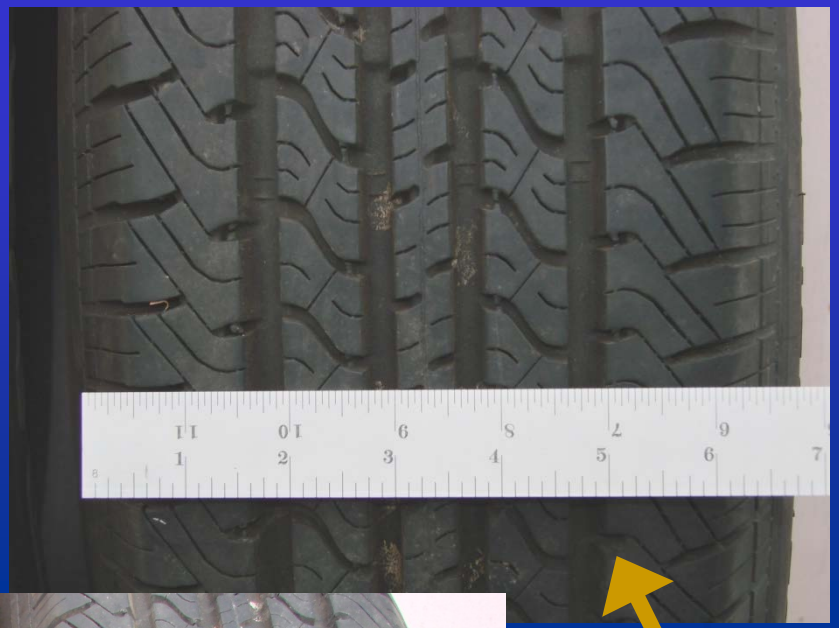
Transverse Tined:
103.0 dBA OBSI (60)


Tire/Pavement Noise Sound Intensity - OBSI (60)
Pavement Test Sections
Level (dBA)
105
100
95
90
85
80
75
70
65
400
500
630
800
1000
1250
1600
2000
2500
3150
4000
5000
Frequency Range Analyzed
PFC-AR
CRCP
Seal Coat Grade 3 Lightweight

TxDOT OBSI System

TxDOT OBSI System:

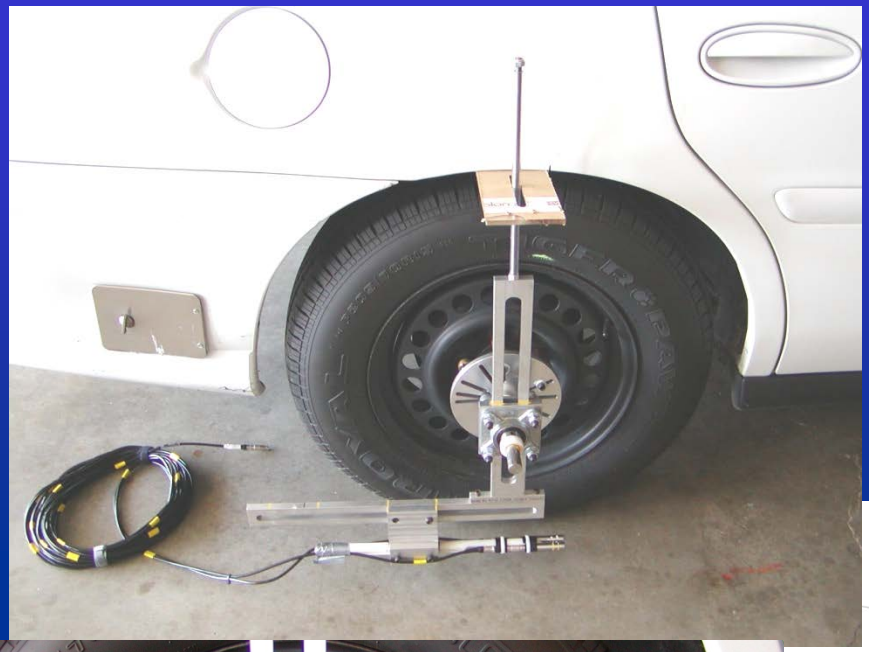
- Uses Dual Probe OBSI System
- TPF (5)135 Developed Analyzer - National Instruments
- 2008 Chevrolet Impala Test Vehicle
- 16” Tiger Paw SRTT Test Tire (since 7/15/08)

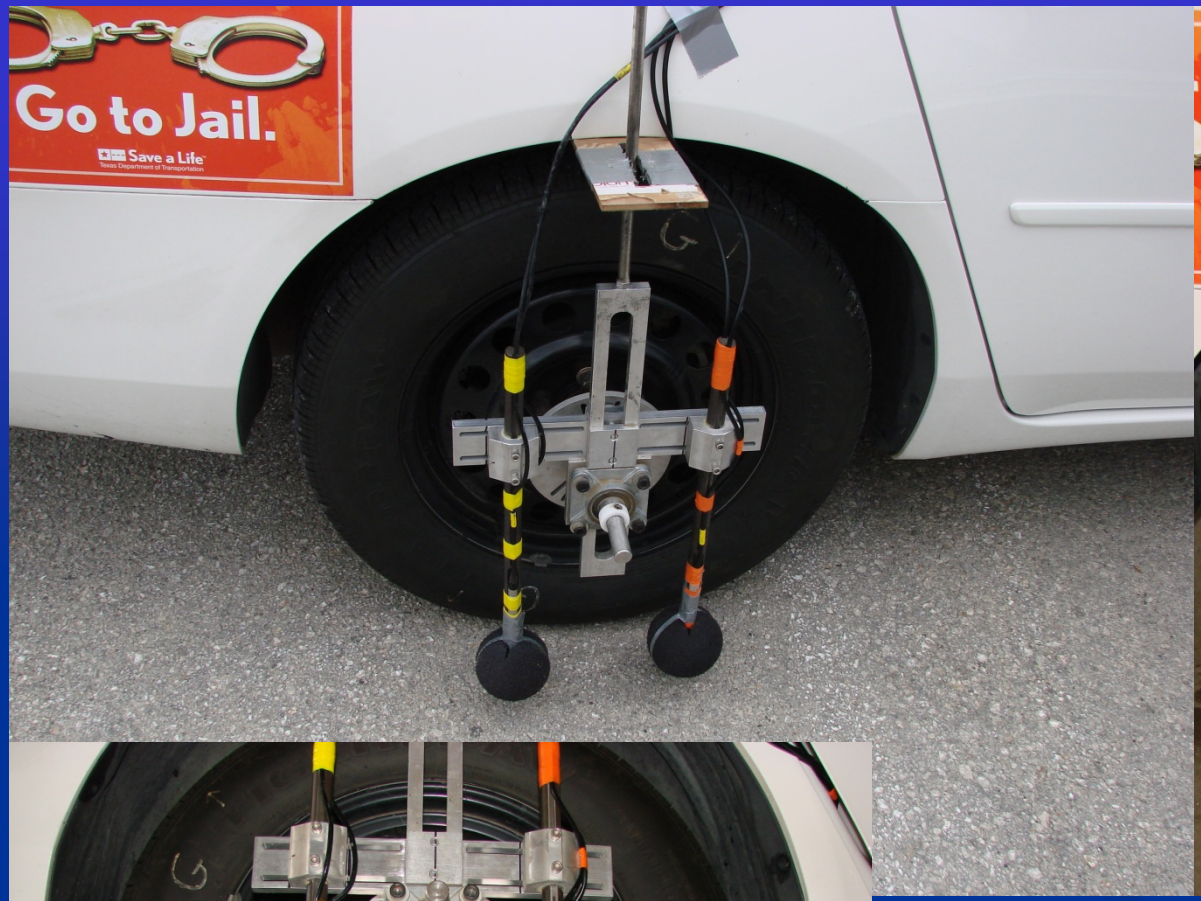


SRTT

AWP

AWP Tire





SRTT Tire

Sound Intensity Analyzer System for On-Board Sound Intensity Measurement

Updated: 8/1/2011 With Quotes from Paul Donavan

Supplier: **National Instruments**
Proposed New System

Description	No. Req'd	Unit Cost	Total Cost
NI USB-9234 Dynamic Signal Acquisition Module	1	$1,859.00	$1,859.00
GRAS Type 26AK 1/2" Mic Preamplifier	4	$726.00	$2,904.00
GRAS Type 40AI pair 1/2" Mics, Phase Matched	2	$2,577.00	$5,154.00
G.R.A.S Type AA009 Mic Extension Cable - 10m	4	$288.00	$1,152.00
G.R.A.S. AM0069 Spherical Windscreen	2	$18.40	$36.80
GRAS Type 12AN Power Module	1	$2,498.00	$2,498.00
OBSI Fixture	1	$3,000.00	$3,000.00
BNC Female to BNC Female Cables	4	$10.00	$40.00
Larson Davis CAL200 94 dB 1000 Htz Calibrator	1	$529.00	$529.00
		TOTAL	**$17,172.80**

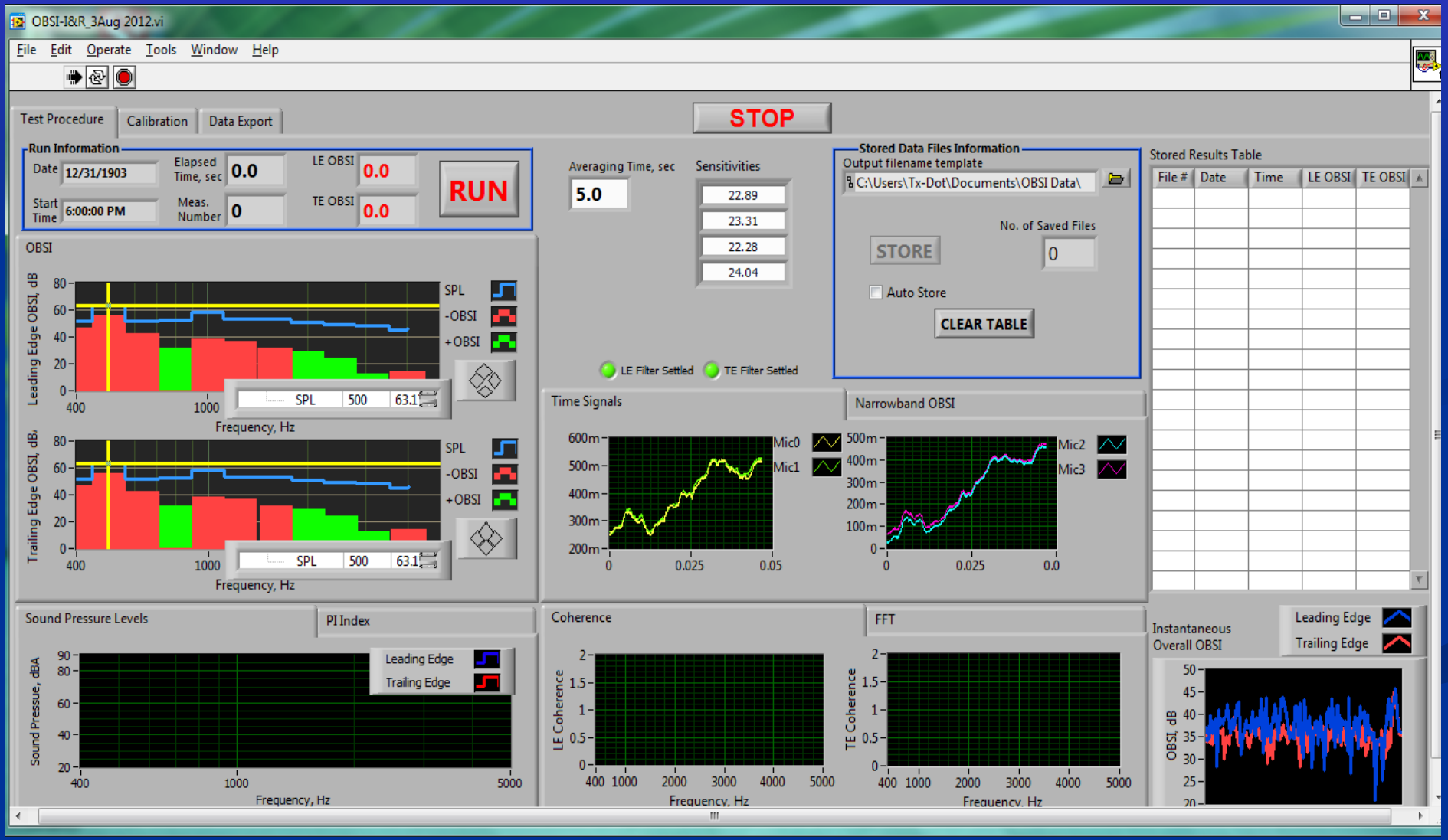
OBSI System Cost Comparison

Updated: 7/30/2012

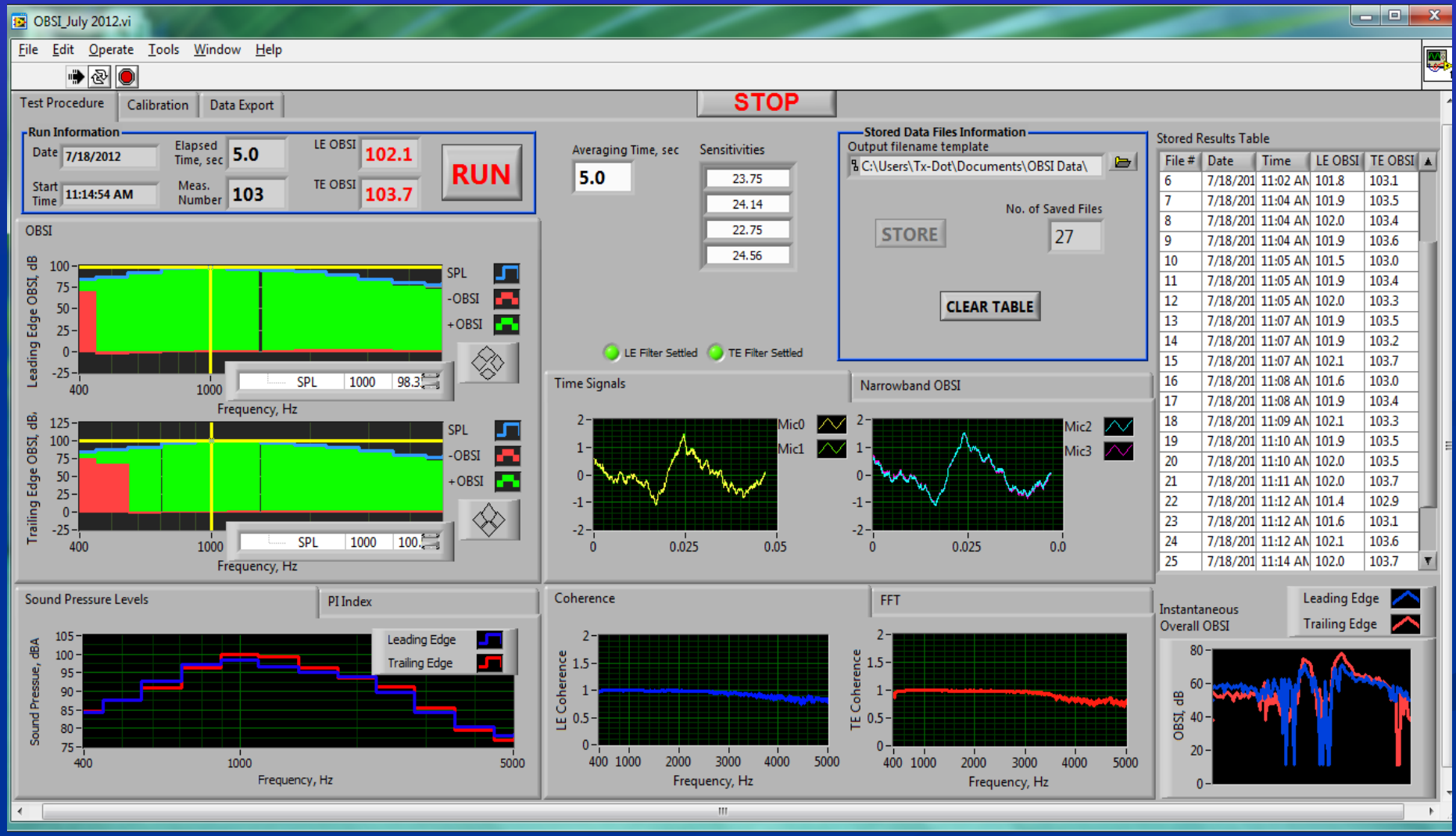
Cost	Brüel & Kjær North America, Inc.	Harmonie	National Instruments
Entire New System including: Fixture and 4 Microphones	**$52,089.80**	**$35,253.80**	**$17,172.80**

NI System Hardware

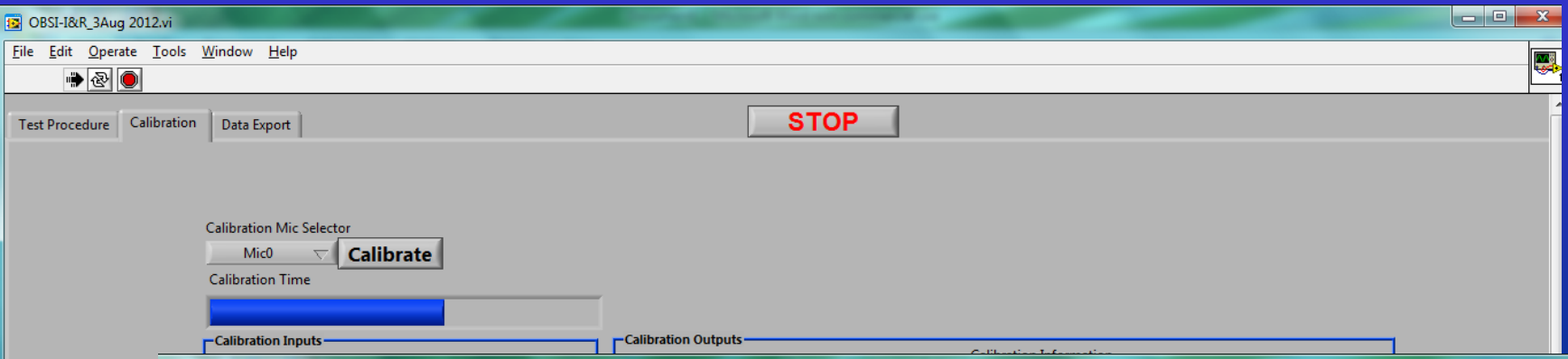
Vehicle not in motion

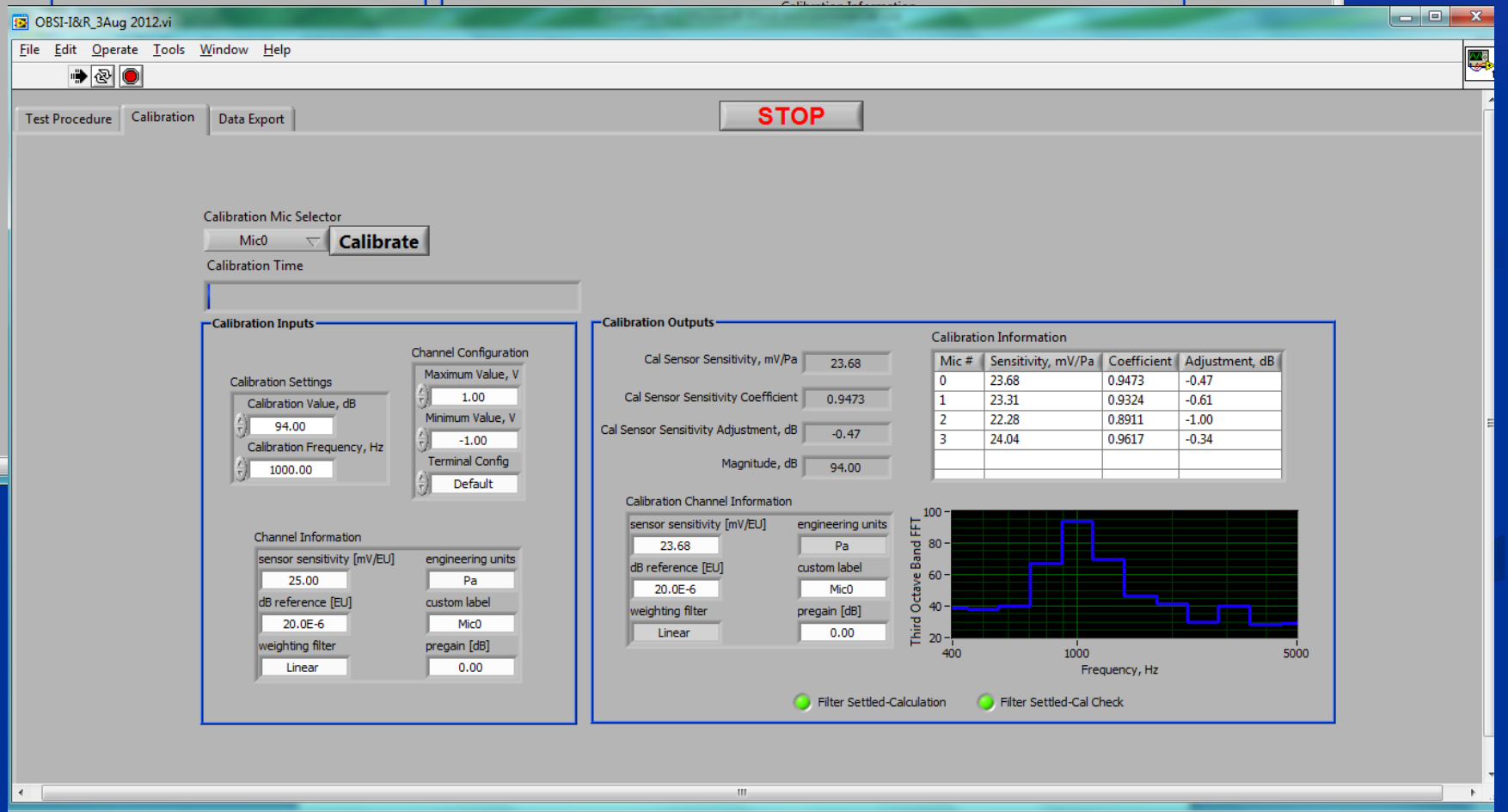


Vehicle testing at 60 mph

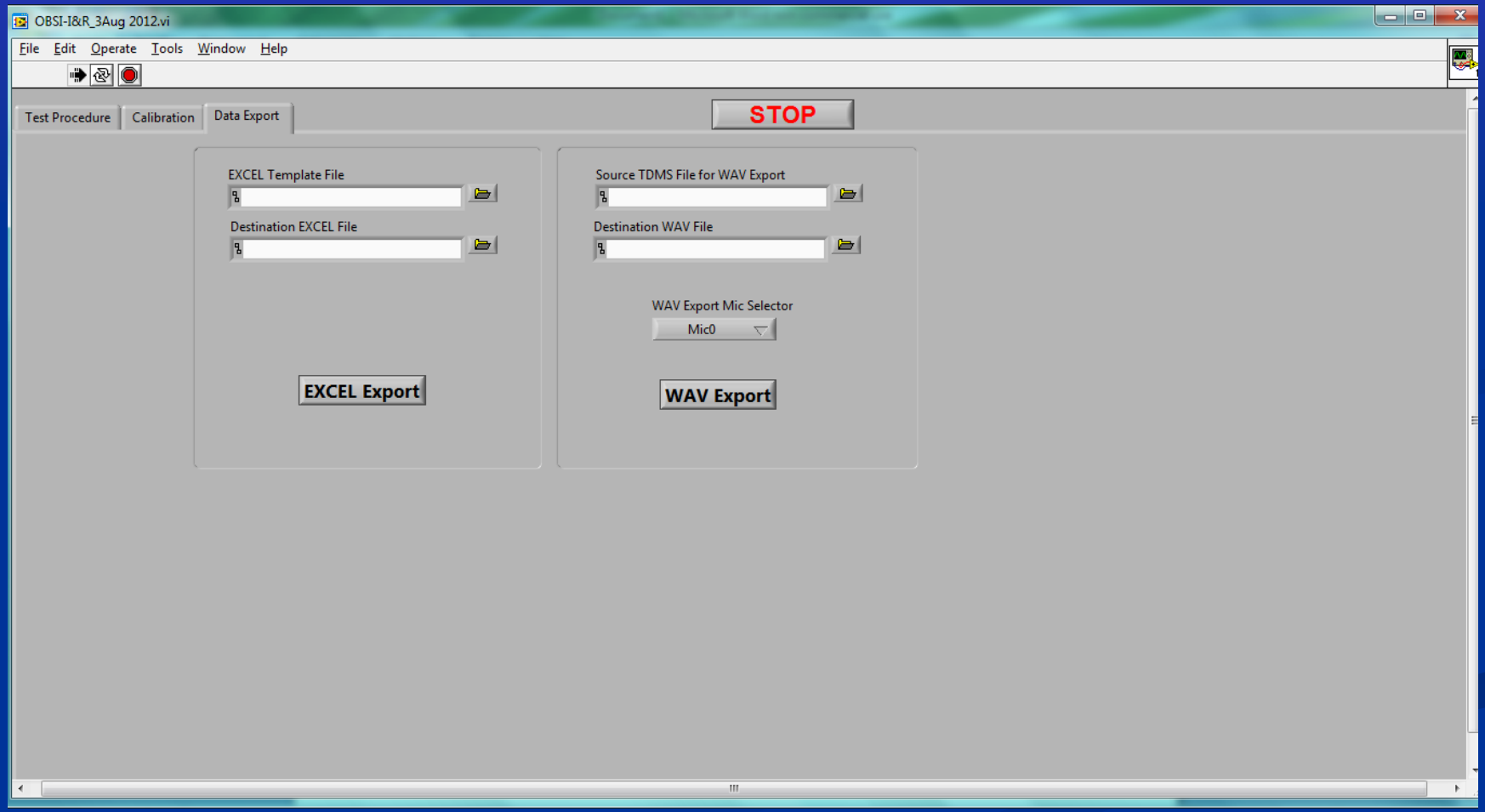


Calibration View





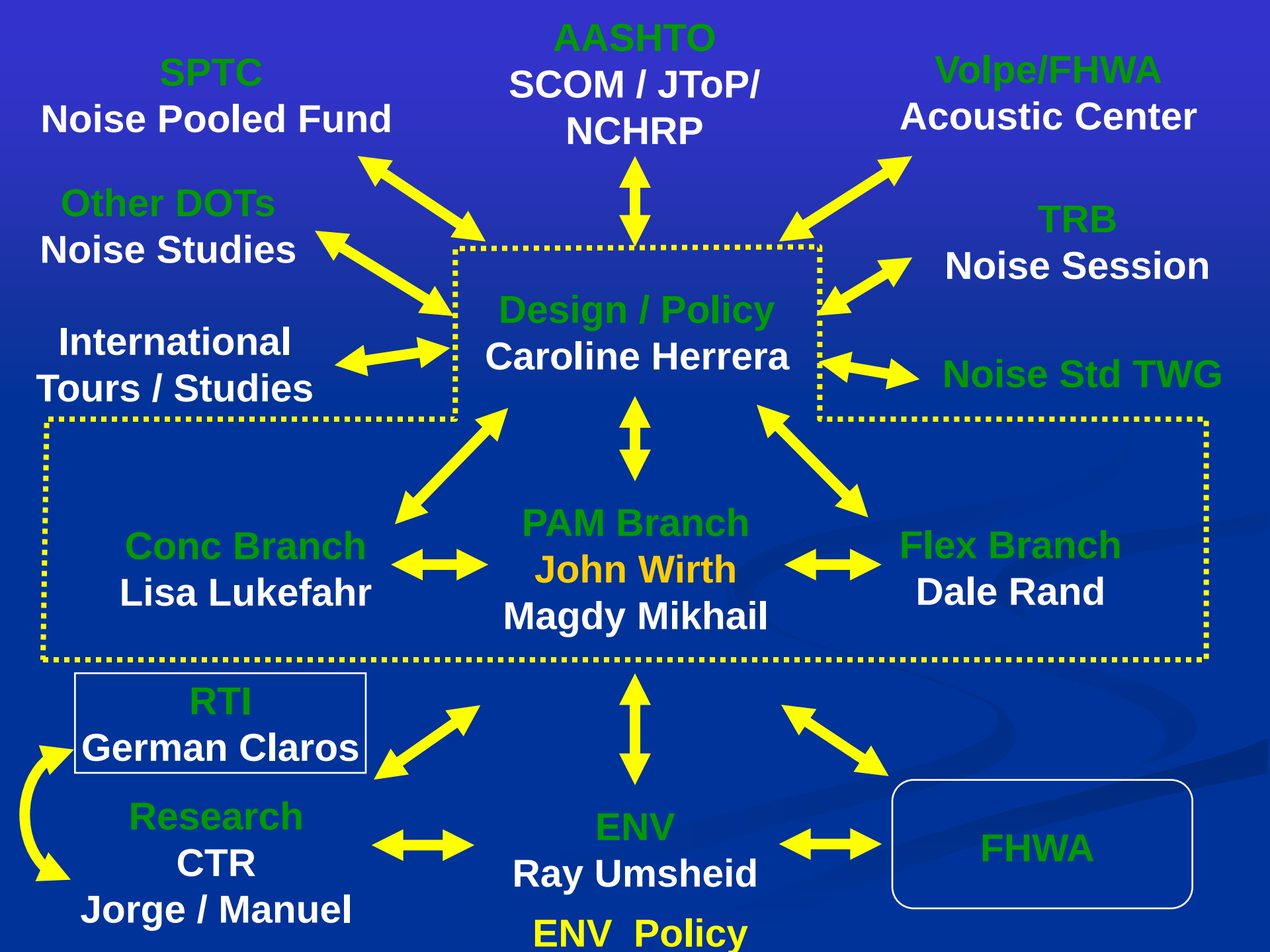
Data Export View



Additional OBSI System Items

- Low Noise 12Vdc inverter.
  - Excessive noise can be observed on Time Signal displays
- Laptop
  - Noise Wav data is stored in one file for each run.
  - Wav file for each run can be exported as needed.
- Exported Excel file needs to be processed
  - Edit charts to meet users needs
  - Much easier than old files

Another Example of Noise:


AASHTO
SCOM / JToP/
NCHRP
SPTC
Noise Pooled Fund
Volpe/FHWA
Acoustic Center
Other DOTs
Noise Studies
TRB
Noise Session
International
Tours / Studies
Design / Policy
Caroline Herrera
Noise Std TWG
Conc Branch
Lisa Lukefahr
PAM Branch
John Wirth
Magdy Mikhail
Flex Branch
Dale Rand
RTI
German Claros
Research
CTR
Jorge / Manuel
ENV
Ray Umsheid
ENV Policy
FHWA

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