2017 PURDUE ROAD SCHOOL
MARCH 6-9, 2017

How to Design and Build Smoother Pavements

BY

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DEVELOPER/TRAINER OF FHWA PROVAL

PROVAL

Outlines

- What is Smoothness
- Design Consideration
- Best Practices for Asphalt Paving
- Improve Smoothness with ProVAL

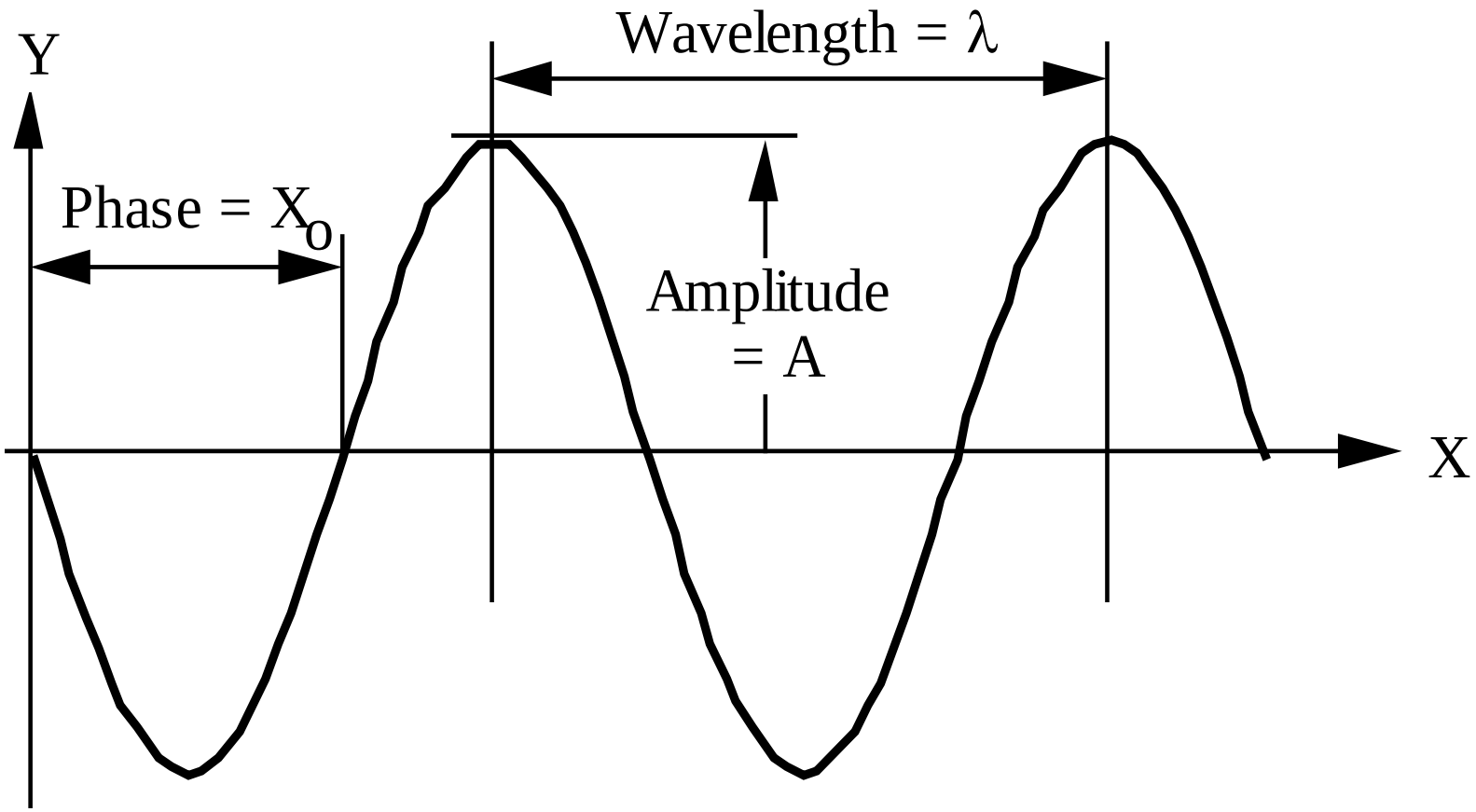
Outlines

- **What is Smoothness**
- Design Consideration
- Best Practices for Asphalt Paving
- Improve Smoothness with ProVAL

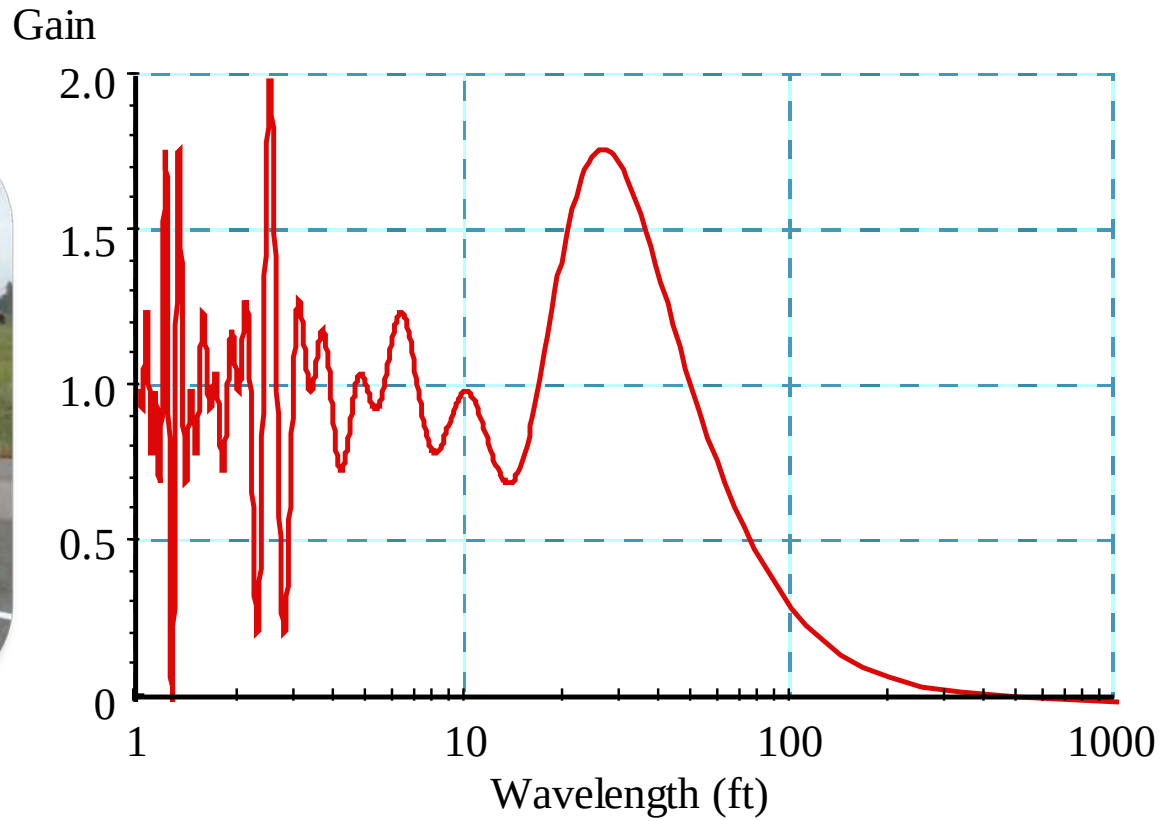
What is Pavement Profile ?

A **profile** is a slice of the road surface following an imaginary line

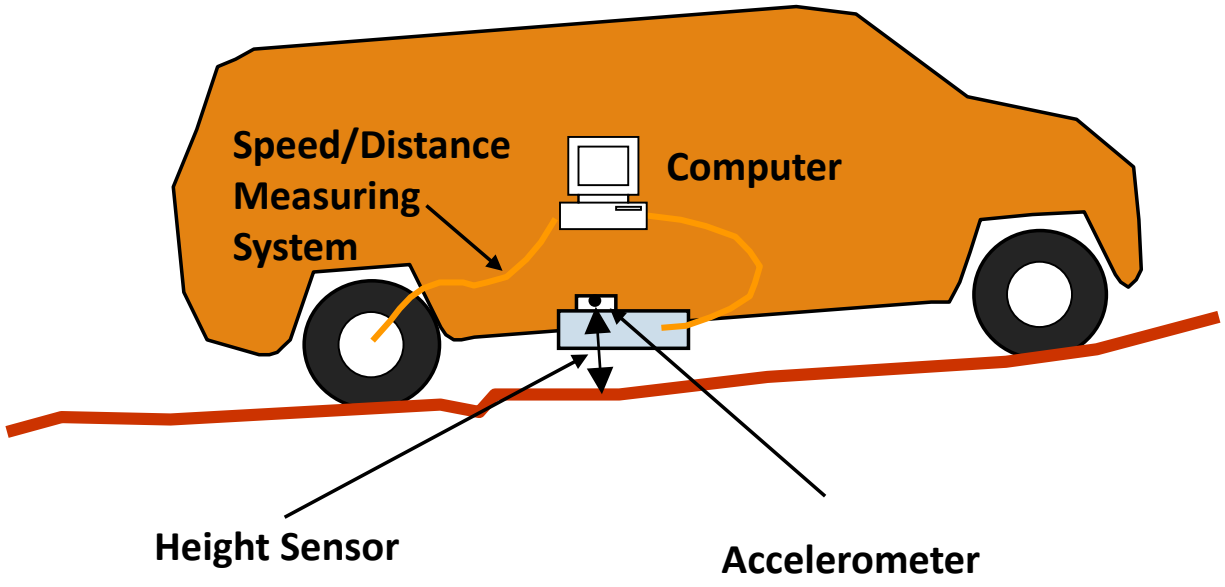
Sinusoids

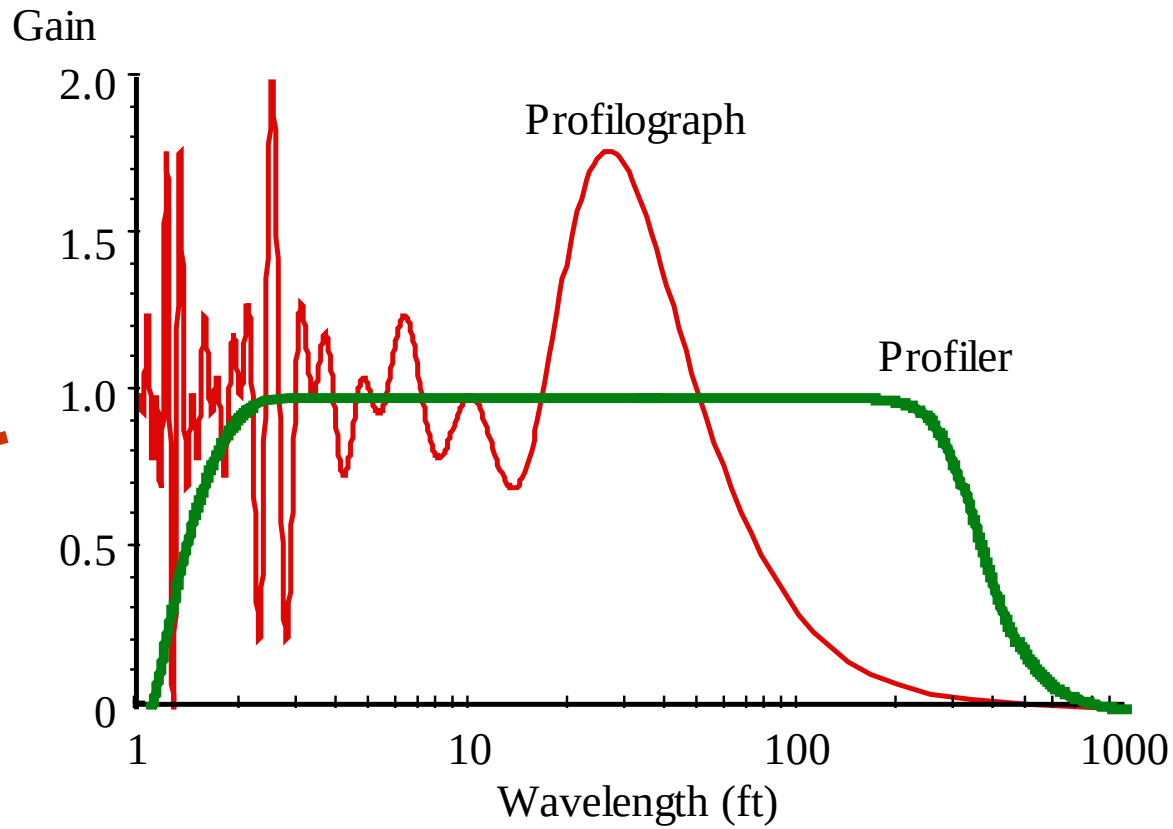


California Profilograph



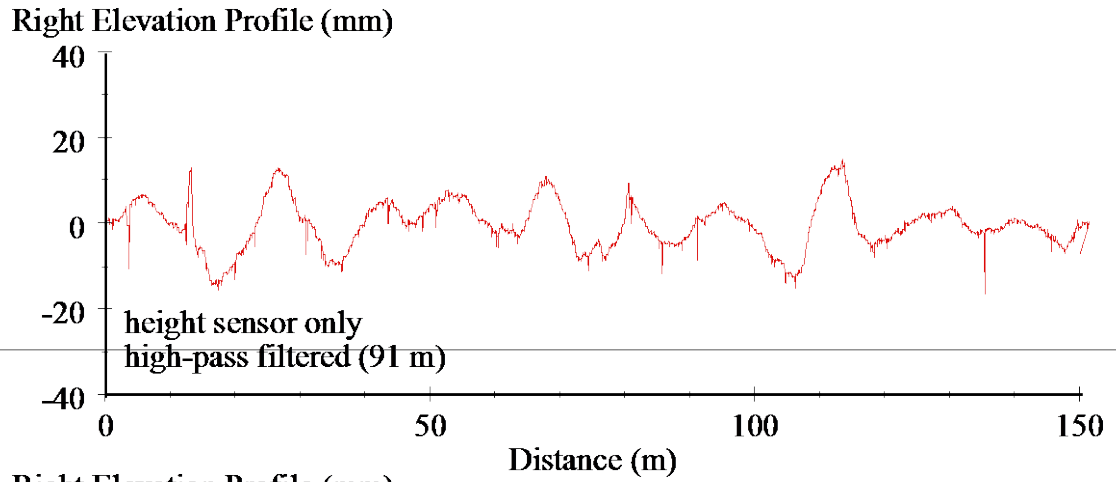
Inertial Profilers



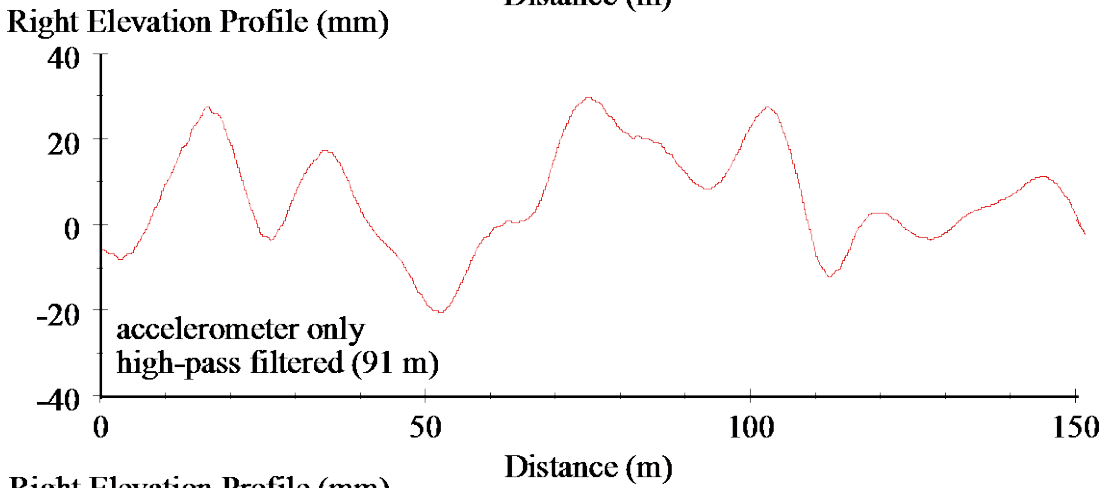


Profile Components

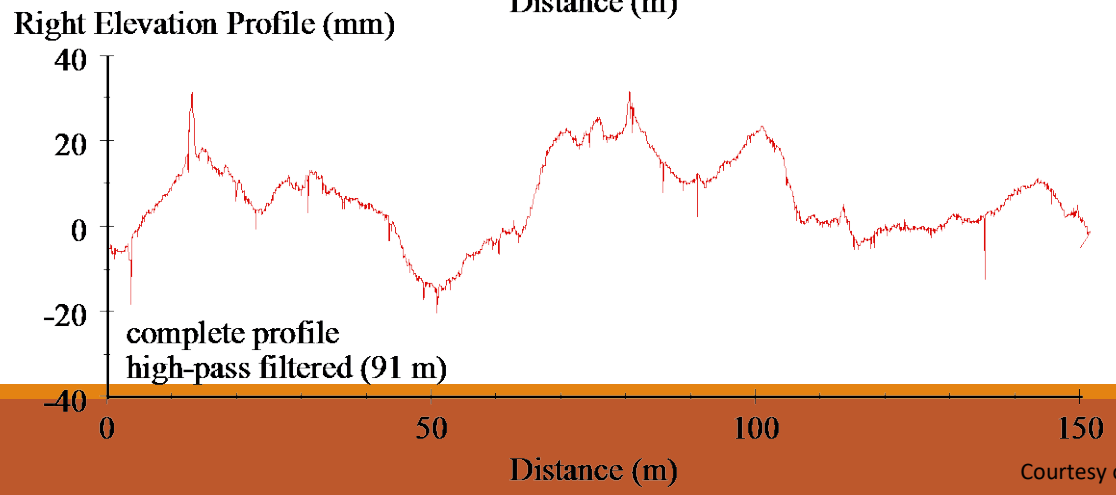
Height Sensor



Accelerometer-Based Reference

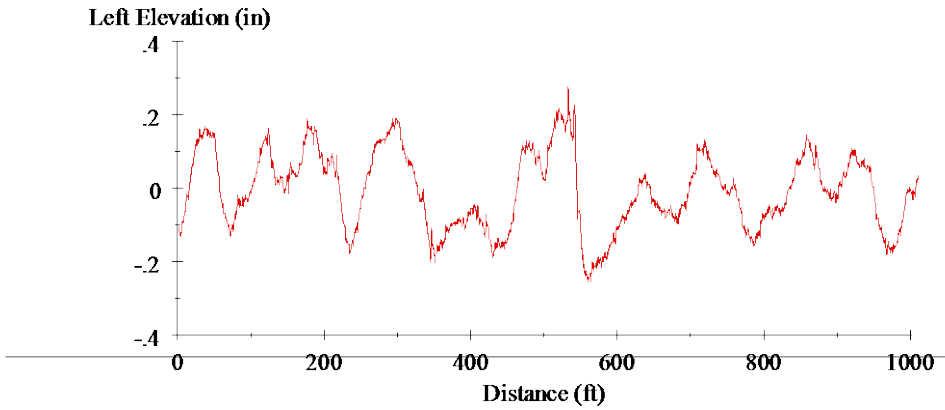


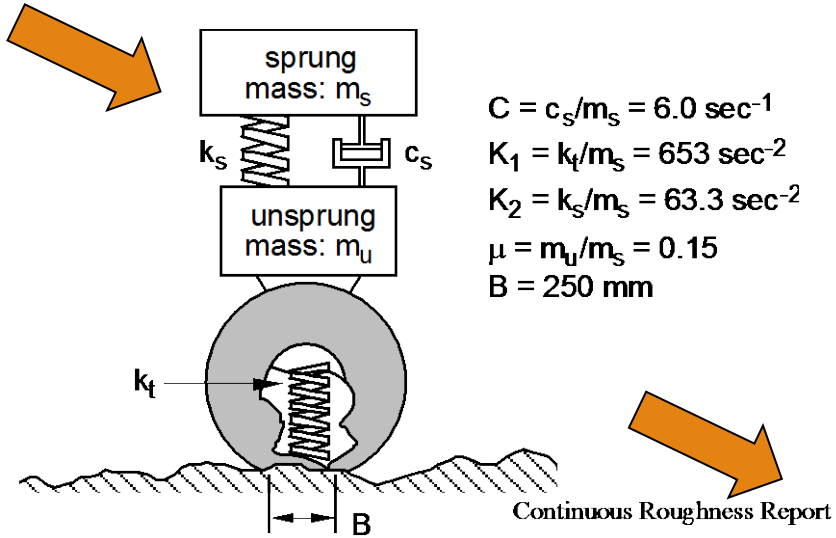
Computed Profile



Courtesy of Steve Karamihas, 2014

International Roughness Index
IRI





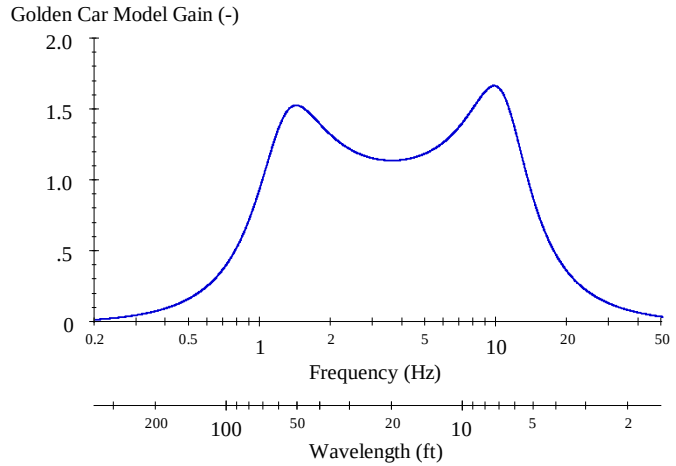
$C = c_s/m_s = 6.0\ sec^{-1}$

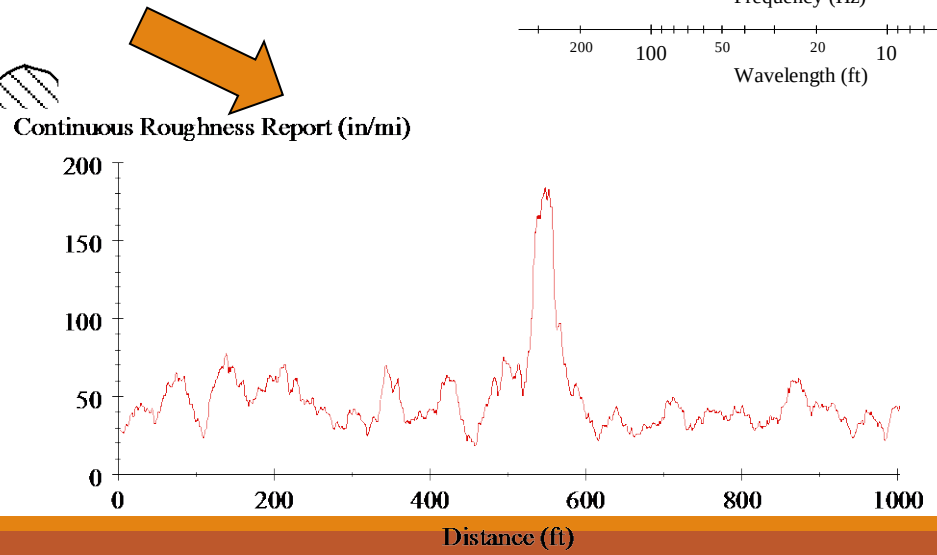
$K_1 = k_t/m_s = 653\ sec^{-2}$

$K_2 = k_s/m_s = 63.3\ sec^{-2}$

$\mu = m_u/m_s = 0.15$

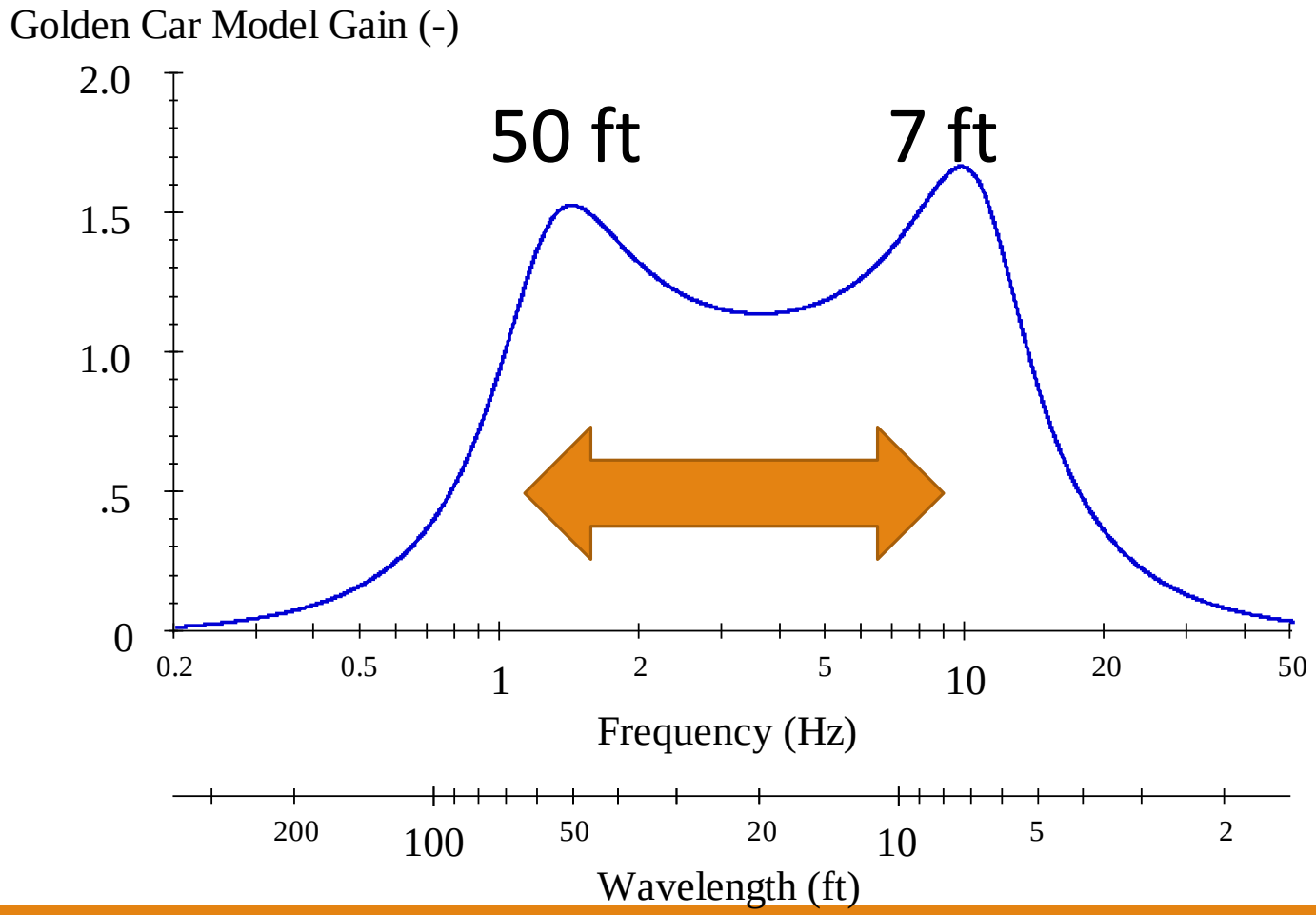
B = 250 mm





Courtesy of Steve Karamihas, 2014

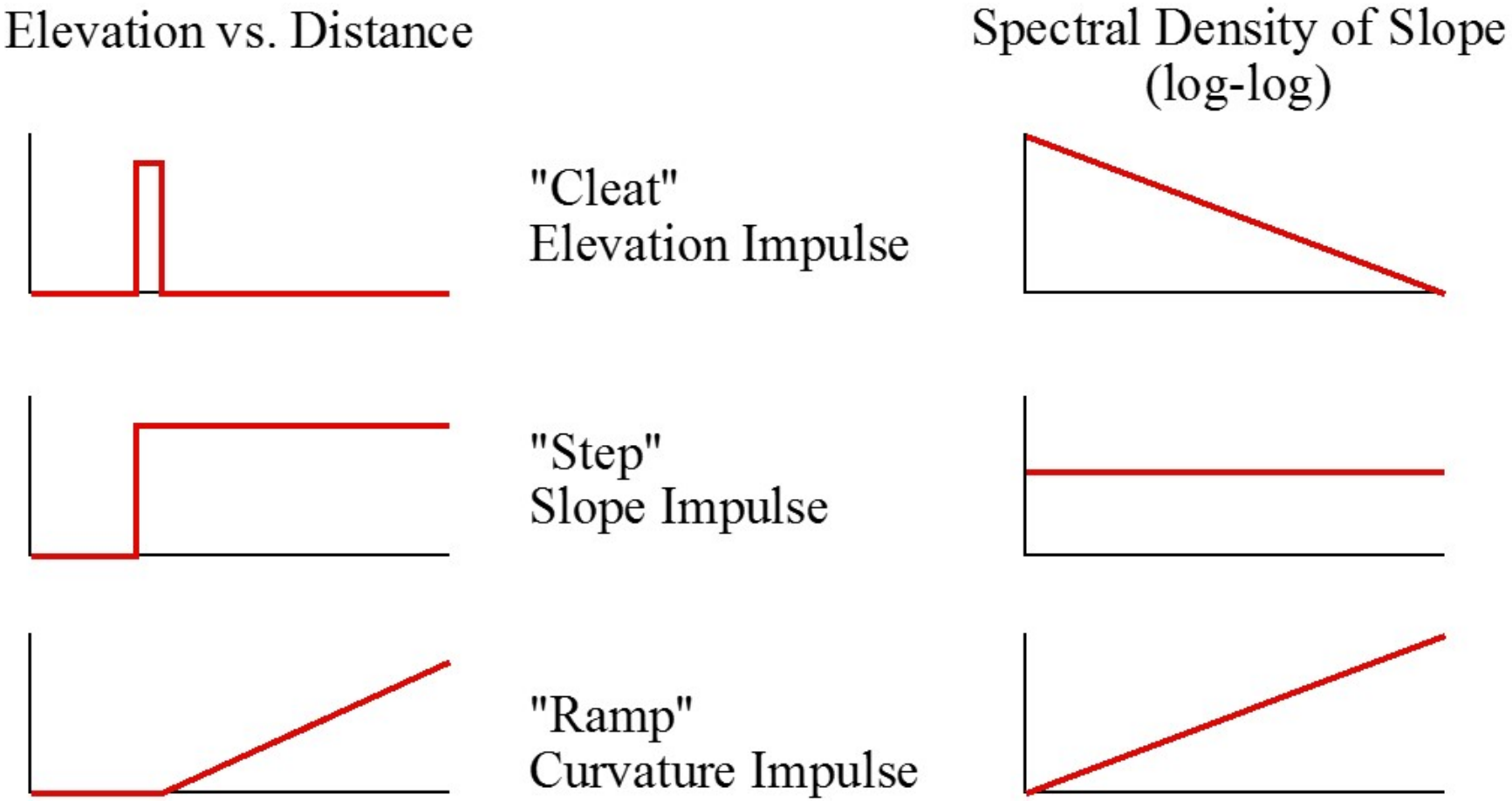
IRI Gain Chart



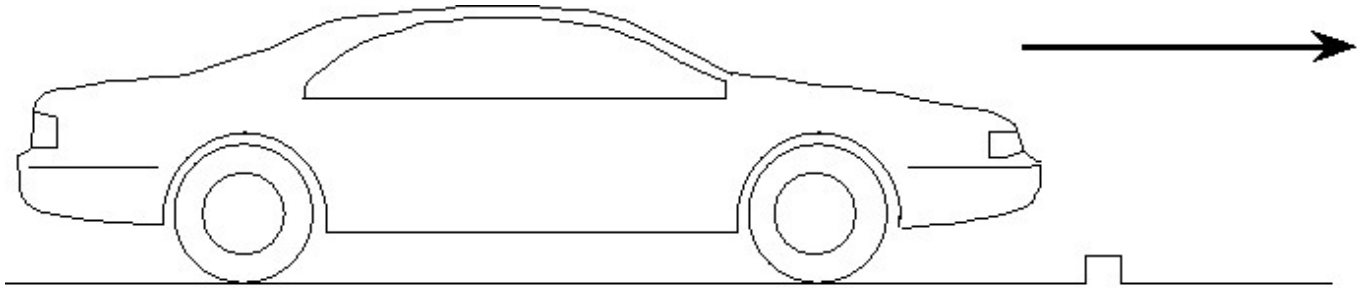
Outlines

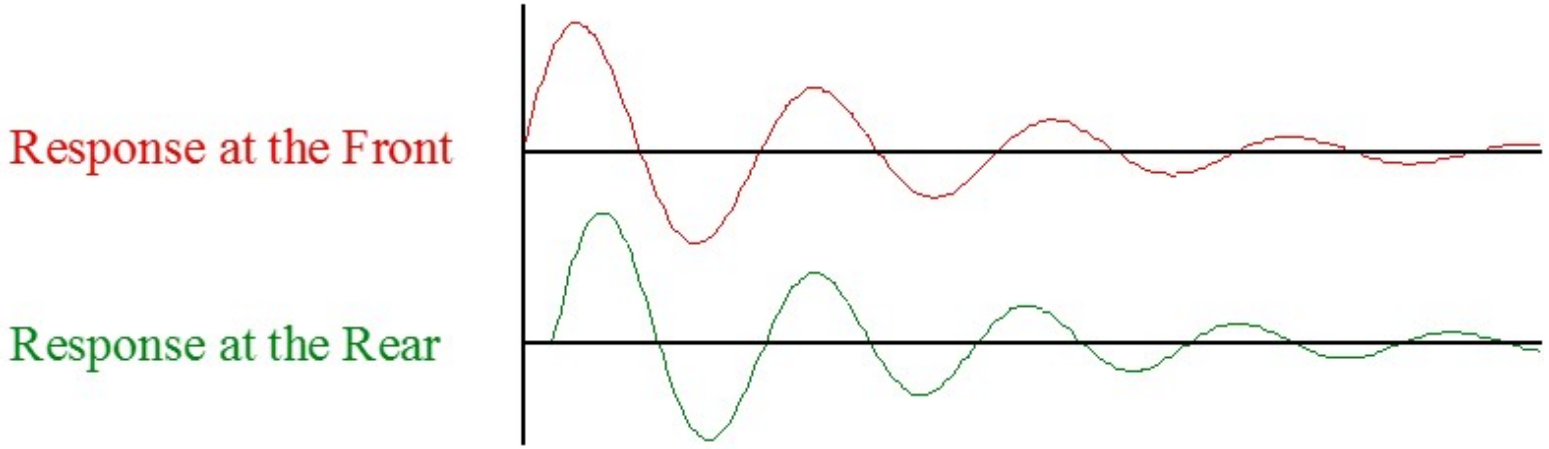
- What is Smoothness
- **Design Consideration**
- Best Practices for Asphalt Paving
- Improve Smoothness with ProVAL

Effects of Geometric Lines on Smoothness



Car Response to Bumps





ACP Design Factors

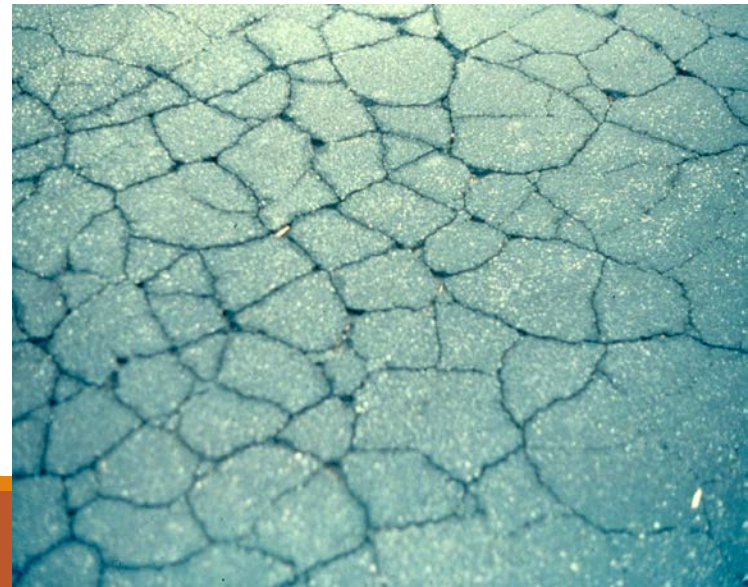
- Project location: Rural or Urban
- Condition/roughness of existing pavement
- Mix Type and Lift thickness
- Number of “Opportunities”
- Job Specifications

Urban obstacles

- Matching curb and gutter
- Matching drains / manholes
- Increased traffic considerations
- More stop and go paving required

Condition of Existing Pavement

- Severe distress and/or roughness
- Surface preparation
  - Stabilize PCC slabs (underseal, crack/seat, rubbilize)
  - Remove and/or replace distressed asphalt pavements
- Multiple opportunities on deficient pavements
- Before and after smoothness measurements
- Percent % improvement



Mix Type and Lift thickness

Proper lift thickness

- Nominal maximum size (NMS) of aggregate
- Optimal lift thickness at least 3.0 times NMS
- E.g. NMS (12.5mm) x 3 = lift thickness (37.5 mm)

Uniform thickness

- Adequate surface preparation
- QC on paving

Number of Opportunities

- Surface prep / milling
- Every lift of asphalt
- Expected % improvement

Surface Preparation

- Base or intermediate layer
  - Attention to smoothness
  - Attention to uniformity
  - “2nd opportunity” for smoothness
- Roughness reduced by half with each pavement layer

Job Specifications

Thickness / Yield

- Uniform thickness?
- Predetermined yield?
- Better if thickness / yield can vary somewhat

Mill-and-Fill Projects

- Shoulder / adjoining lane stay in place?
- Match existing elevations?
- Joint matching shoe on grade control
- Better if use automatic grade control with long reference and vary elevation

Outlines

- What is Smoothness
- Design Consideration
- **Best Practices for Asphalt Paving**
- Improve Smoothness with ProVAL

Good Communication

Good Subbase for New Paving

1. Spread

2. Grade

3. Compact

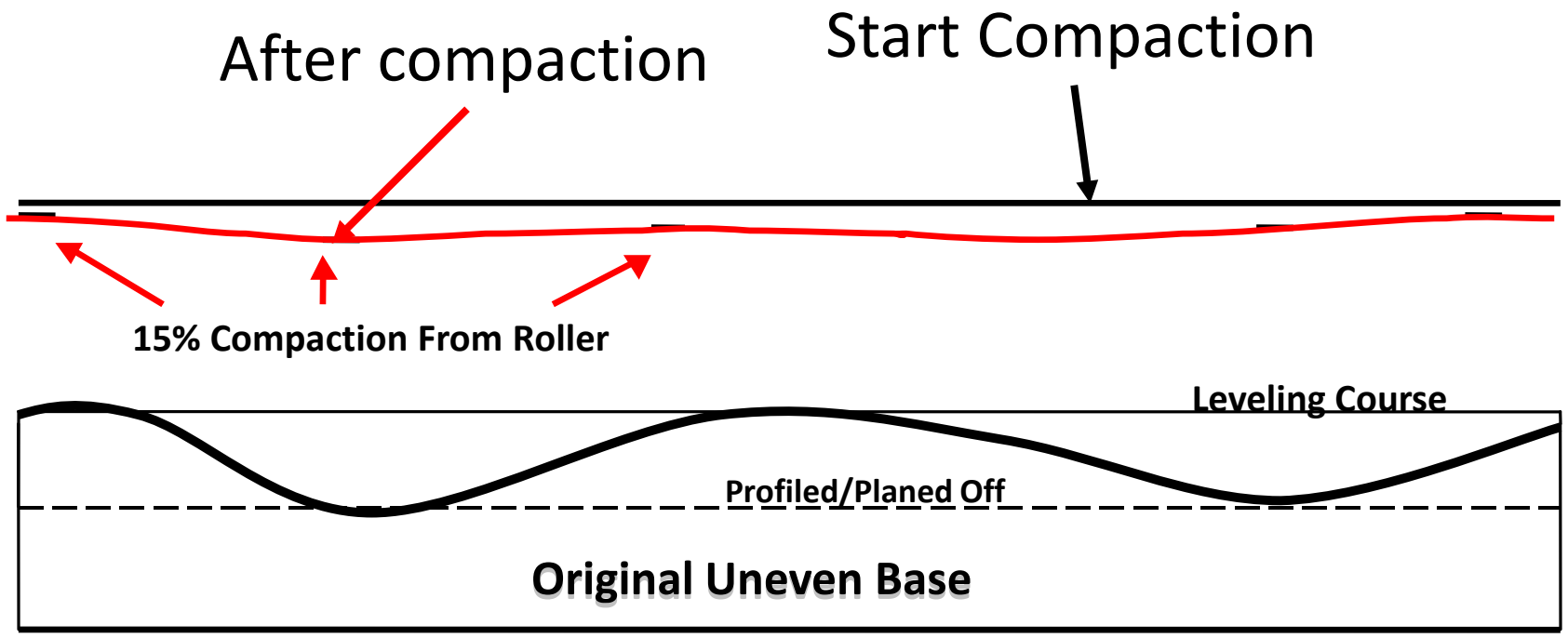
Paved Subbase Materials

Existing Pavement Condition

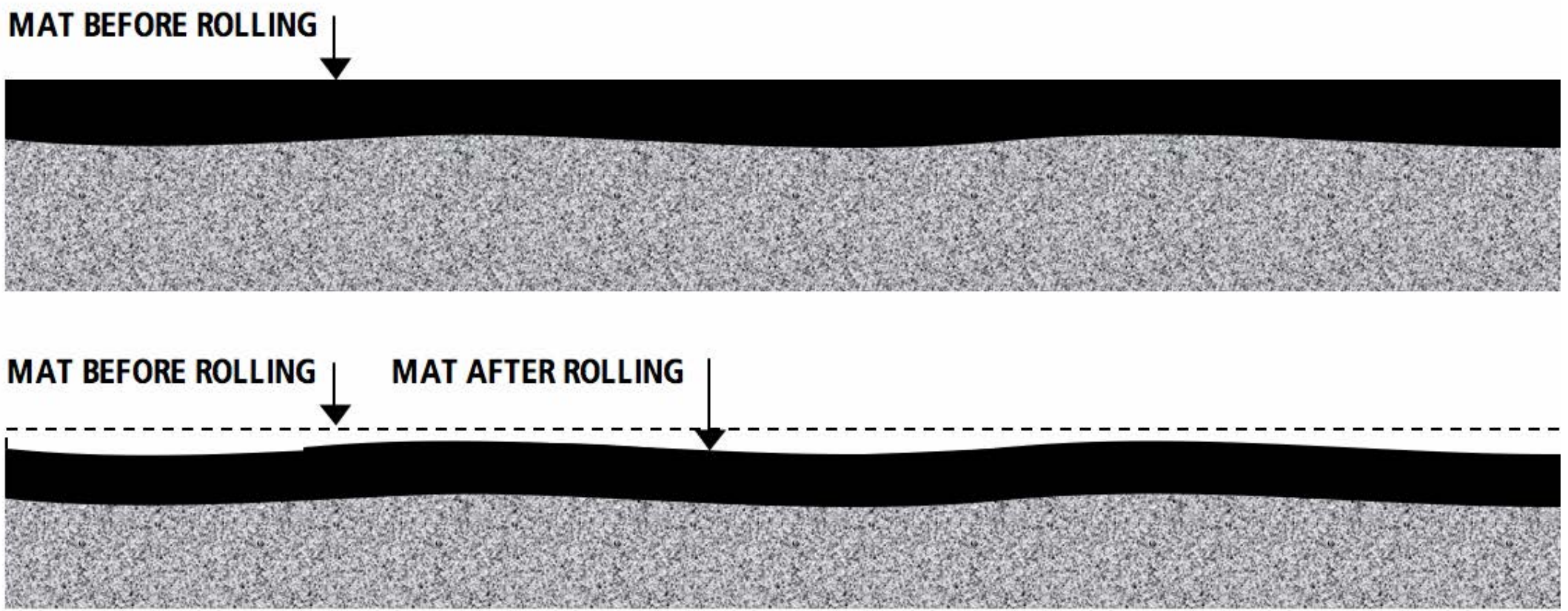
Existing Distresses – Rutted/Shoved

Milled Surfaces

Effects of Uneven Base



Fixed Depth Mill/Fill

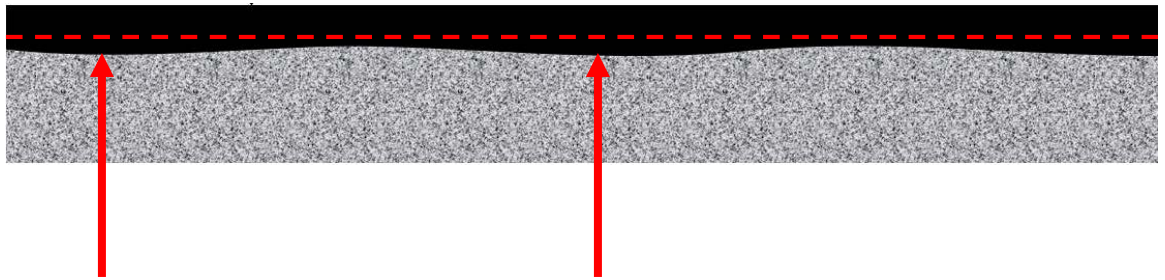


3D Variable Depth Milling

3D Target

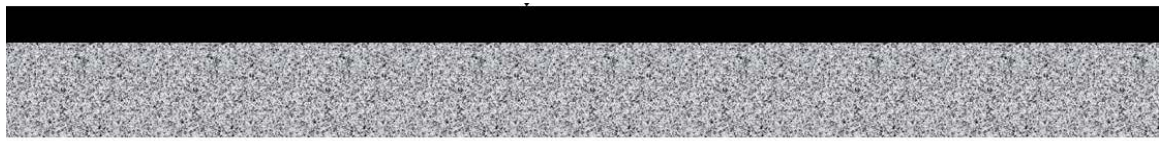
3D Robotic Total Station Tracking 3D Target

Fixed Depth vs. Variable Depth Milling

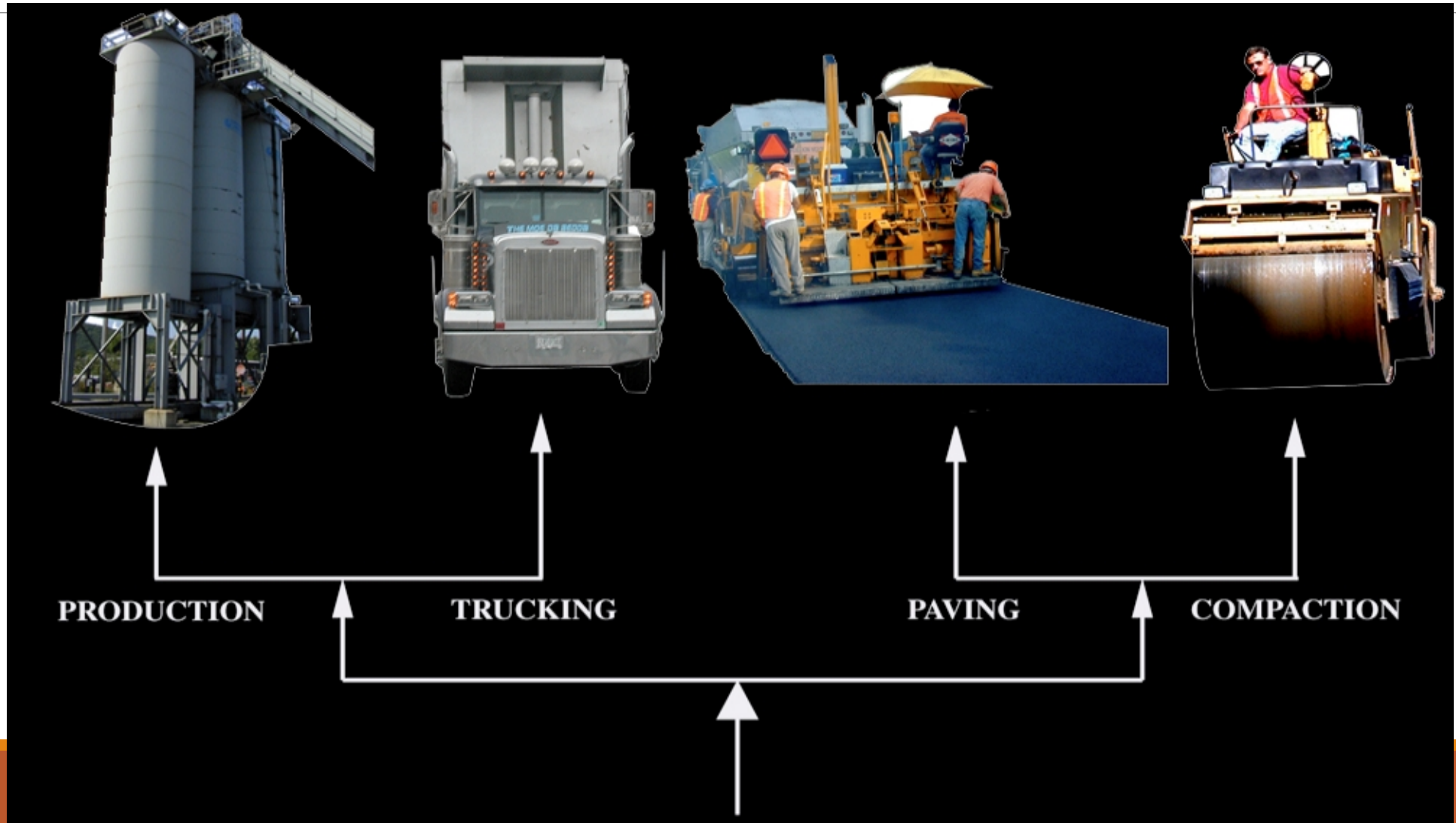


Asphalt filling of low spots

Variable Depth Milling minimizes asphalt usage

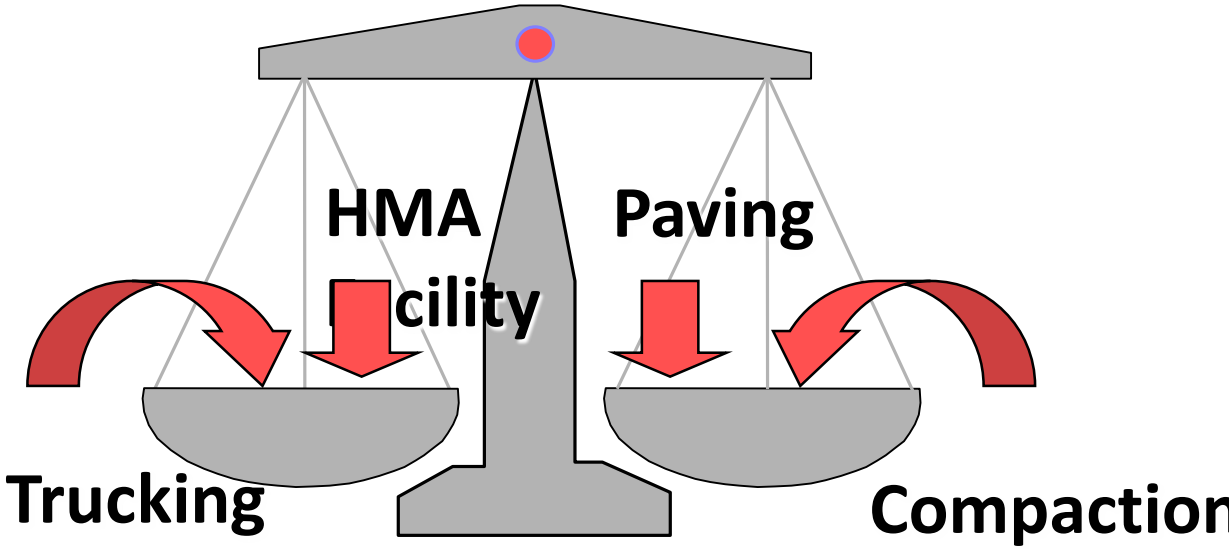


Coordinate Paving Process



Balance Paving Operation

- Verify available Plant Rate
- Calc. # of Trucks
- Calc. Paver Speed and Rate
- Calc. Roller Speed and Rate
- Check Balance
- Make Adjustments



Check Balance

	Tons	Speed	Prod. rate
Plant	190 x 8	---	---
Trucks	190 x 8	---	---
Paver	190 x 8	28.5 fpm	22.8 fpm
Roller	---	261 fpm	29.9 fpm

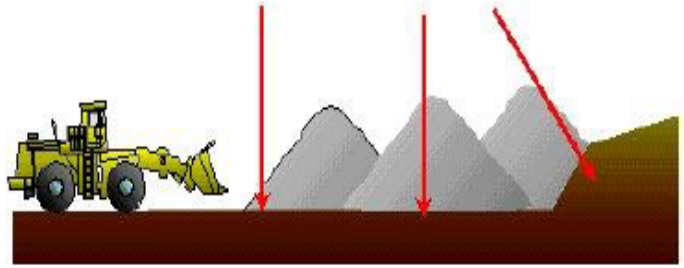
Stockpile Segregation

Avoid Stockpile Segregation

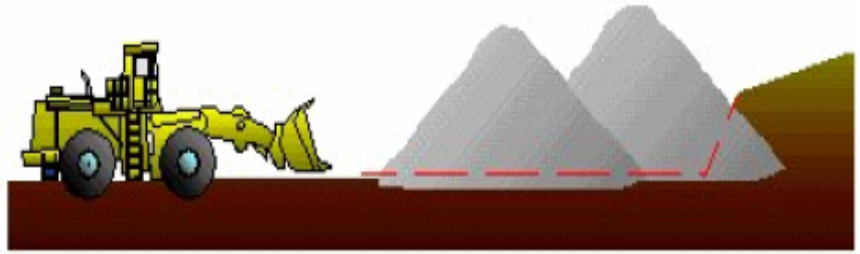
DON'T CONE UP

DO DUMP TIGHTLY IN SINGLE PILES

DON'T DIG UP THE MAT



DO KEEP THE BUCKET UP



CONTAMINATION

Meet Aggregate Blending Requirement

Meet Job Mix Formula

Asphalt Plant Automation and Monitoring

Silo Storage

Load Asphalt to Haul Trucks

End Dump

Windrow

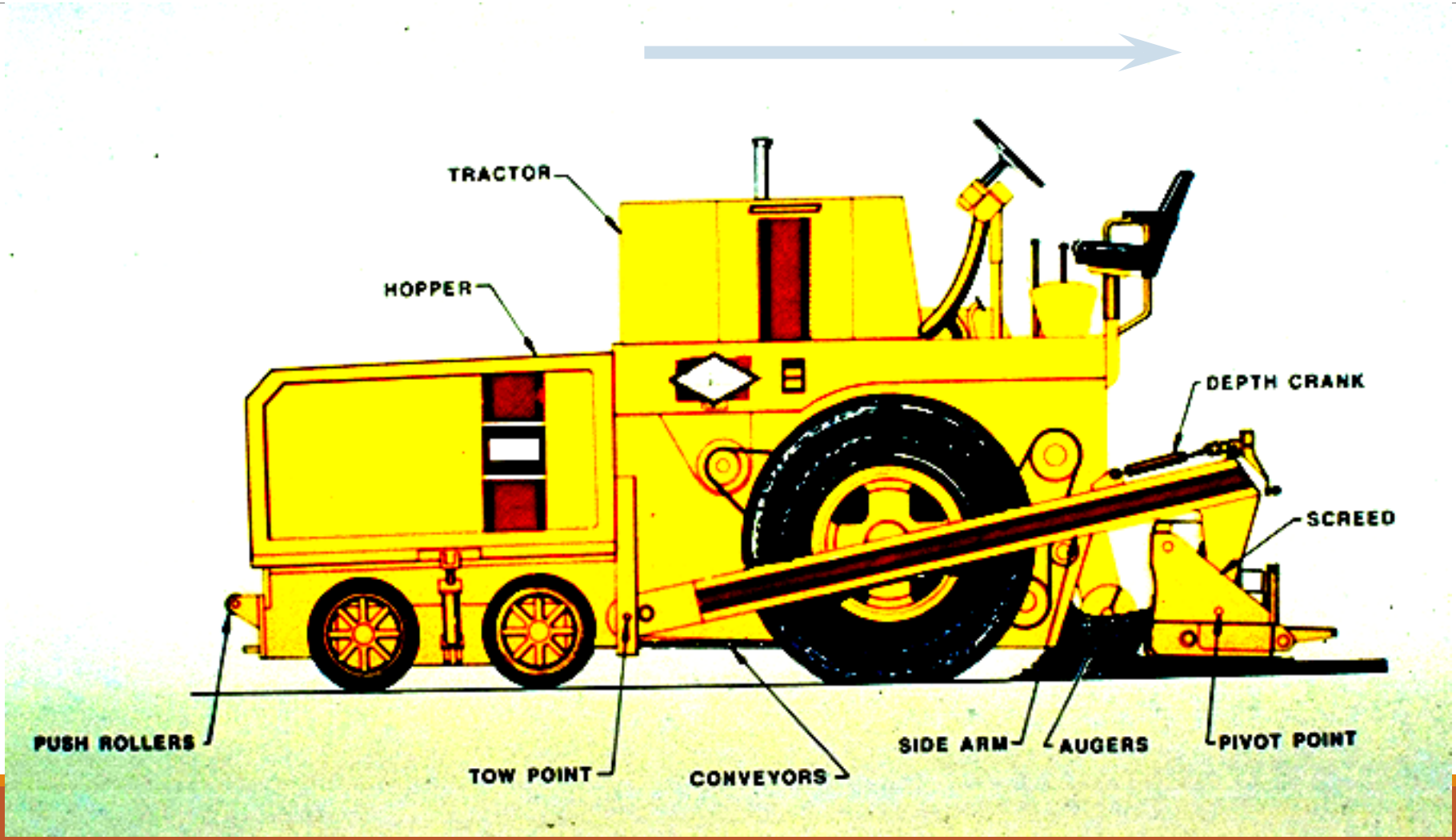
Re-mix with MTV

MTV to Hopper

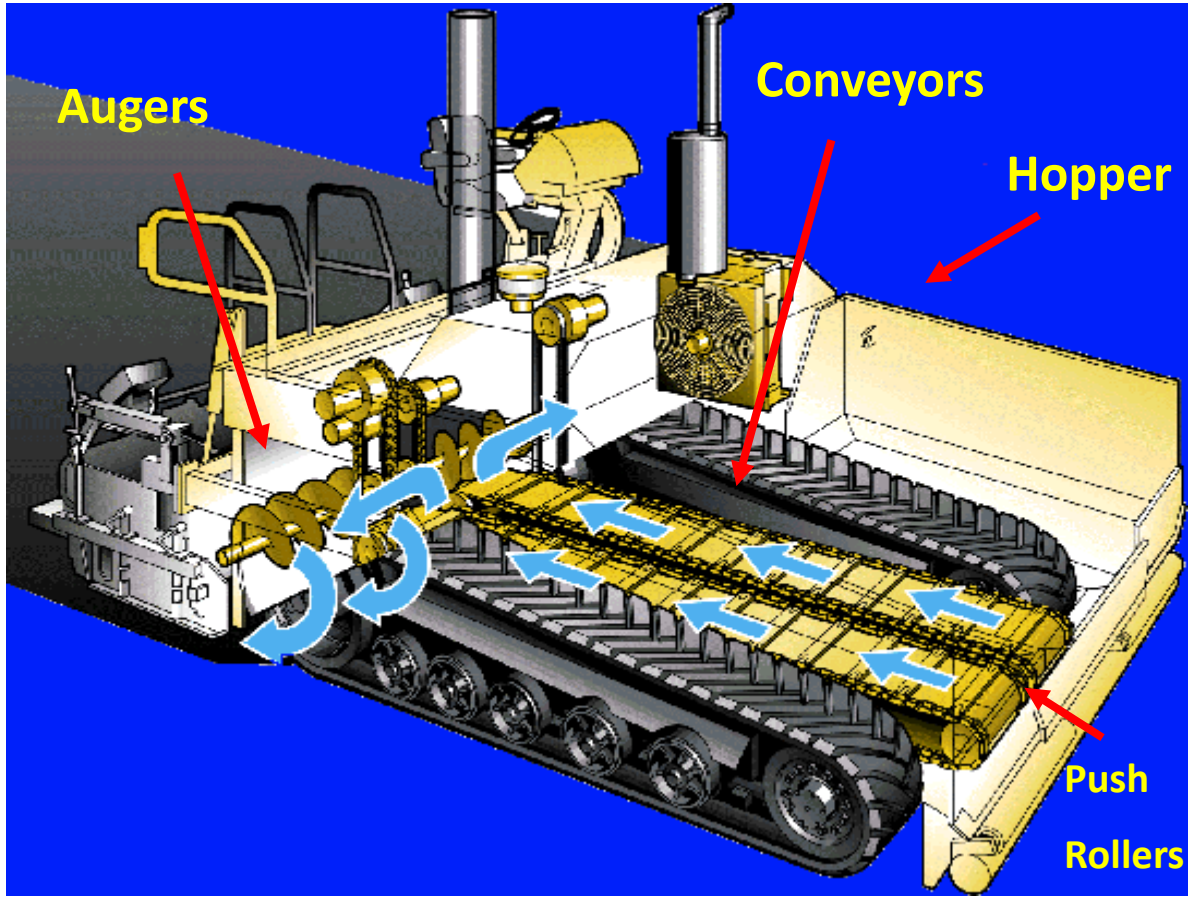
Comparison of Temperature Segregation

Hopper

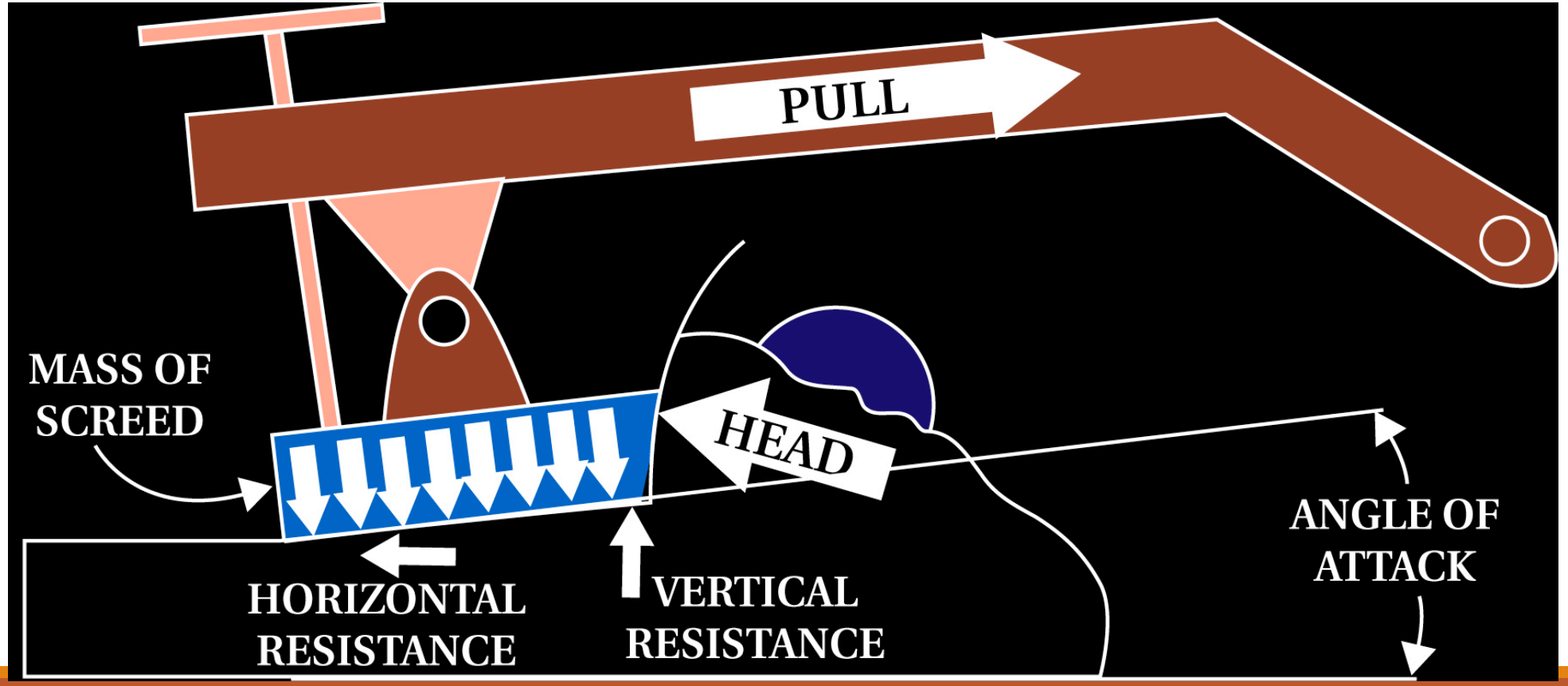
Components of Paver



Dual-Feed Paver System



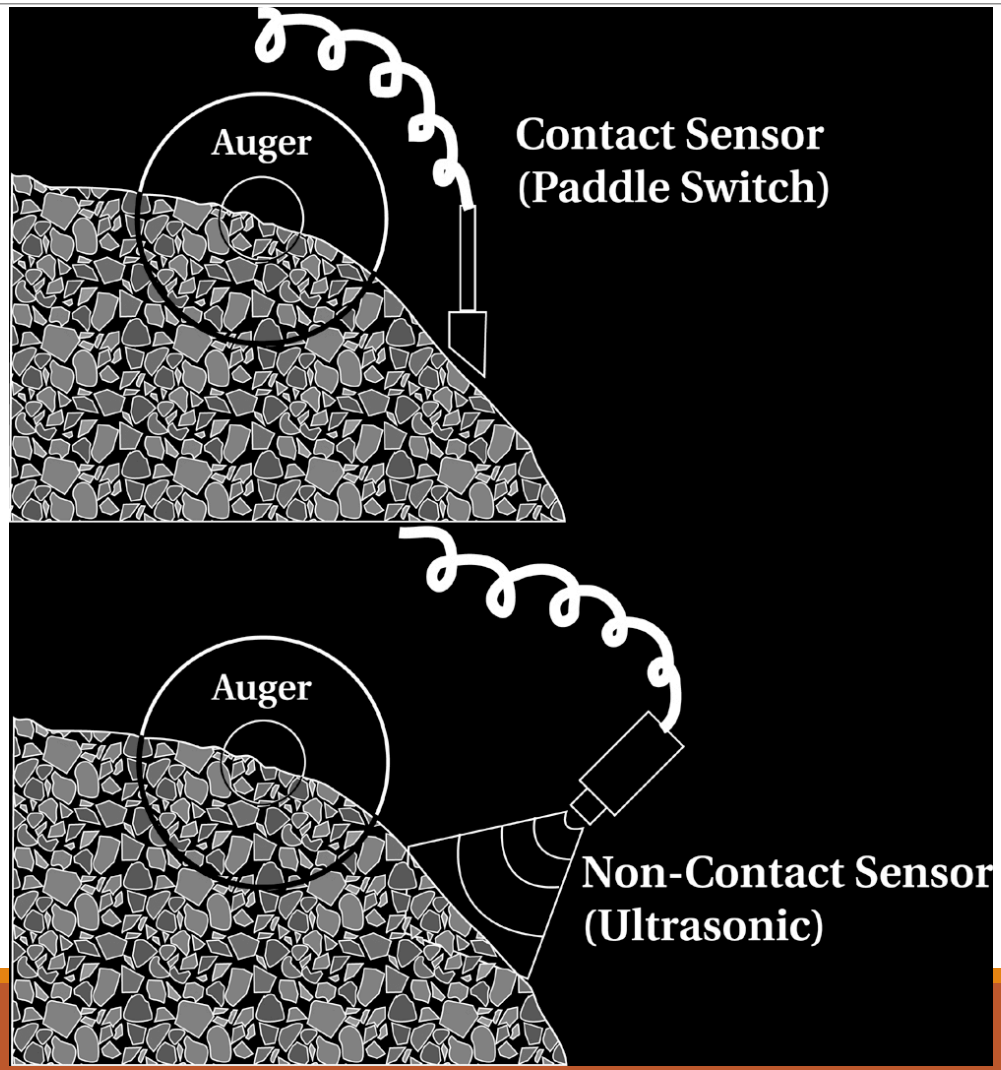
Mechanism of Screed



Uniform and Constant Head

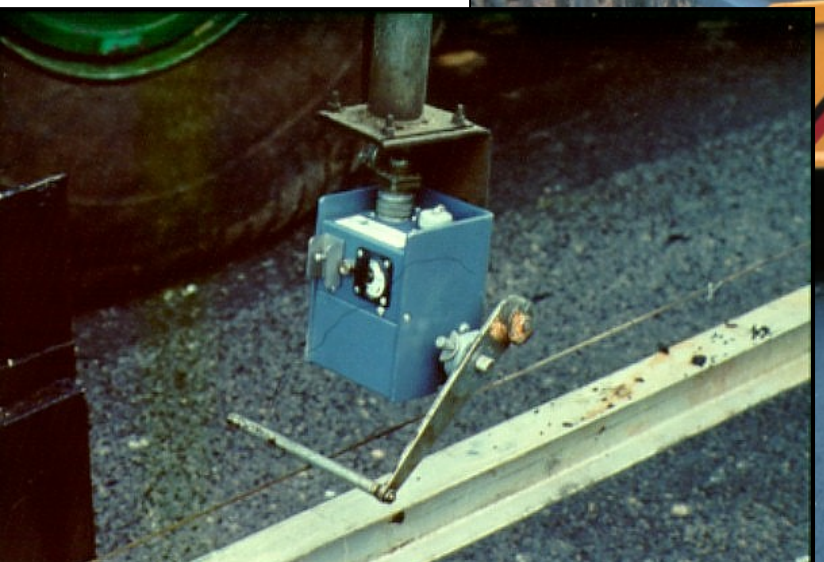
NAPA

Automatic Flow Controls

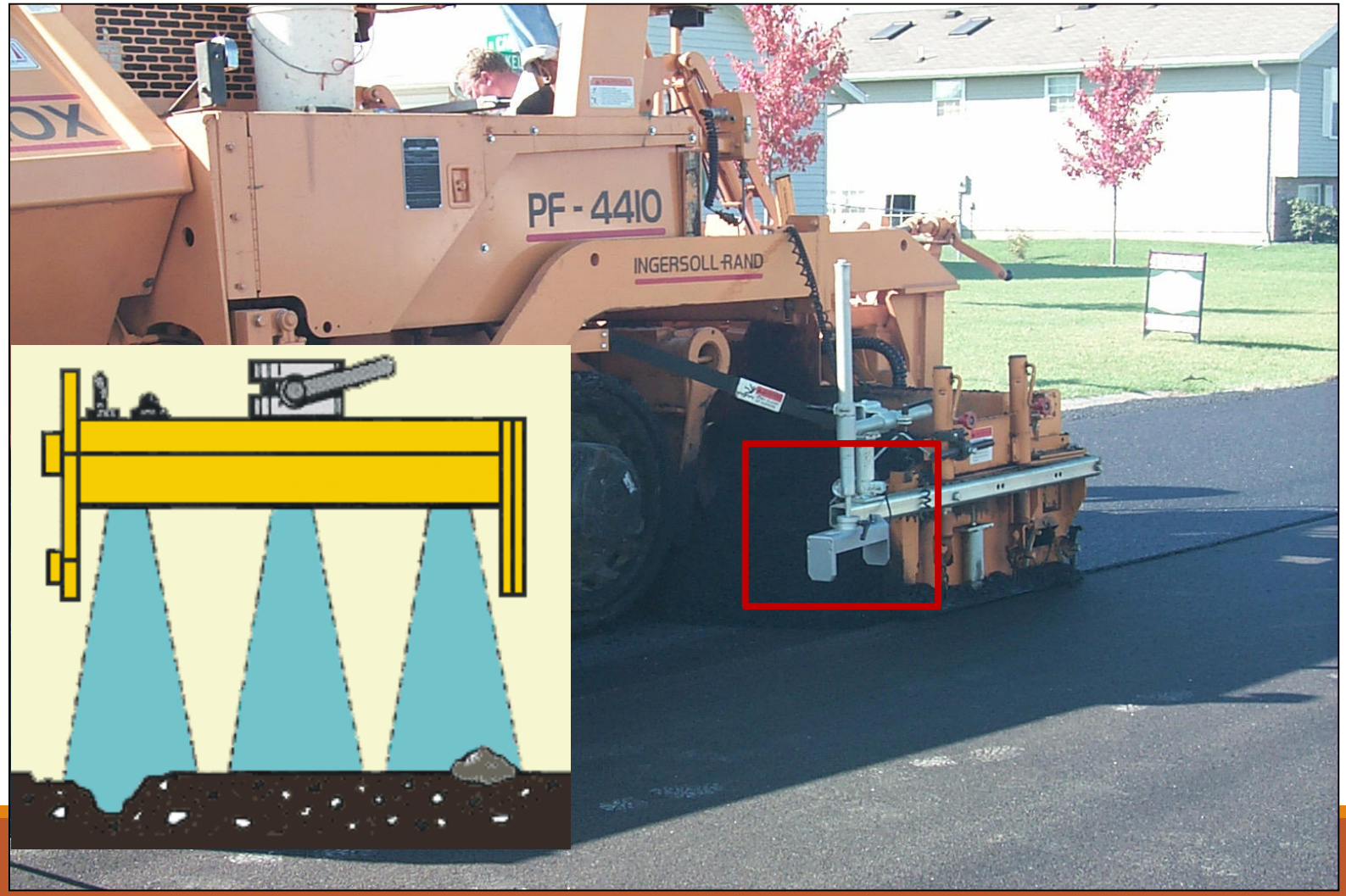


Elevation/Slope Control

Elevation/Slope Control



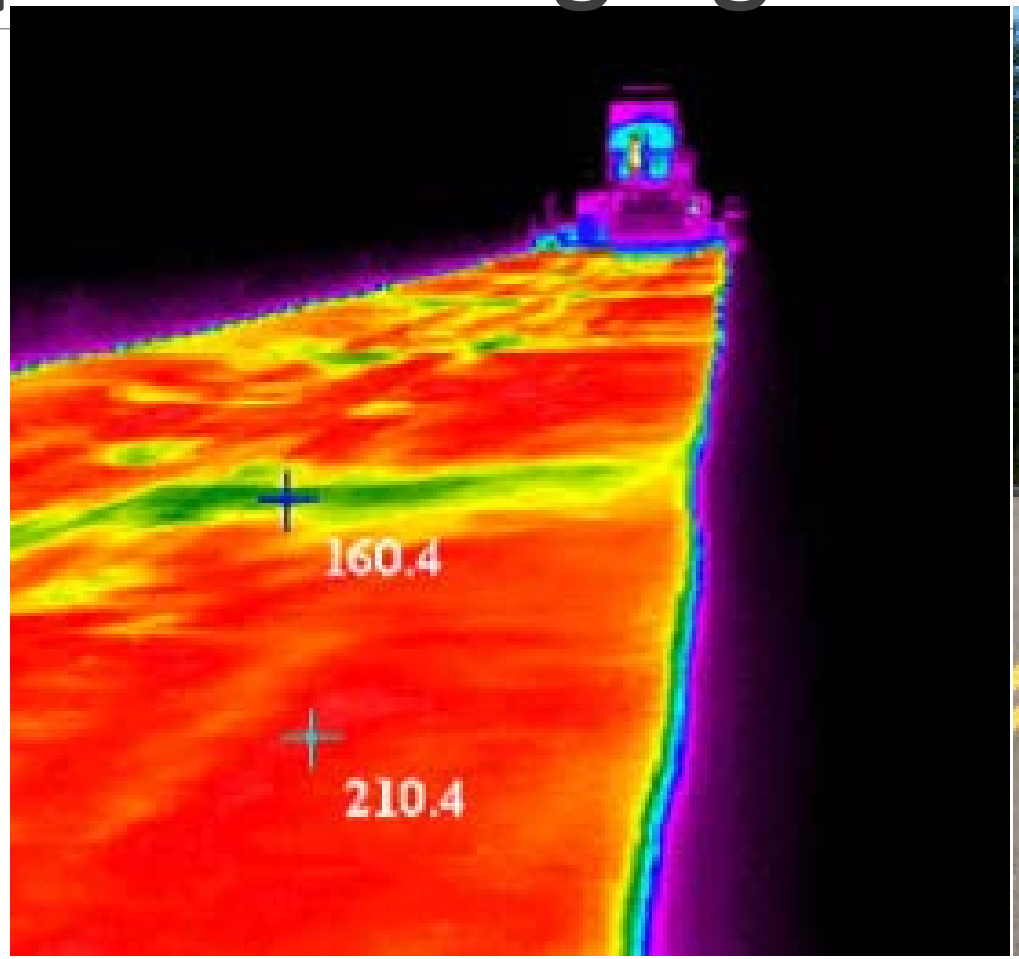
Elevation/Slope Control



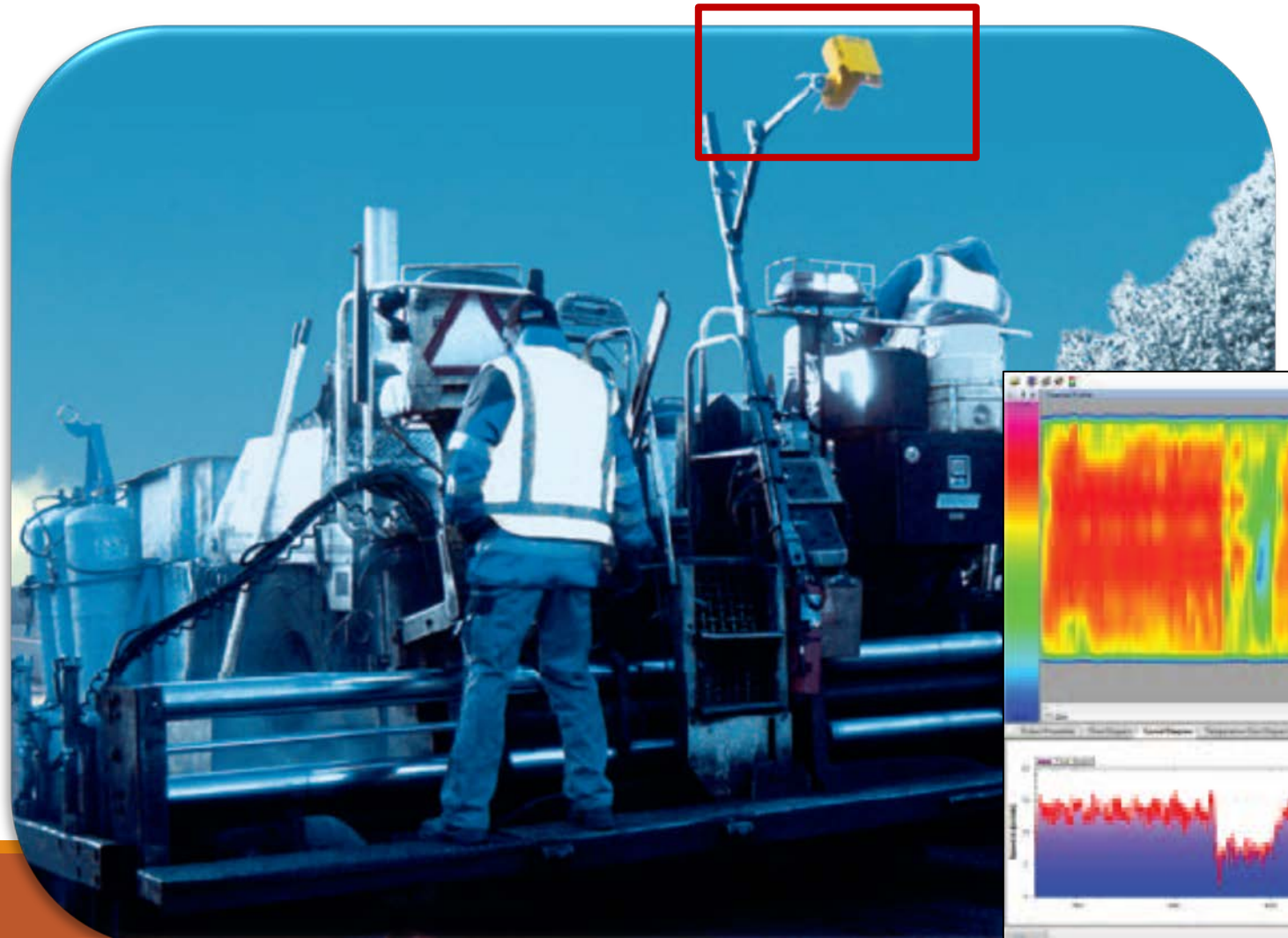
Real Time Smoothness

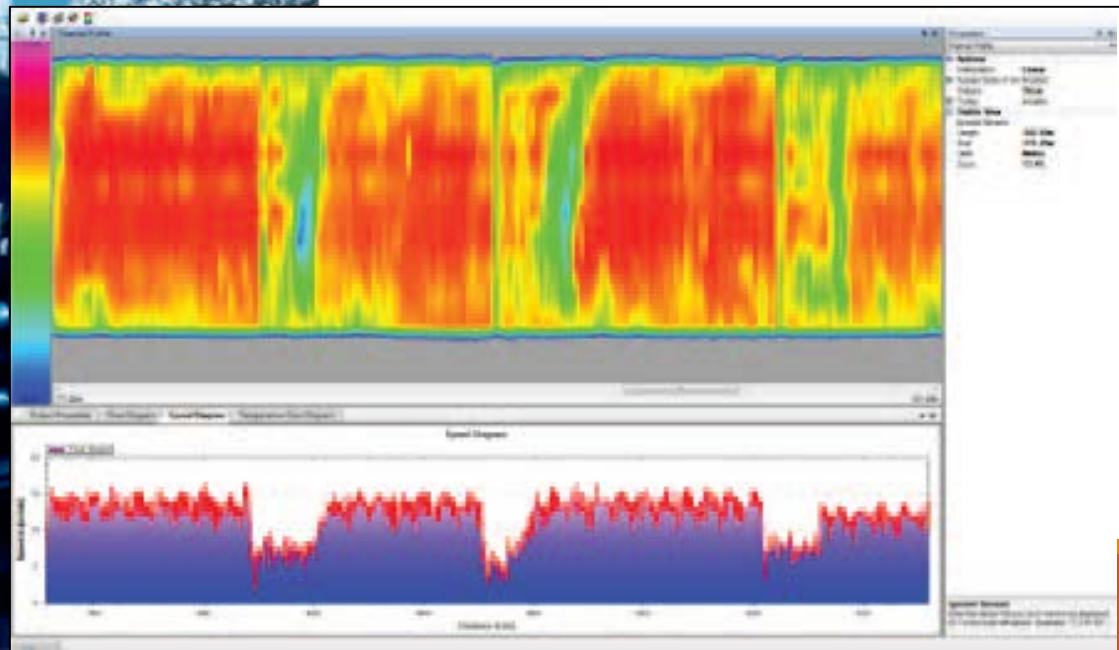
Real Time Temperature Monitoring

Temperature Segregation

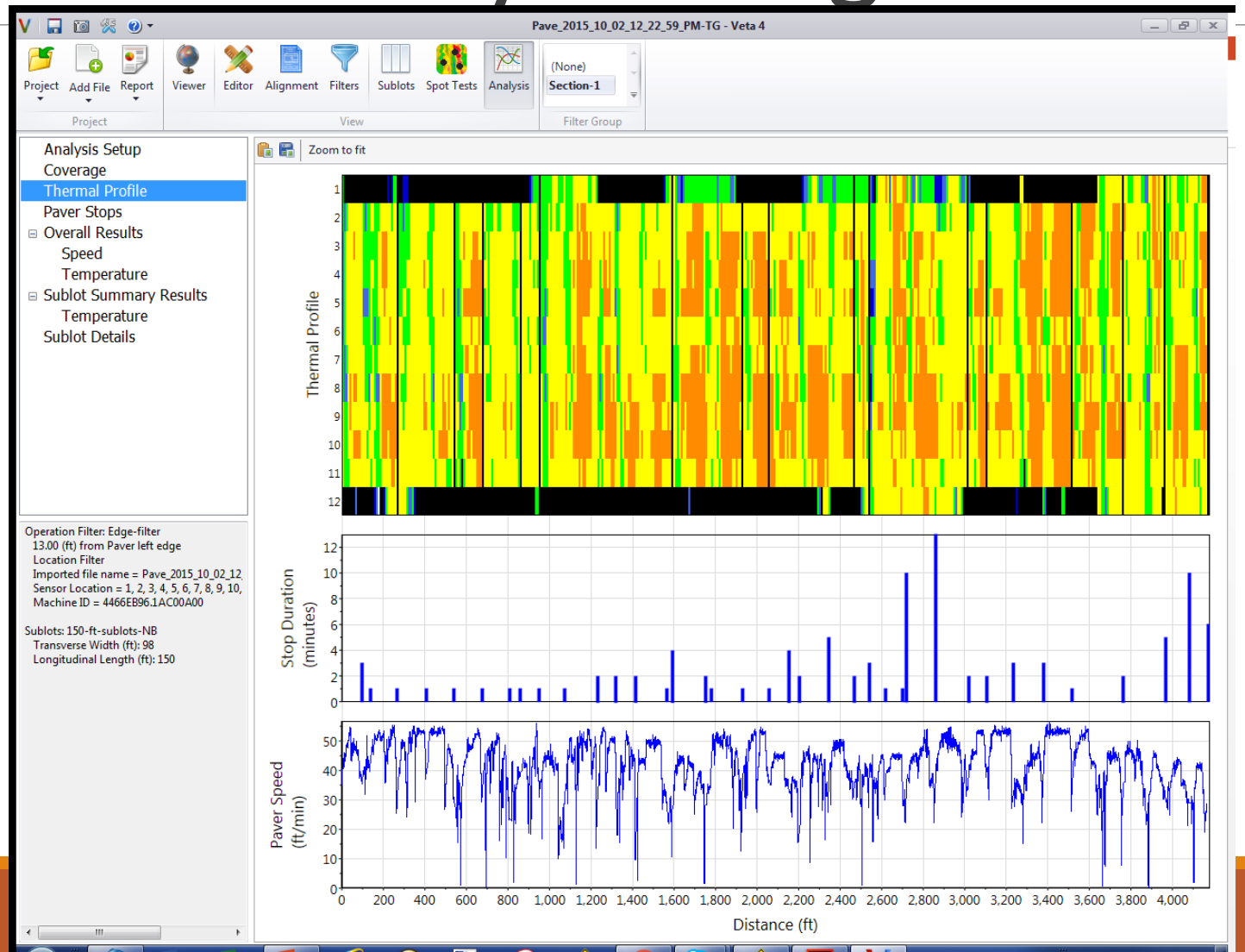


Paver-Mounted Thermal Profiler

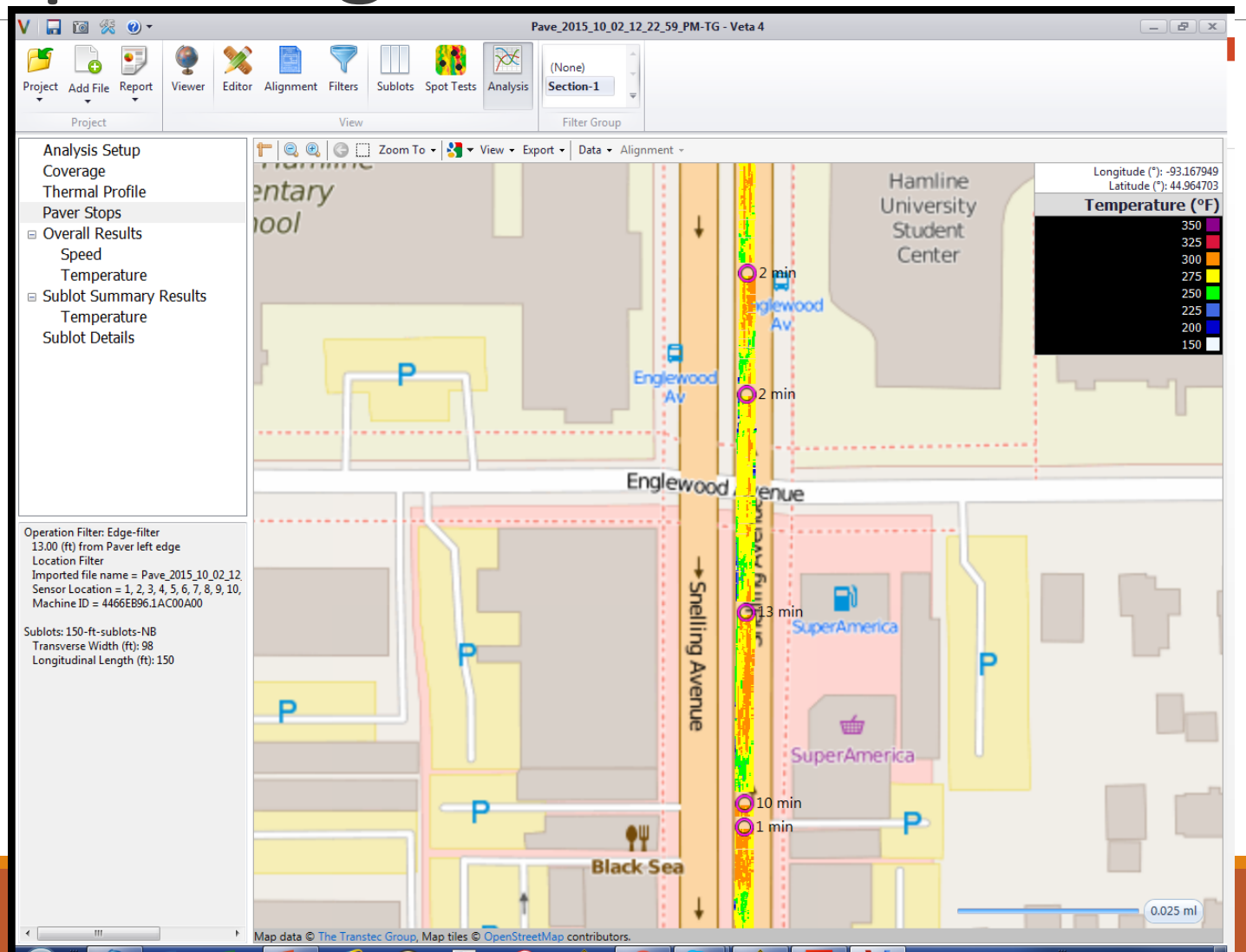




Thermal Profile Analysis using Veta



Paver Stops using Veta



Materials Segregation

Incorrect Mix Aggregate Size

Leveling Excessive Crown

Placing Leveling Courses

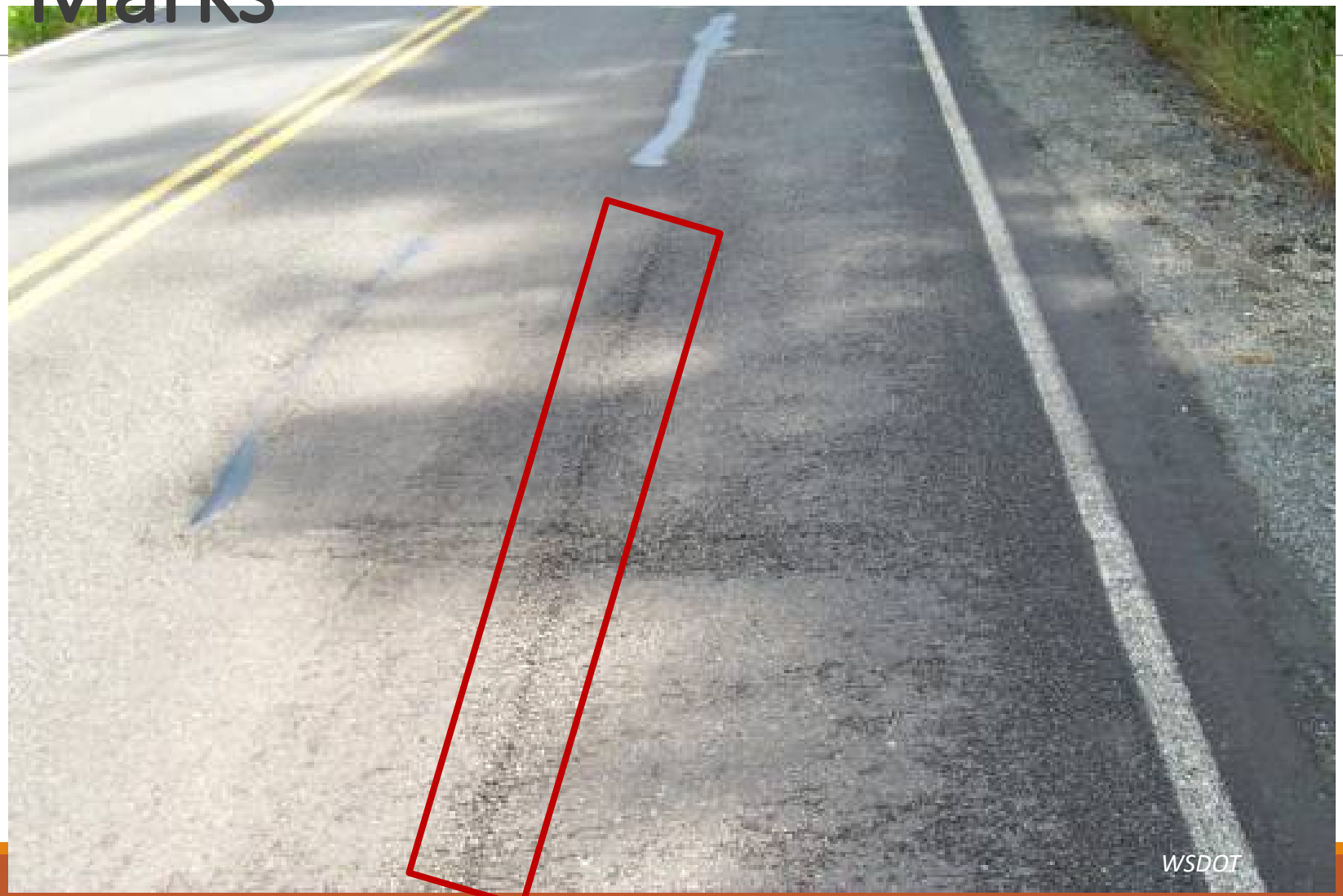
Balanced Paver Speed

Paver Stops

Compaction

Roller Marks

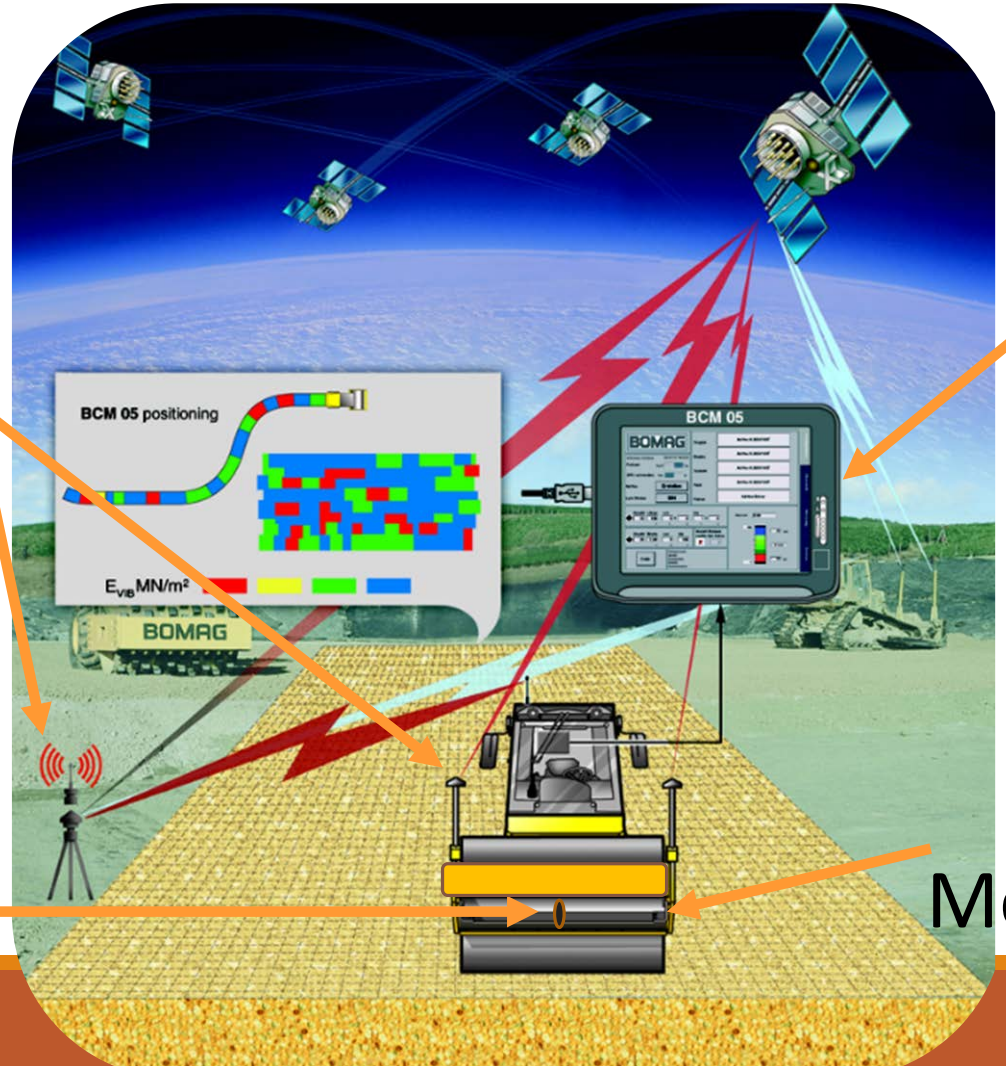
Roller Marks



3D Paving

Intelligent Compaction (IC)

Global Positioning System GPS

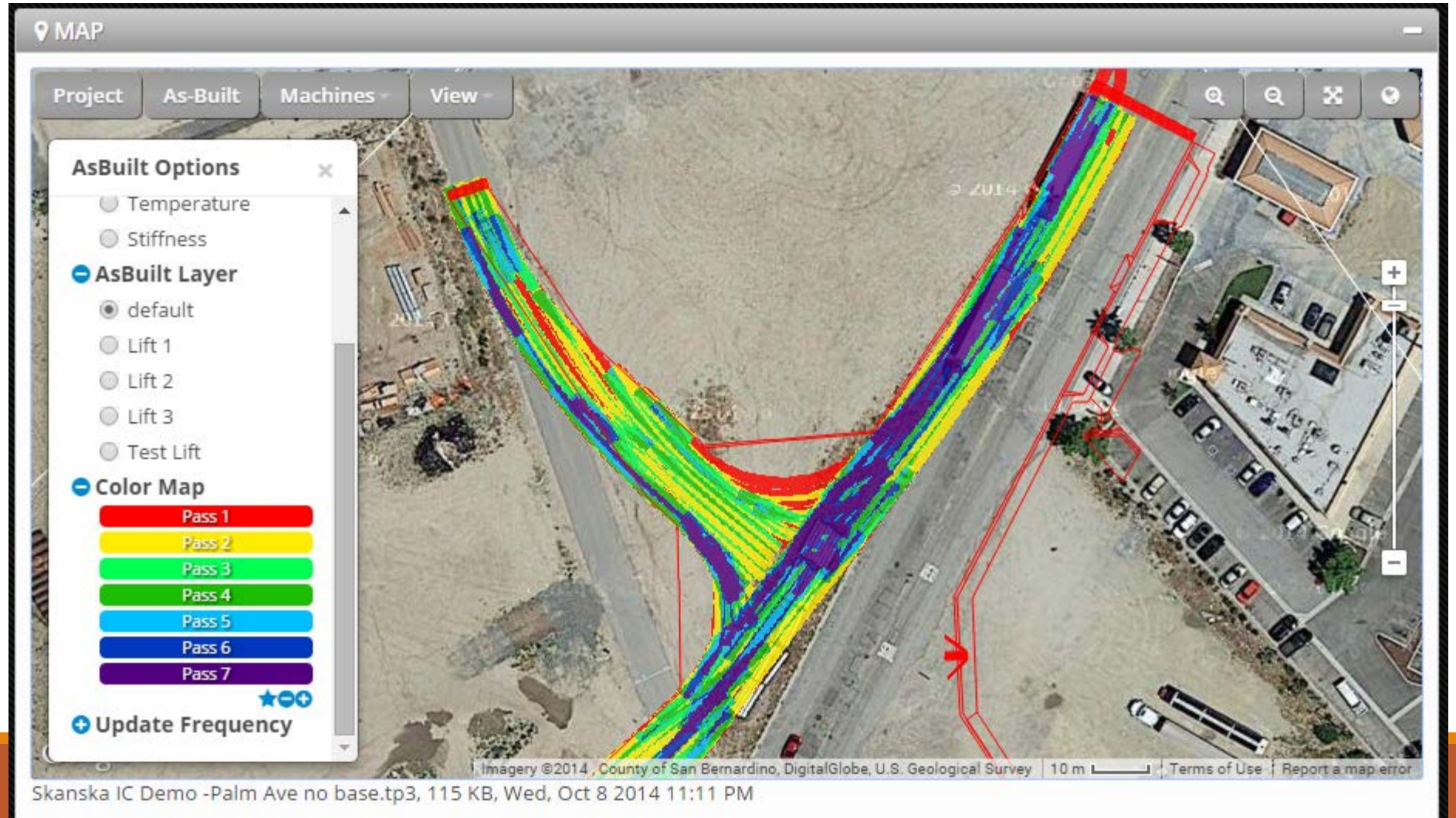


Onboard Report System

Temperature Sensors

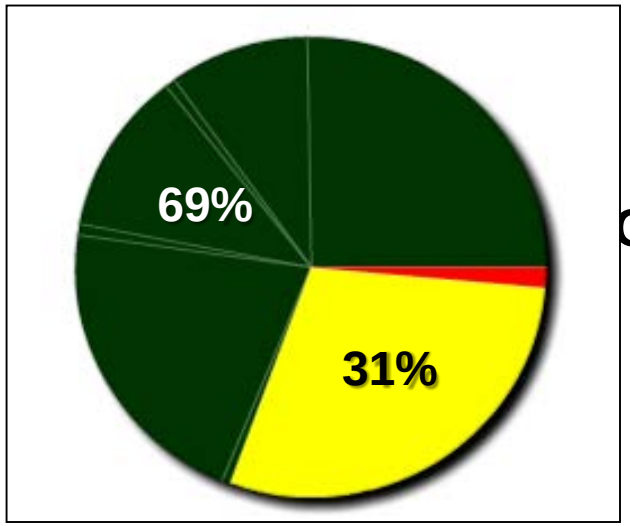
Continuous Measurement System

IC Tracks Roller Passes, Temperatures….

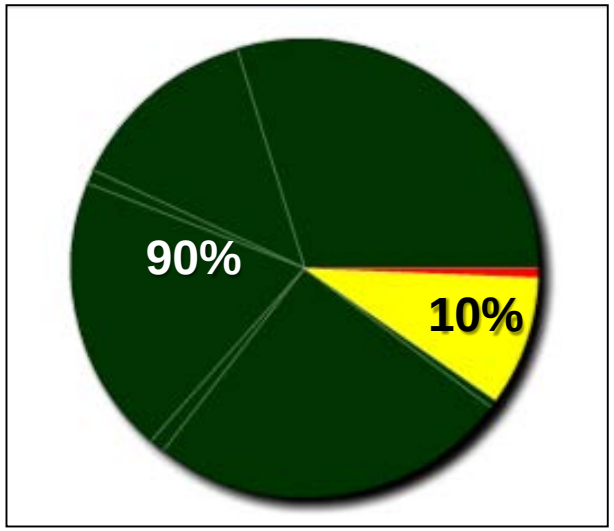


Skanska IC Demo -Palm Ave no base.tp3, 115 KB, Wed, Oct 8 2014 11:11 PM

IC Improve Roller Coverage & Consistency



30% Increase in Compaction Efforts



Lift 1 without IC

< 3 Passes: 31 %
≥ 3 Passes: 69 %
COV : 71%

Lift 2 with IC

< 3 Passes: 10 %
≥ 3 Passes: 90 %
COV: 55%

Courtesy of MNDOT

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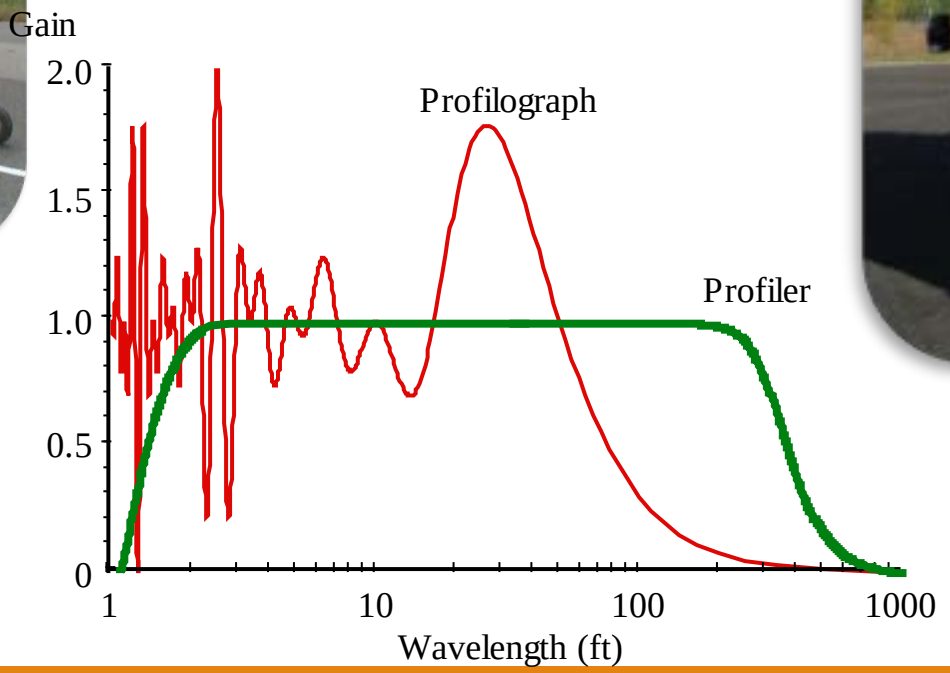
- What is Smoothness
- Design Consideration
- Best Practices for Asphalt Paving
- **Improve Smoothness with ProVAL**

INDOT – from PrI to IRI



INDOT – from PrI to IRI

INERTIAL PROFILER WITH SMOOTHNESS PAY ADJUSTMENTS FOR HMA

The Standard Specifications are revised as follows:

SECTION 401, BEGIN LINE 535, DELETE AND INSERT AS FOLLOWS:

401.18 Pavement Smoothness

Pavement smoothness will be accepted by means of *an* ~~profilograph~~*inertial profiler*, a 16 ft long straightedge, or a 10 ft long straightedge as described below.

(a) ~~Profilograph~~*Inertial Profiler with Smoothness Pay Adjustments*

When a pay item for ~~Profilograph~~*Inertial Profiler*, HMA is included in the contract,

401.18 Pavement Smoothness

Pavement smoothness will be accepted by means of *an* ~~profilograph~~*inertial profiler*, a 16 ft long straightedge, or a 10 ft long straightedge as described below.

(a) ~~Profilograph~~*Inertial Profiler with Smoothness Pay Adjustments*

rate of surface, intermediate, and base courses is 385 lb/sq yd or greater.

The ~~profilogram~~*profiles, International Roughness Index, IRI, results including smoothness histograms and areas of localized roughness, and fixed interval IRI results* produced shall become the property of the Department. The ~~profilograph~~*inertial profiler* shall remain the property of the Contractor.

INDOT Draft IRI Spec for HMA

PAY FACTORS FOR SMOOTHNESS Design Speed greater than 45 mph	
IRI, in./mi.	*Pay Factor, PF*
over 0 to 40	*1.06*
over 40 to 45	*1.04*
over 45 to 50	*1.03*
over 50 to 55	*1.02*
over 55 to 70	*1.00*
over 70 to 75	*0.98*
over 75 to 80	*0.97*
over 80 to 85	*0.96*
over 85	*0.94*

Localized Roughness

> 150 in./mi.

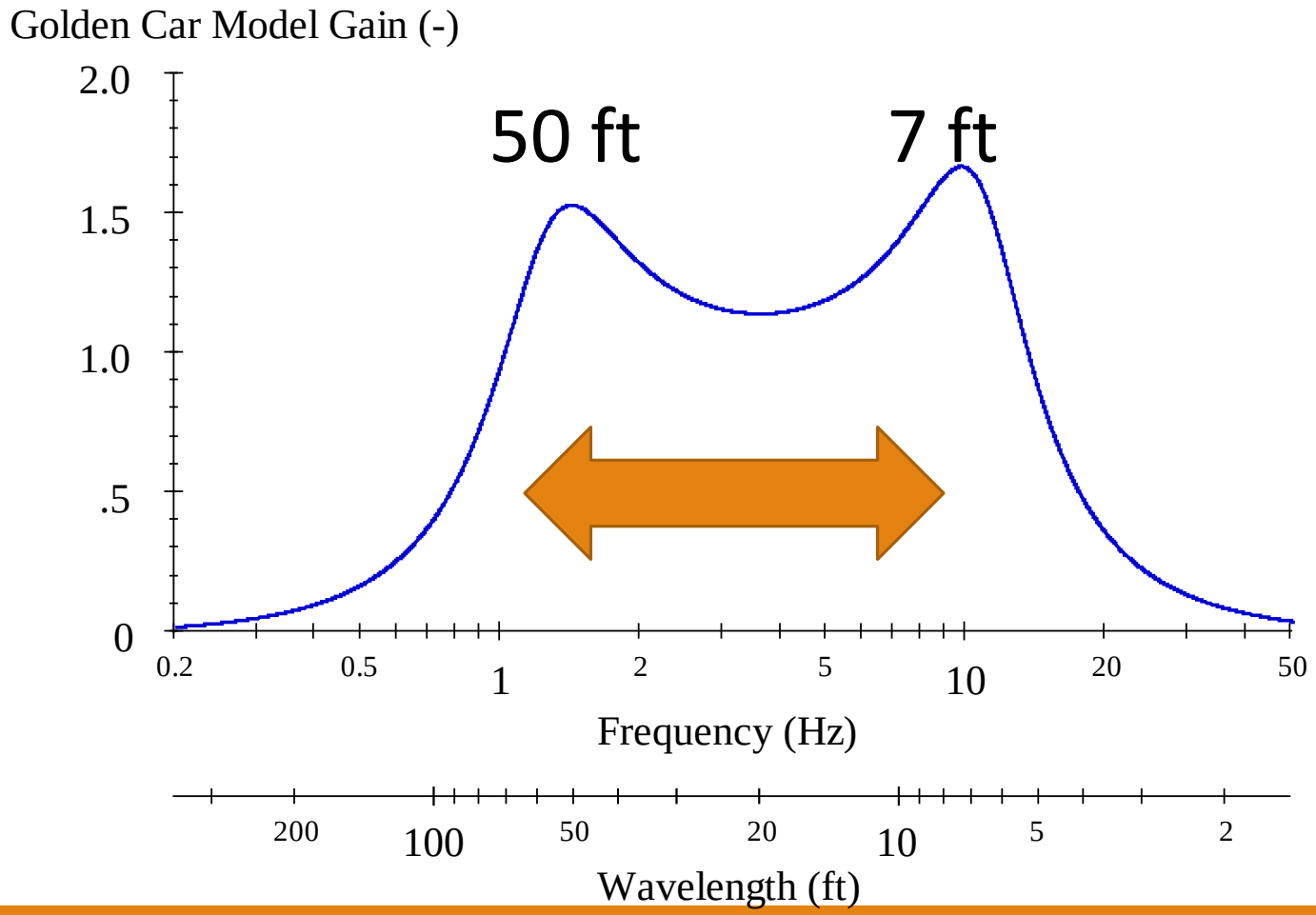
INDOT Draft IRI Spec for PCCP

PAY FACTORS FOR SMOOTHNESS Design Speed greater than 45 mph	
IRI, in./mi.	*Pay Factor, PF*
over 0 to 35	*1.08*
over 35 to 40	*1.07*
over 40 to 45	*1.05*
over 50 to 55	*1.02*
over 55 to 60	*1.01*
over 60 to 70	*1.00*
over 70 to 75	*0.99*
over 75 to 80	*0.98*
over 80 to 85	*0.96*
over 85	*0.95*

Localized Roughness

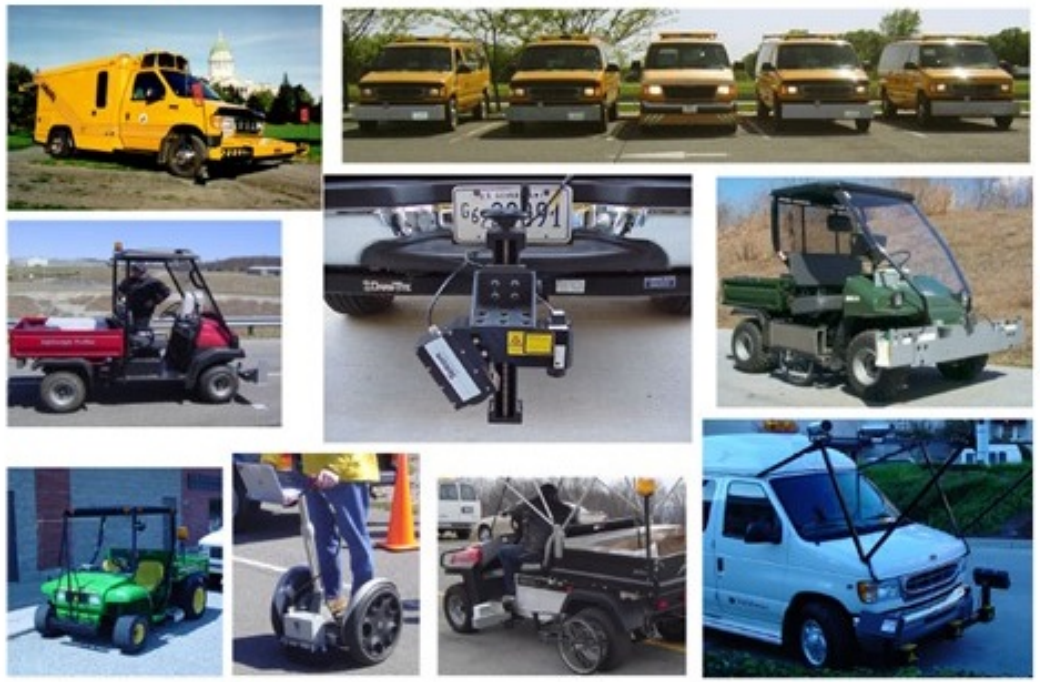
> 150 in./mi.

IRI Gain Chart

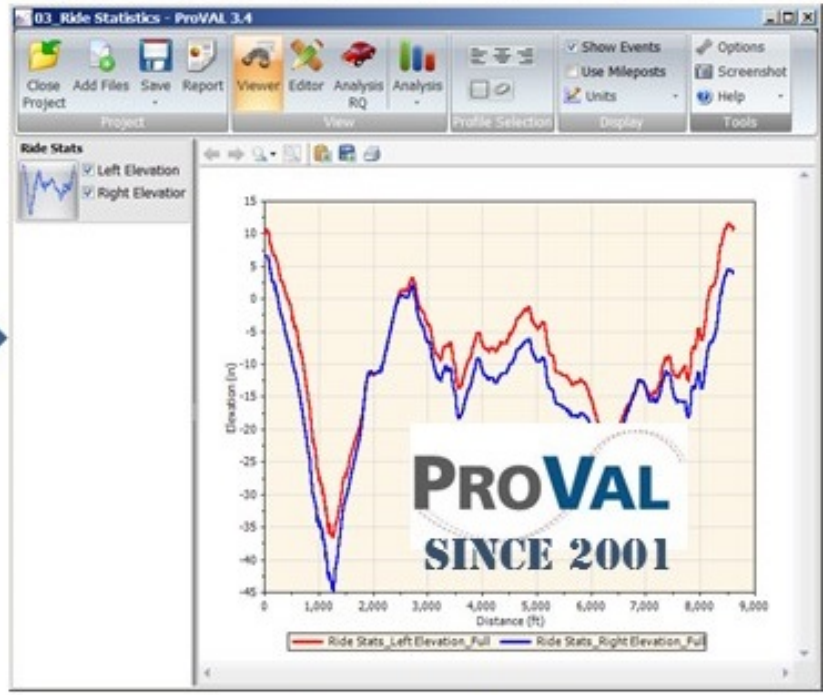


Use ProVAL to Improve Smoothness

Many Different Profilers…

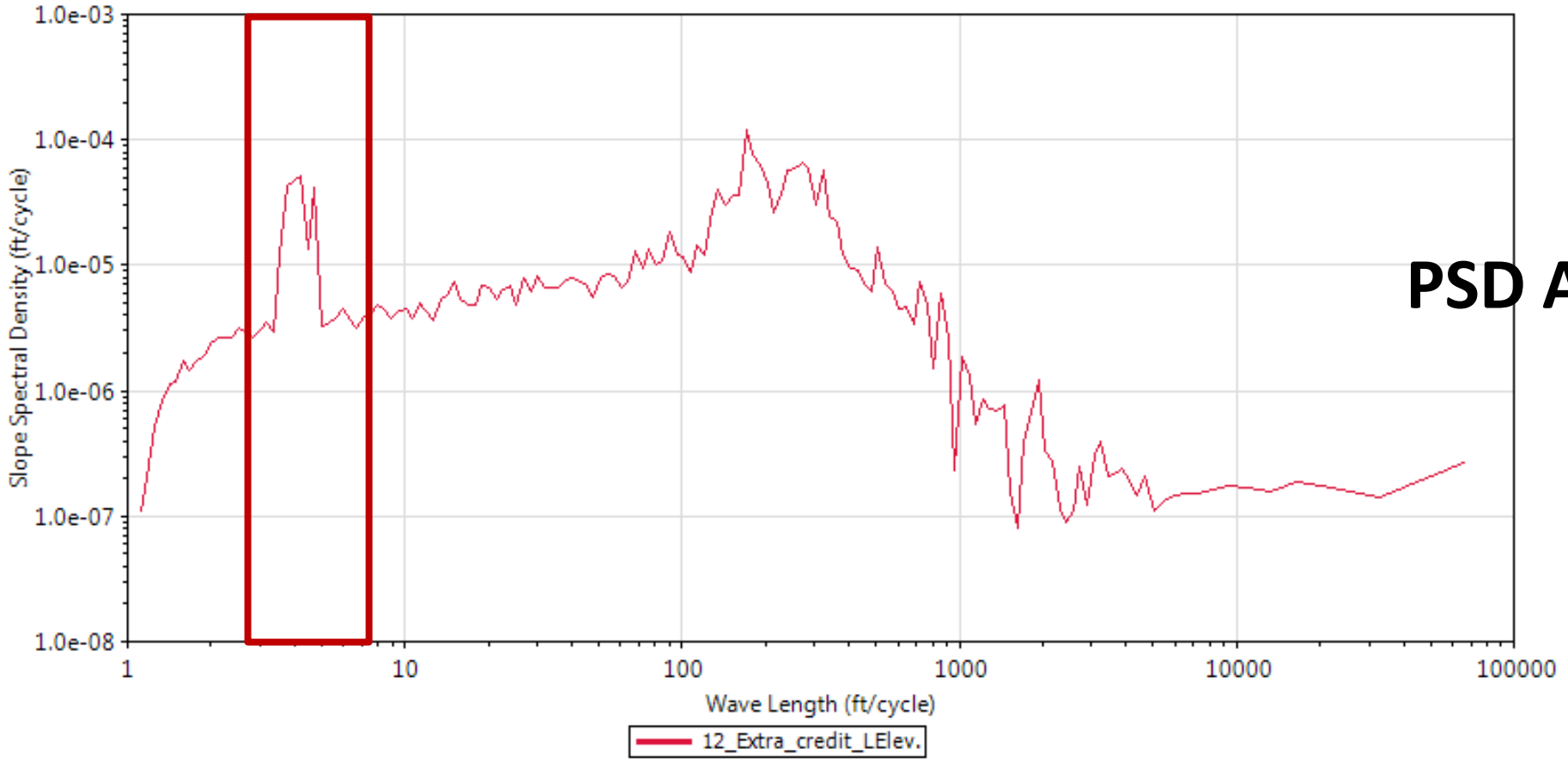


One Standard Software



Use ProVAL to Diagnose Smoothness Issues

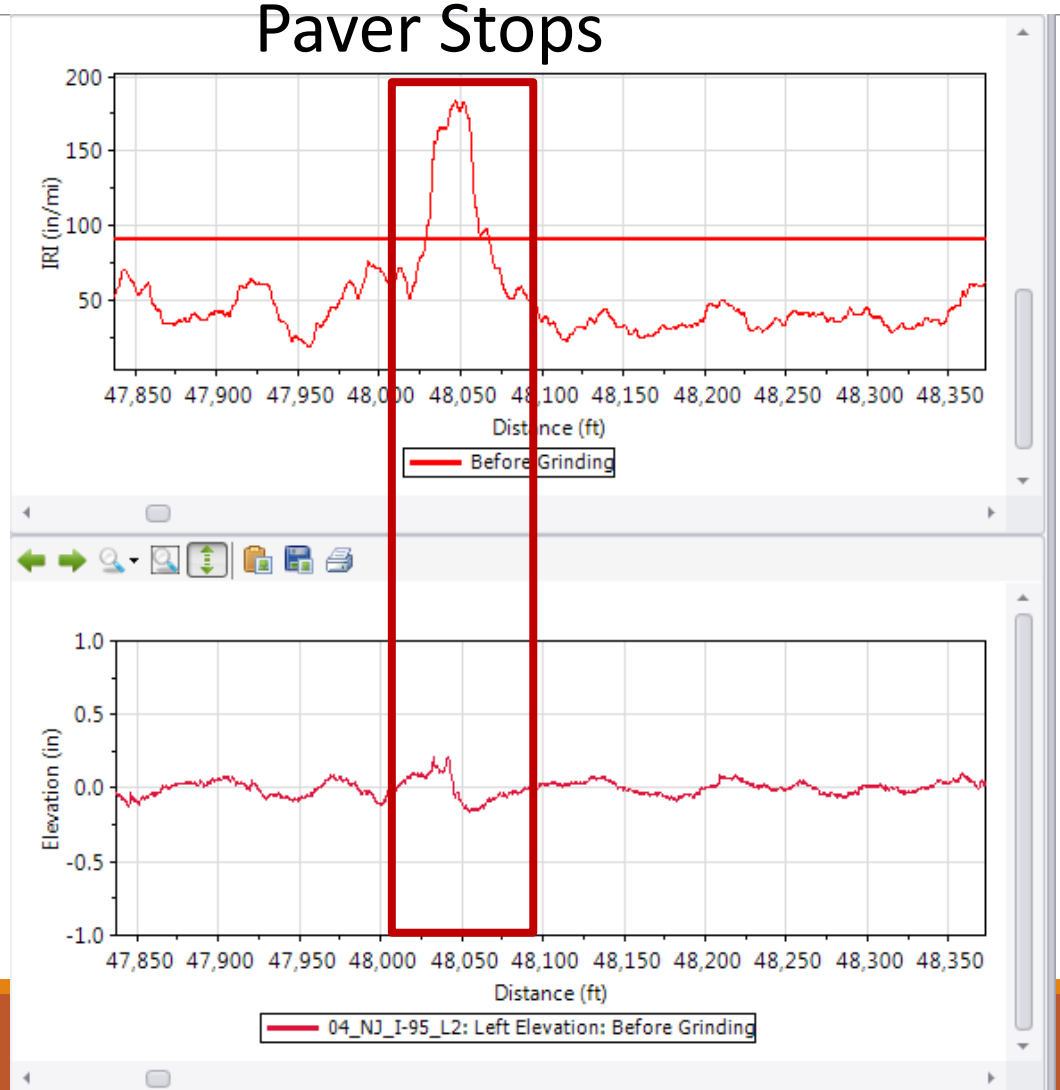
Inadequate Roller Freq/Amp Settings



PSD Analysis

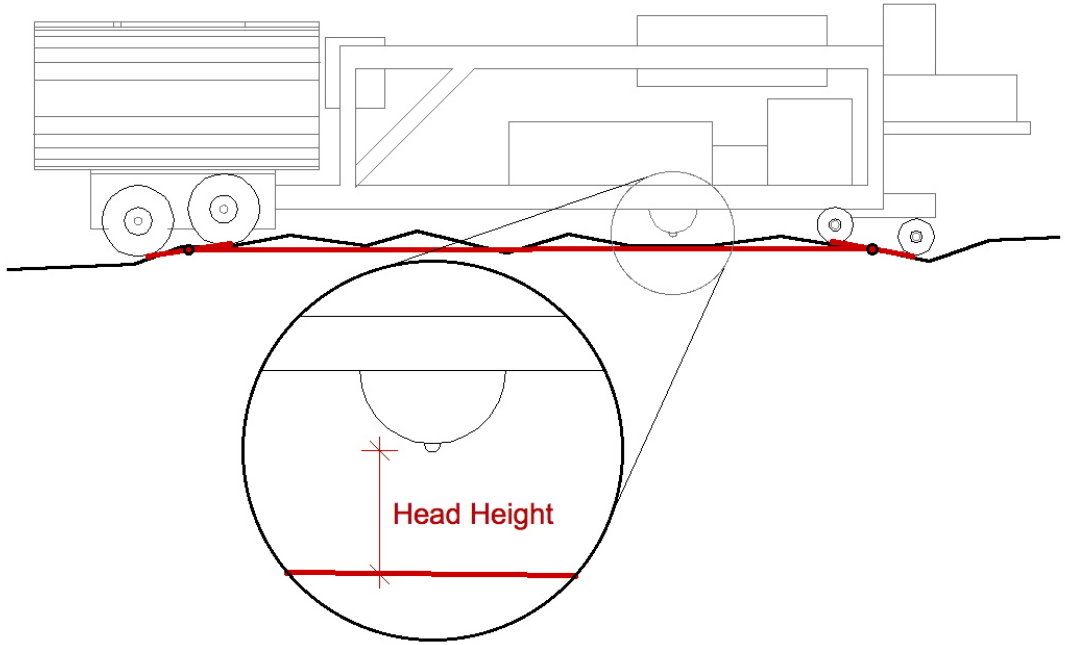
Use ProVAL to Diagnose Smoothness Issues

Paver Stops

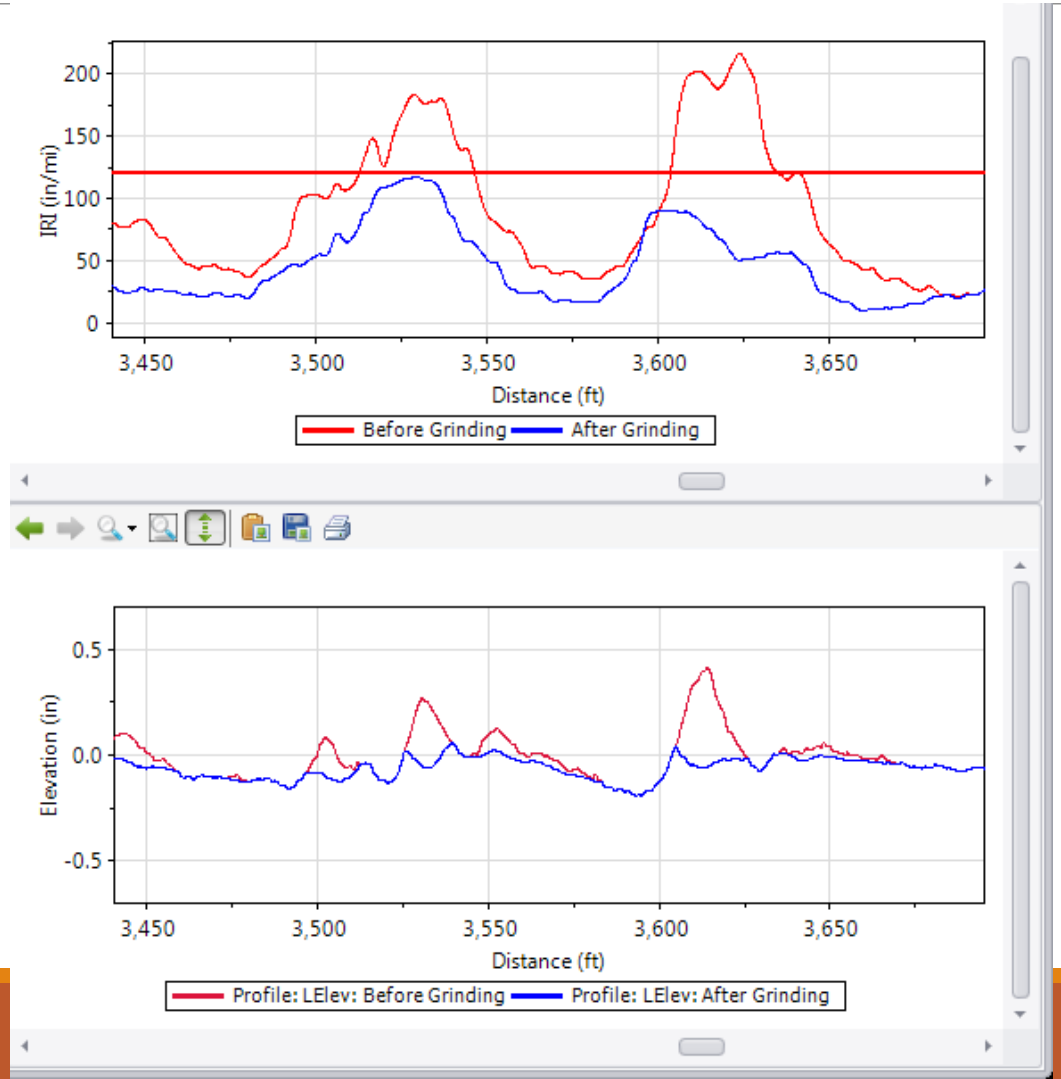


SAM Analysis

ProVAL Grinding Simulation

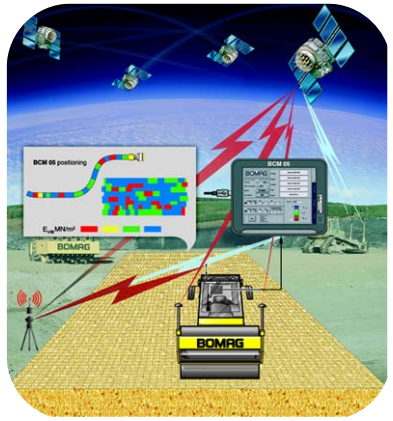


Use ProVAL to Optimize Grinding



Quality Paving – Smoother Pavements

Best Practices with Modern Tools



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Further information

www.RoadProfile.com

Thank You!

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