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# Asphalt Pavement Scanner

Dielectric – Compaction – Roughness

Thickness – Surface Temperature

Push Cart – Vehicle Mount – Roller Mount

Presented by Chuck Oden

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# Asphalt Pavement Scanner (APS)

- Wireless (WiFi)
- 2 GHz GPR
- Precision GNSS
- IR temperature
- IMU


- Height / roughness
- Pass count
- Thickness
- Temperature
- Dielectric / compaction / density

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# Scan Head Overview

- ⇒2 GHz GPR, IR Temperature sensor
- ⇒IMU, GNSS
- ⇒Dual batteries – hot swap – 9 hours
- ⇒PointPerfect GPS
  - ⇒5 cm accuracy
  - ⇒Contiguous US, Europe, Southern Canada, S. Korea, and coastal Australia and Brasil
- ⇒RTK GPS
  - ⇒1 cm accuracy
  - ⇒Requires CORS network

# Push Cart

- Lowest cost
- Dielectric, density, thickness, surface temperature
- Great for joint and center line measurements
- Light weight (~40 lbs), easy to load/unload
- Not recommended for roughness measurements

# Vehicle Mount

- Safer than cart for workers
- Easier to cover more ground
- Use existing job site vehicle
- User does not leave vehicle
- 2” trailer hitch
- Typical survey speed is 10 mph
- Automatic lift for periodic background calibration
- Can choose sensors / spacing

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# Vehicle Mount

- Lift stays on truck
- Attach outriggers / sensor in 5 minutes
- Consider mounting on small utility vehicle

# Developing Roller Mounted Configuration

- ⇒Clamps adaptable to most rollers
  - ⇒Model specific configuration
- ⇒Quick connect arm extension
- ⇒Base mount stays on roller
- ⇒Auto background calibration (30 minutes)
- ⇒Sensor on both front / back of roller
  - ⇒Better coverage
  - ⇒Use dry side measurement
  - ⇒Surface moisture sensor
- ⇒Stiffness? Intelligent compaction?

# Acquisition Software

- ⇒Real time map display
- ⇒Reporting
  - ⇒Mix calibration
  - ⇒PDF Summary
- ⇒Automatic file export after each line
  - ⇒PDF summary report
  - ⇒Veta file
  - ⇒Proval file
- ⇒Upload to ESS cloud system for group sharing (coming soon)
- ⇒Odometer not required

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# Real Time Maps

⇒Shallow dielectric / compaction / density (1.5” depth)

⇒Deep dielectric / compaction / density (3” depth)

⇒IRI (roughness, qualitative)

⇒Temperature

⇒Pass count

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# Report Generation

## Dielectric Mix Calibration

My Company

### Job Site

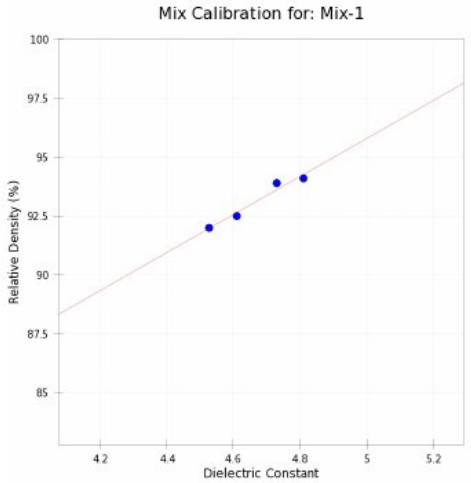
| | | | |
|---|---|---|---|
| Name | TH16-HMA-L2-CL-12R-SB | Description | McDonald's Farm |
| Location | CC County | Date Recorded | September 29, 2023 |
| Equipment Model | GRP40018 Pavement Scanner | Time Recorded | 10:28 AM |
| Notes | slab | Operator | CPO |

### Asphalt Mix

| | | | |
|---|---|---|---|
| Mix Name | Mix-1 | Density Units | Relative Density |
| Mix Type | HMA | Target Air Voids | 6.0 |
| Agency ID | | Min Allowed Limit | 96.0 |
| Daily Cum. Tons | 0.0 | Max Allowed Limit | 92.0 |
| Gyration Temp. | 100.0 | Test Date | Jan. 1, 2000 |
| Comments | | | |

### Mix Calibration

| | |
|---|---|
| Calibration Pucks / Cores | 1 / 2 / 3 / 4 |
| Calibration Correlation Coefficient / Residual | 0.990 / 0.180 |
| Mix Calibration Formula | Density = 8.071984 x Dielectric + 55.434890 |






## Asphalt Paving Survey Report

My Company

### Job Site

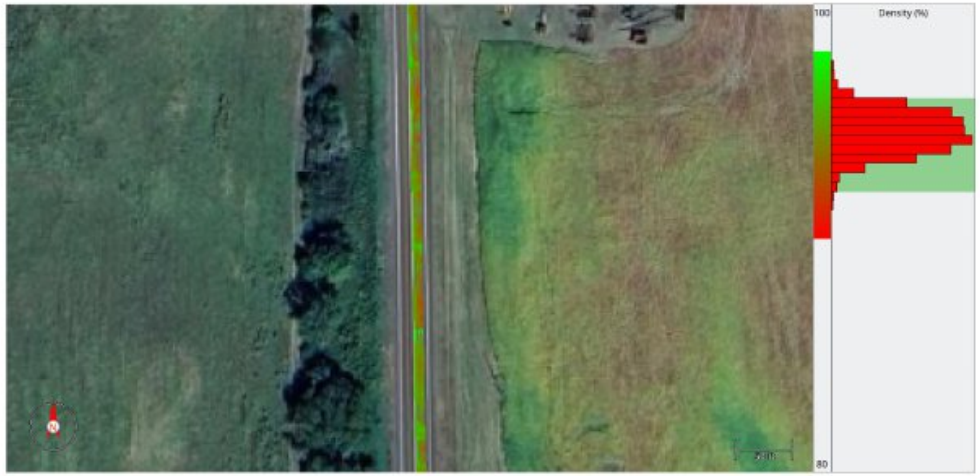
| | | | |
|---|---|---|---|
| Name | TH16-HMA-L2-CL-12R-SB | Description | McDonald's Farm |
| Location | CC County | Date Recorded | September 29, 2023 |
| Equipment Model | GRP40018 Pavement Scanner | Time Recorded | 10:28 AM |
| Notes | slab | Operator | CPO |

### Survey Grid

| | | | |
|---|---|---|---|
| Station at Origin | N/A | Travel Direction | SB |
| Centerline Offsets | CL-12R | Lift | L2 |
| Latitude at Origin | 39.851031 degrees | Map Units | feet |
| Longitude at Origin | -94.546170 degrees | Elevation | 974.98 feet |
| Grid Interval | 0.50 in | Filter Length | 6.00 in |

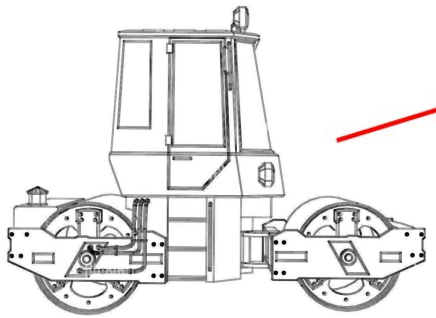
### Summary Statistics

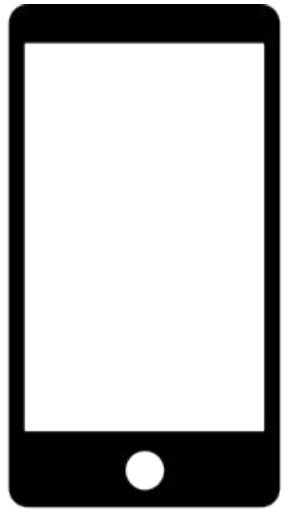
| | | | |
|---|---|---|---|
| Mix Name | Mix-1 | Compaction Units | Relative Density (%) |
| Mix Equation | Den = 8.0720 x Diel + 55.4349 | Target Range | 92.0 - 96.0 |
| Temperature | mean: 67.37 std: 32.20 F | Roughness | mean: 94.73 std: 39.84 in/mi |
| Shallow Dielectric | mean: 4.83 std: 0.12 | Deep Dielectric | mean: 4.85 std: 0.11 |
| Shallow Density | mean: 94.39 std: 1.01 | Deep Density | mean: 94.55 std: 0.93 |
| Shallow PWL | 94.94% | Deep PWL | 95.29% |
| Time Since Tare | 3.69 min. | Radio Noise | 0.49% |

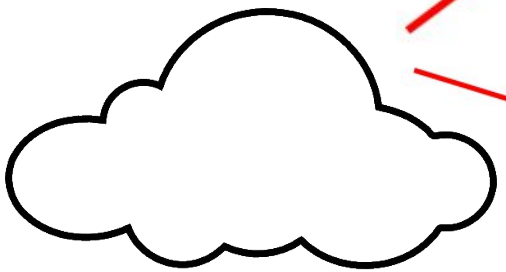


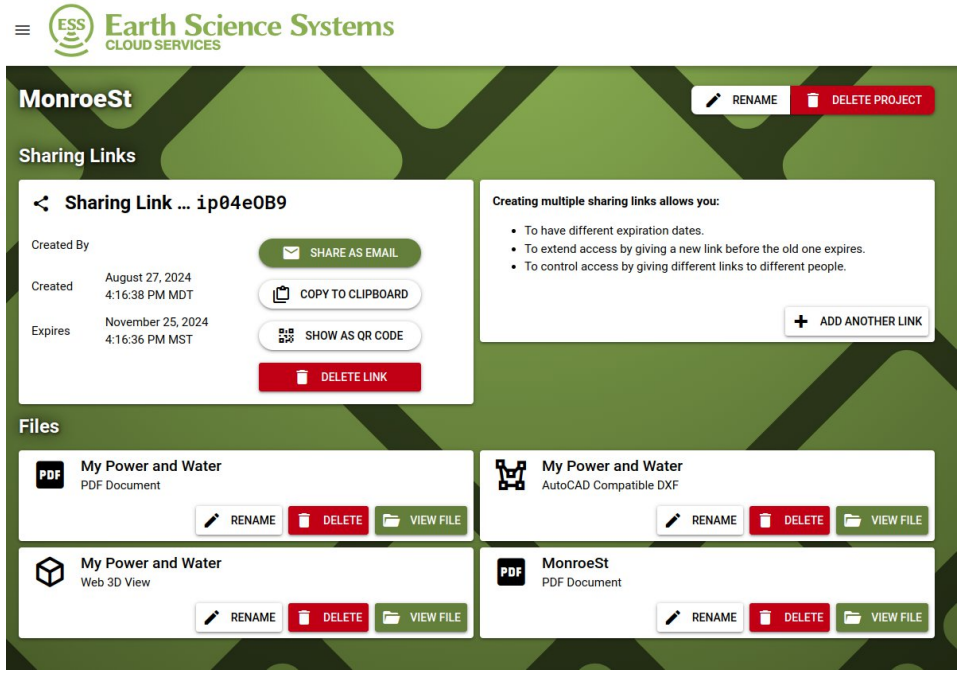
# Developing Connected Jobsite

- Scanner uploads to cloud
- Mobile app on phone for roller operator
- Mobile app on phone for foreman
- Cloud data for office (DOT / owner)









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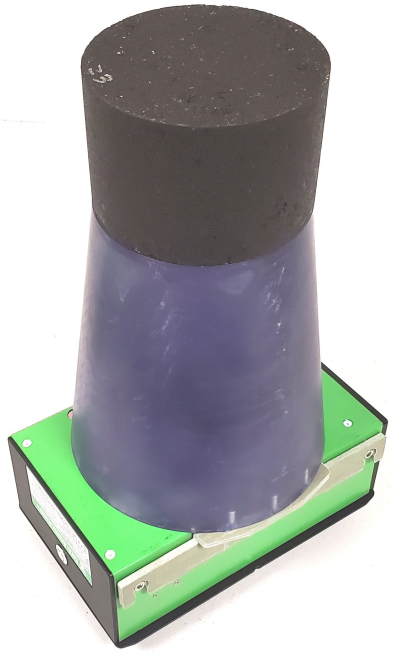
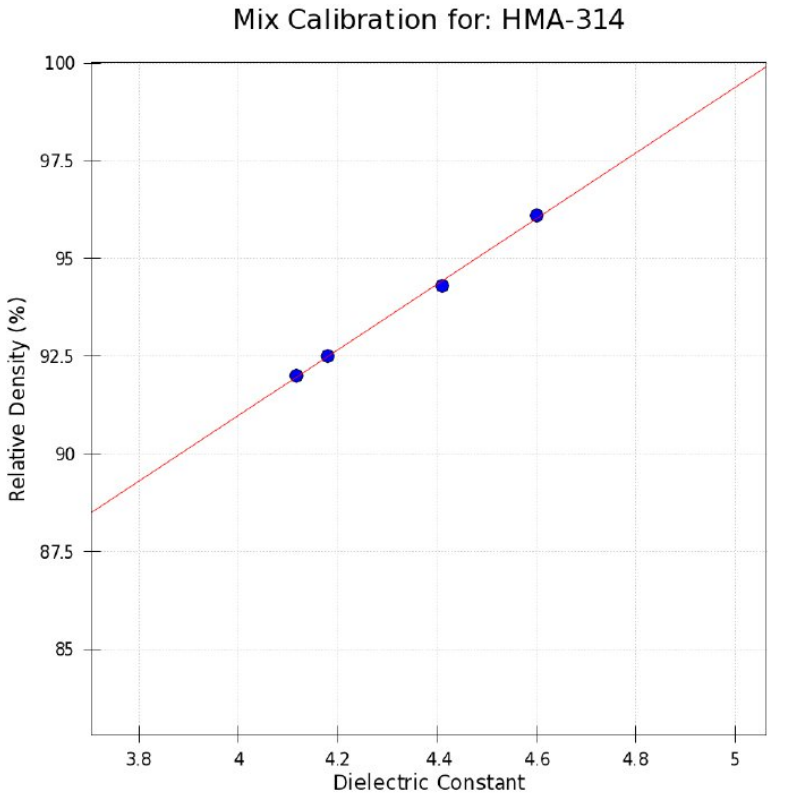
# Asphalt Mix Calibration (AASHTO T-414)

1. Create gyratory pucks

2. Measure dielectric using TOF and density




3. Send calibration to scanner at job site

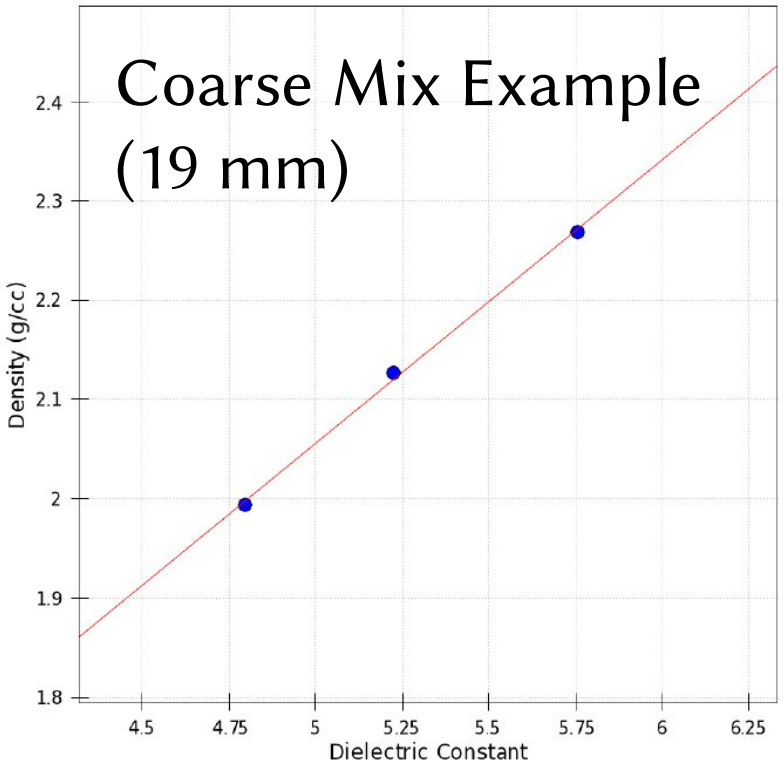


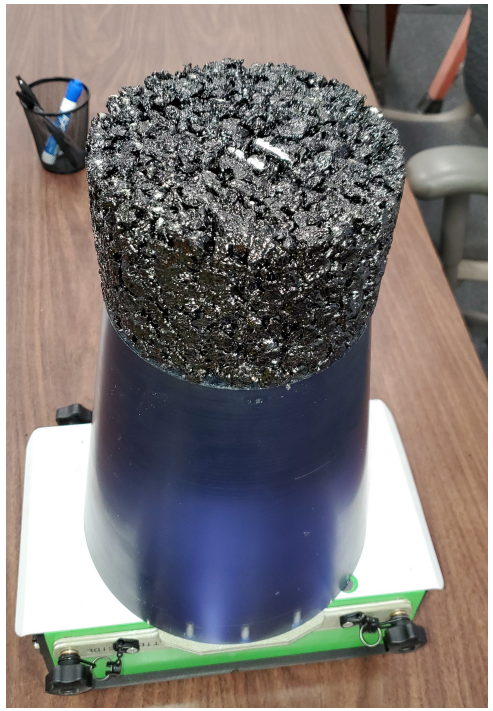

Relative Density = 11.735154 x Dielectric + 26.165066

# Mix Calibration Method (AASHTO T-414)

⇒ **Three puck method**

- Target density and height
- $w_t$, $w_t$-250 g, $w_t$-500 g
- Dielectric from APS
- Density from T166, T275, or T331



| | |
|---|---|
| **Calibration RMS Residual** | 0.005 |
| **Calibration Correlation Coef** | 1.000 |

Relative Density = 0.285402 x Dielectric + 0.628976

# Single Point Calibration

⟹Calibrate against a gauge or core

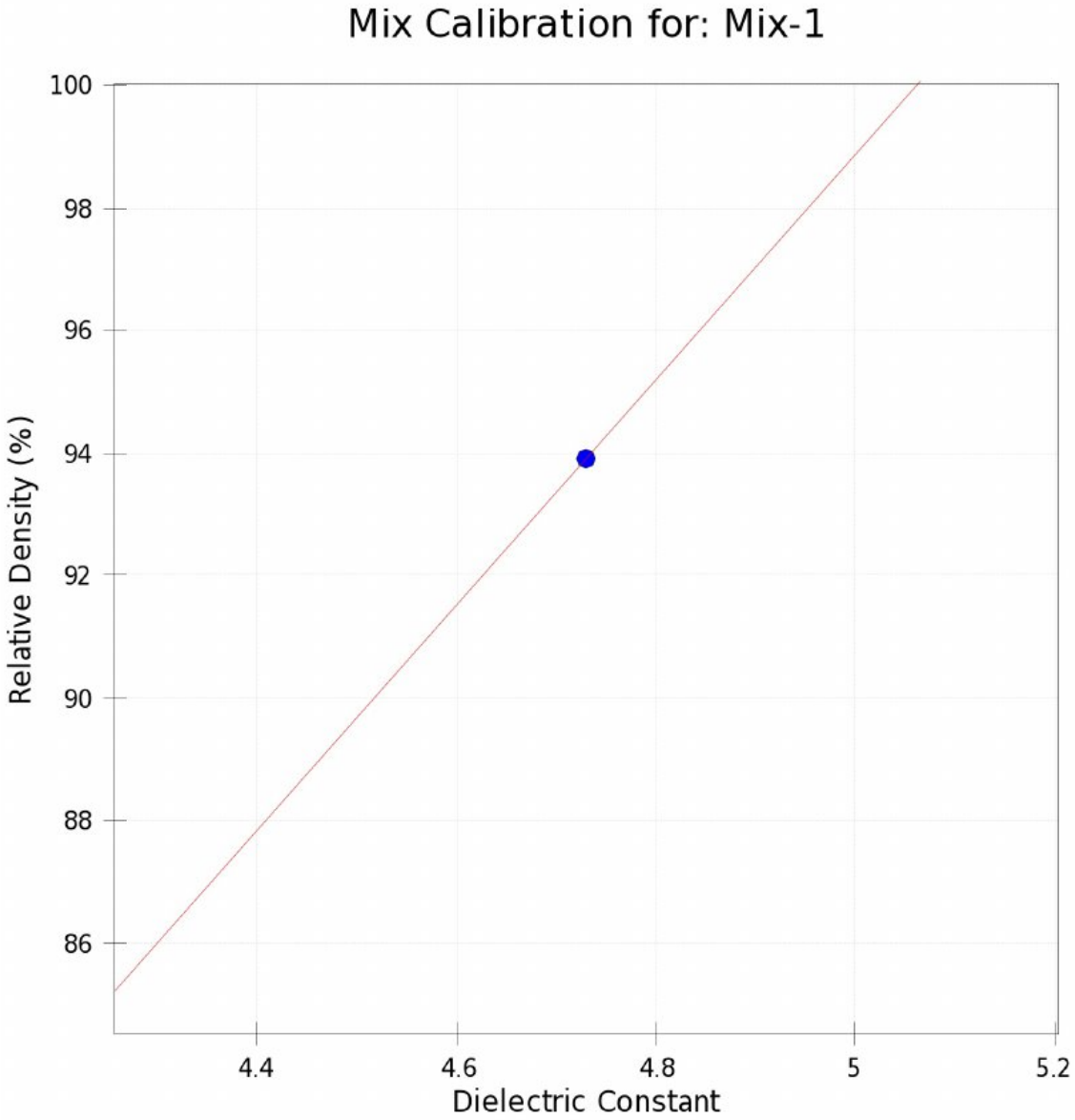
- CRIM model
- Bottcher model
- $d=f(f_{air}, f_{binder}, f_{agg}, d_{air}, d_{binder}, d_{agg})$

⟹Provides a linear mix calibration

$C=4.2718 \bullet d + 20.3683$

⟹Different volumes of investigation

- APS: 7.5 cm deep x 40 cm diameter
- Gauge: ~ 7.5 cm x 7.5 cm diameter
- Core: 10 cm thick x 15 cm diameter

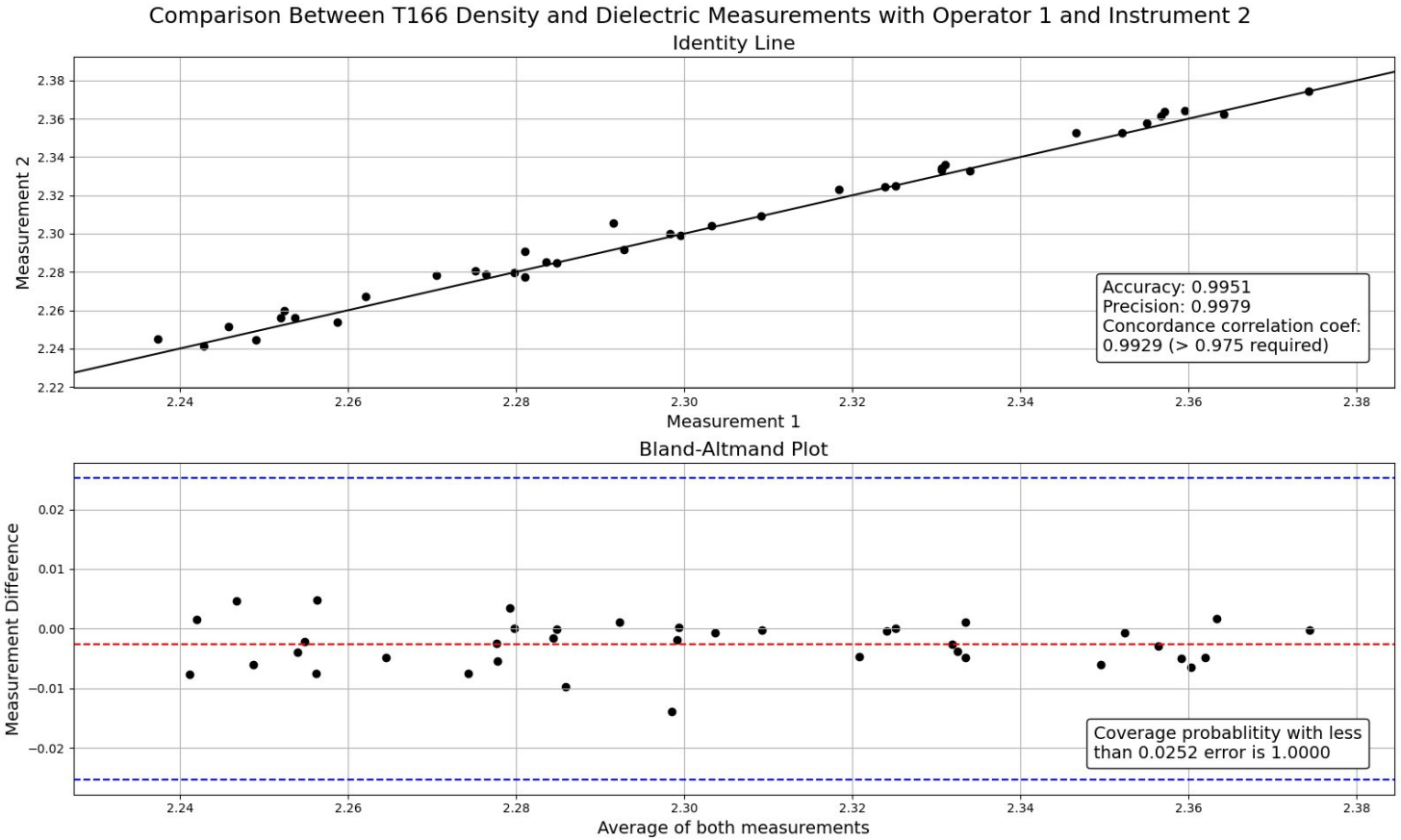


# AASHTO T-414
# Comparing T-166 and Dielectric Density

⇒Density cross plot
- Density from dielectric
- Density from T166

⇒Repeatable results
- Different instruments
- Different operators

⇒Meets NCAT guidelines



# Calibration and Verification Kit

⇒Mix calibration

- Coupling cone for gyratory pucks
- Duck bill calipers for gyratory pucks
- TOF reference puck standard
- Scanner (optional)
- New AASHTO standard

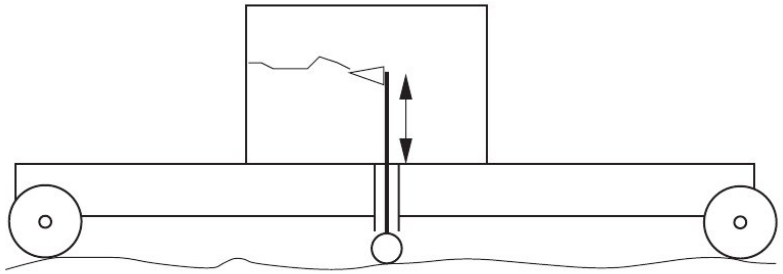


# IRI Measurement From Vehicle Mounted System

⇒Rolling straight edge

⇒Current algorithm

- Suspension compensation
- Step response front, rear axles
- Constant speed
- Tire circumference filter



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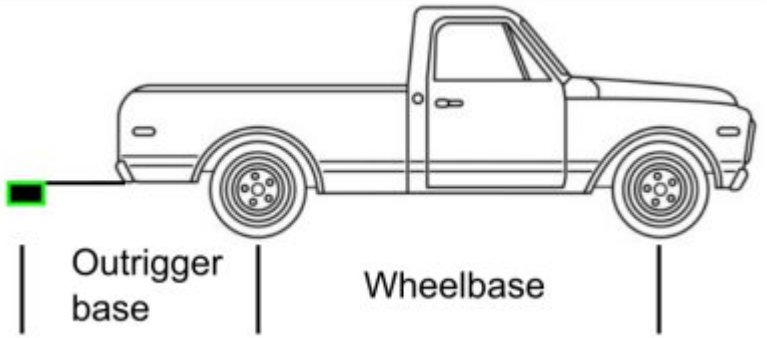
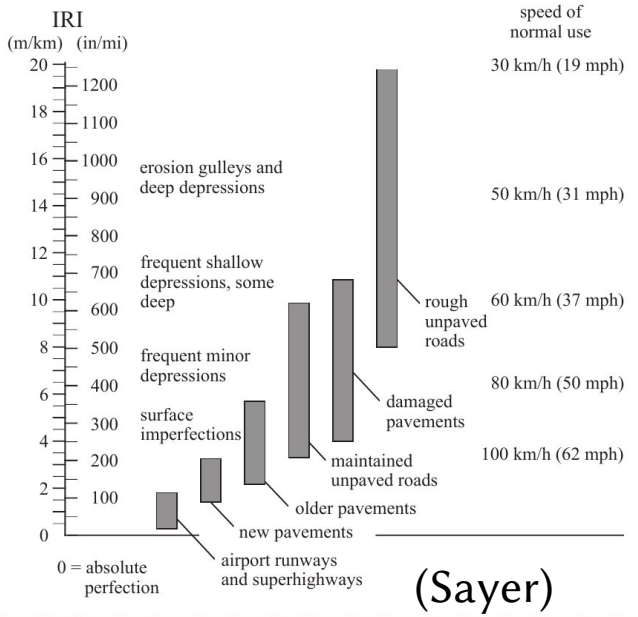


# IRI Measurement and Performance

⇒Continuous IRI

⇒Compare 14 Repeat runs

⇒Compatible with industry standard ProVal software

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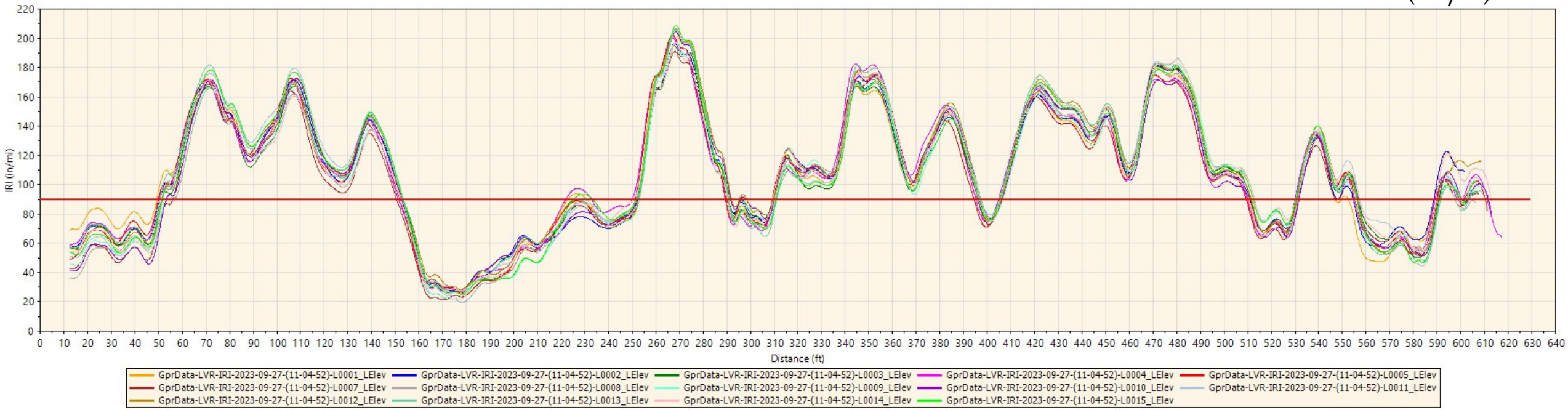

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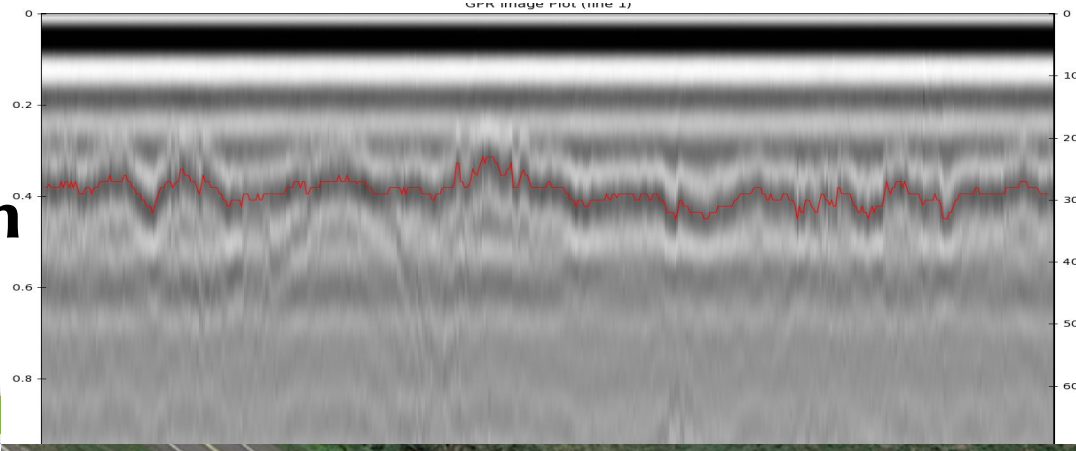
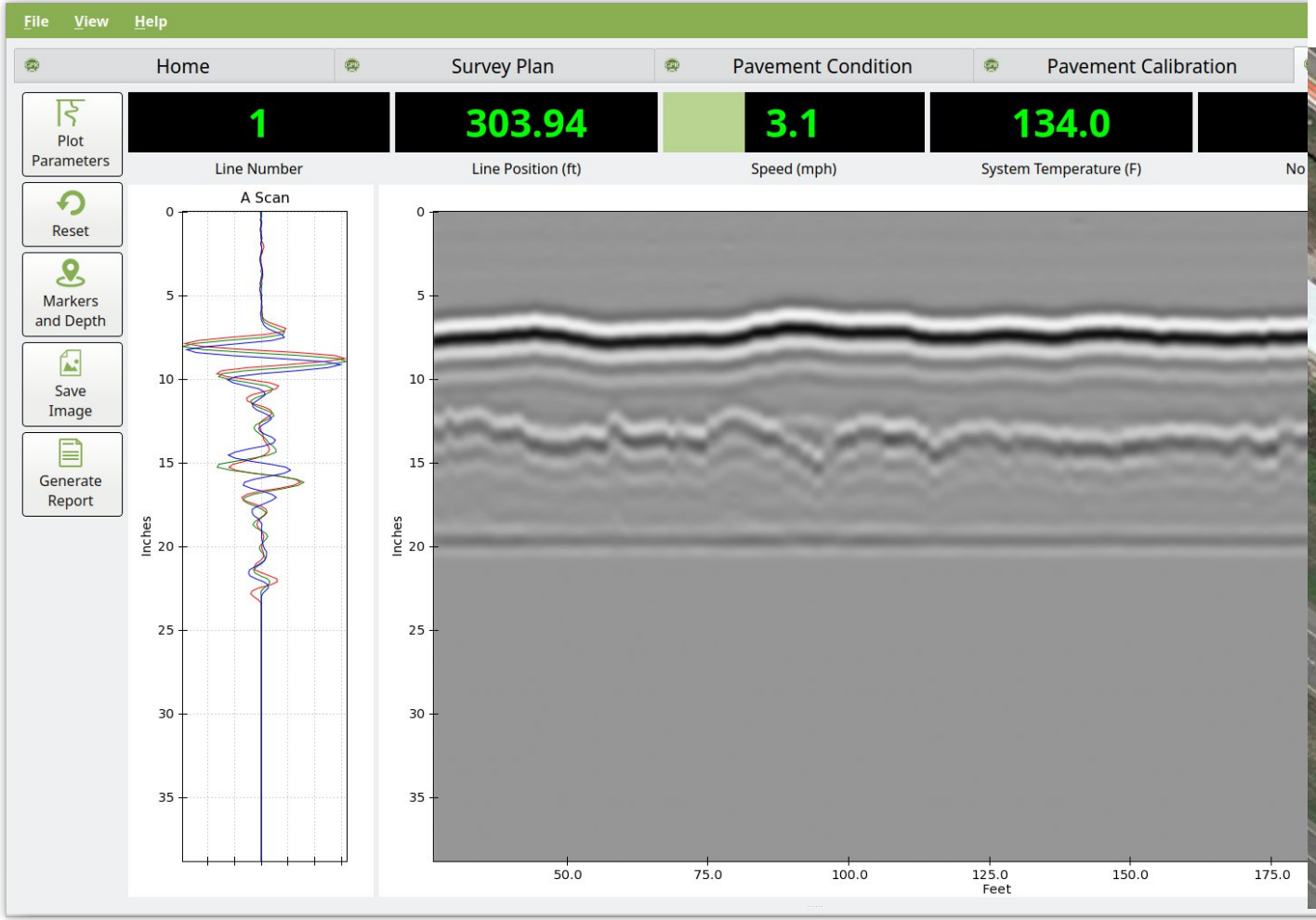
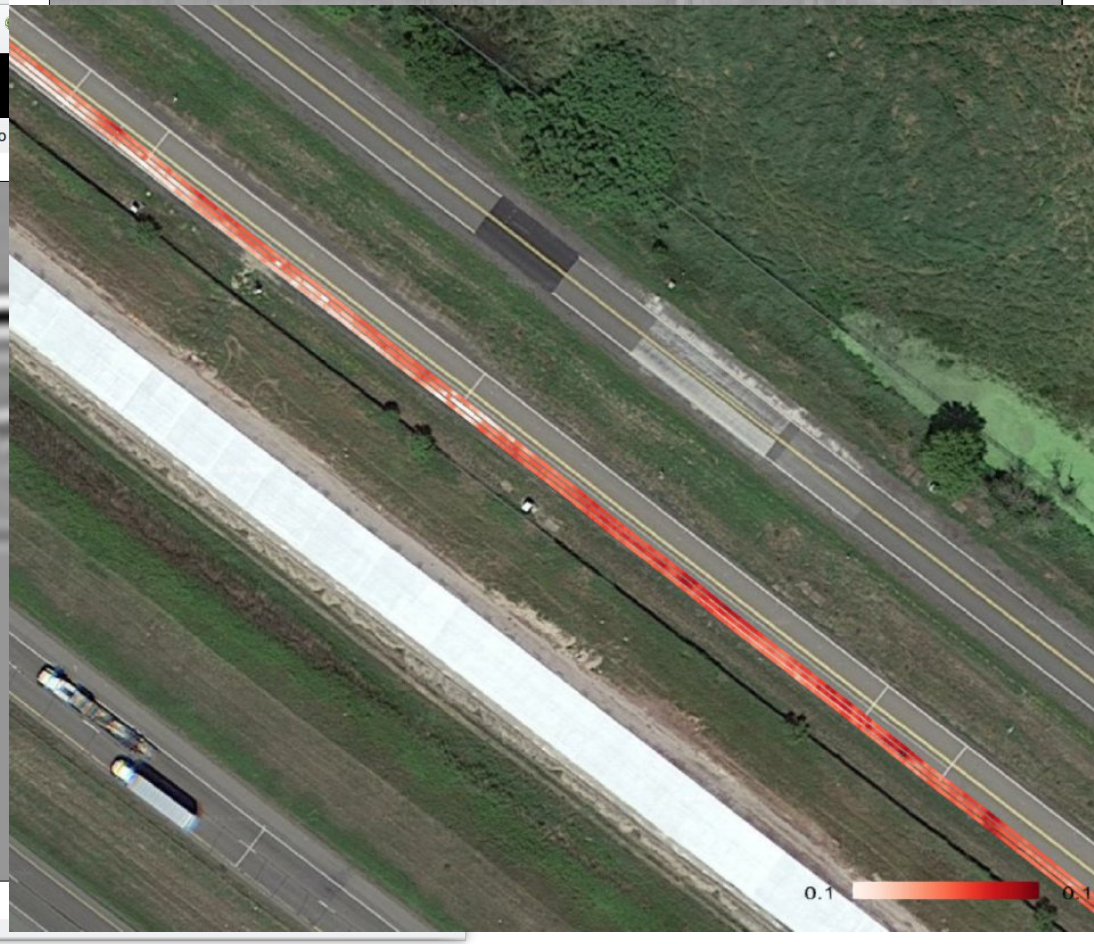
# Thickness From Vehicle Mounted System

- Thickness of entire asphalt lift sequence



# Asphalt Pavement Scanner: Process Monitoring for Asphalt Construction

- ⇒Pushcart for small jobs like subdivisions
- ⇒Vehicle mounted for highway jobs
- ⇒Roller mounted for real time feedback (coming soon)
- ⇒Veta intelligent compaction software
  - ⇒Paver mounted thermal profiler
  - ⇒Intelligent compaction
  - ⇒Roller pass count
  - ⇒Dielectric / Density
- ⇒ProVal
  - ⇒IRI and roughness

# AASHTO Standards

⇒PP-98: Standard Practice for Asphalt Surface Dielectric Profiling System using Ground Penetrating Radar

⇒T-414: Determining the Dielectric Constant of Compacted Asphalt Mixture Specimens (July 2024)

# SKUs

| P/N | Name | Desc |
|---|---|---|
| P-000002-000119 | GPR Dual Battery Asphalt Pavement Scanner (Cart) | Push cart, scan head, rugged shipping case, 2 batteries, charger |
| P-000001-000113 | DT Research DT311 Tablet Kit | Tablet PC and mounting kit |
| P-000002-000113 | Asphalt Density Calibration Kit | Scan head, coupling cone, relector plate, puck standard, wide jaw calipers, rugged shipping case |
| P-000002-000117 | Asphalt Density Calibration Kit (no scan head) | Coupling cone, relector plate, puck standard, wide jaw calipers, rugged shipping case |
| P-000002-000121 | Asphalt Field Calibration Kit | Dielectric slabs and rugged shipping case |
| P-000002-000120 | GPR Dual Battery Asphalt Pavement Scanner Scan Head | Scan head only |
| P-000002-000114 | Spare Battery for Asphalt Pavement Scanner | Battery only |
| | | |
| esscloud.net | ESSential Underground software subscription | Software for generating thickness maps |
| esscloud.net | Point Perfect GNSS | Data stream for accurate GNSS positioning |
| esscloud.net | Cellular data for ESS tablet PC | Multi-carrier cellular data plan |

# Push Cart System Compaction Maps

⇒Center joints have lower compaction

⇒Last two runs of the day had lower compaction

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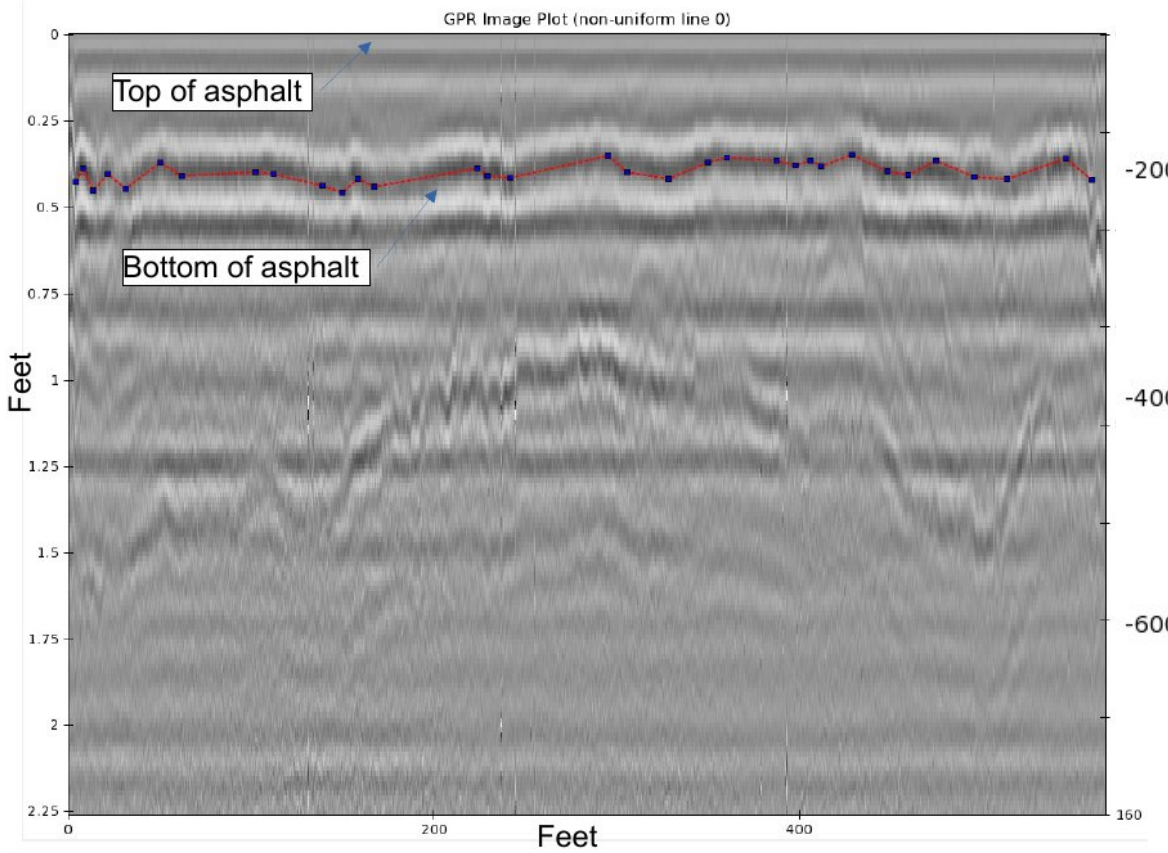
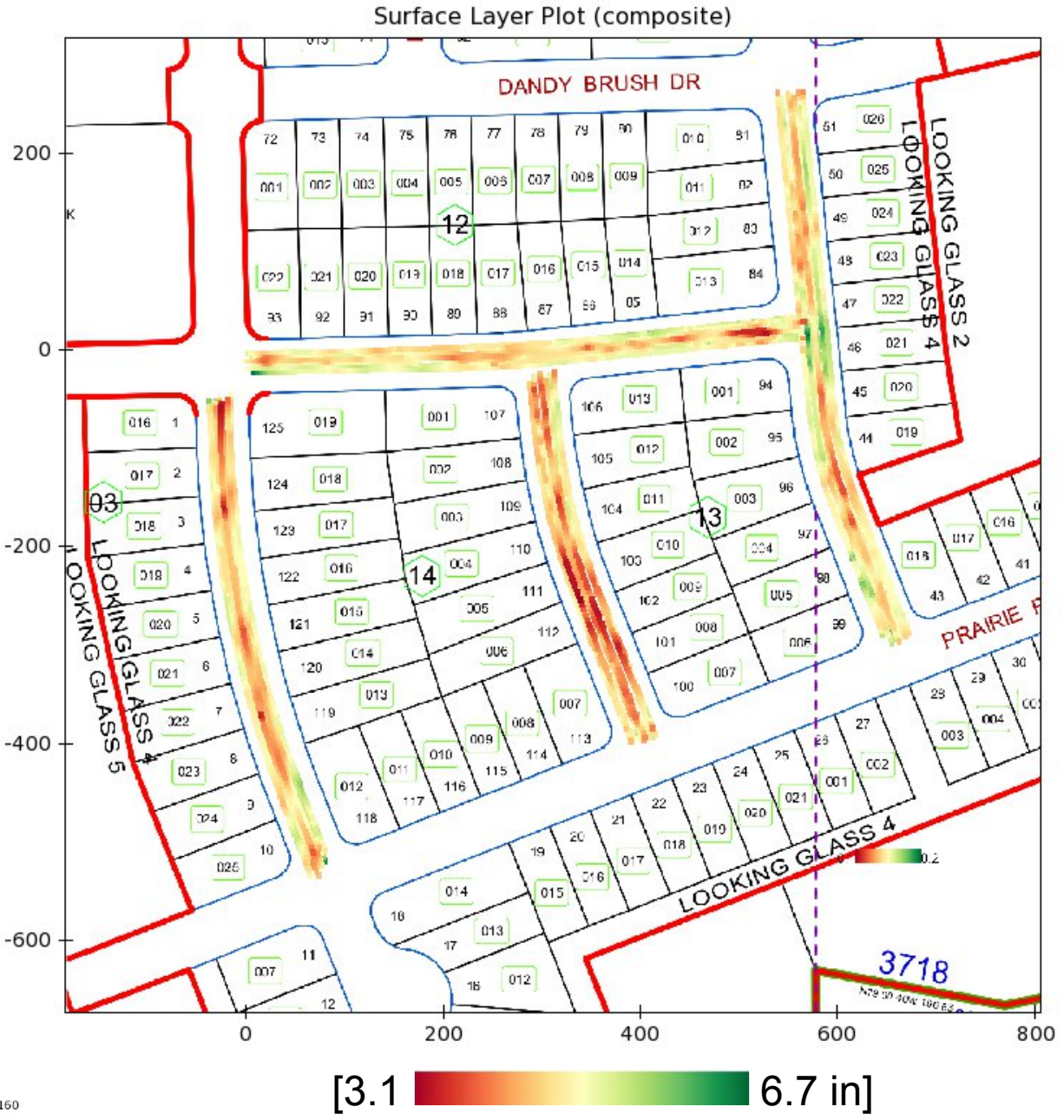
# Push Cart System Thickness Maps

⟹ Pick bottom from B-scans



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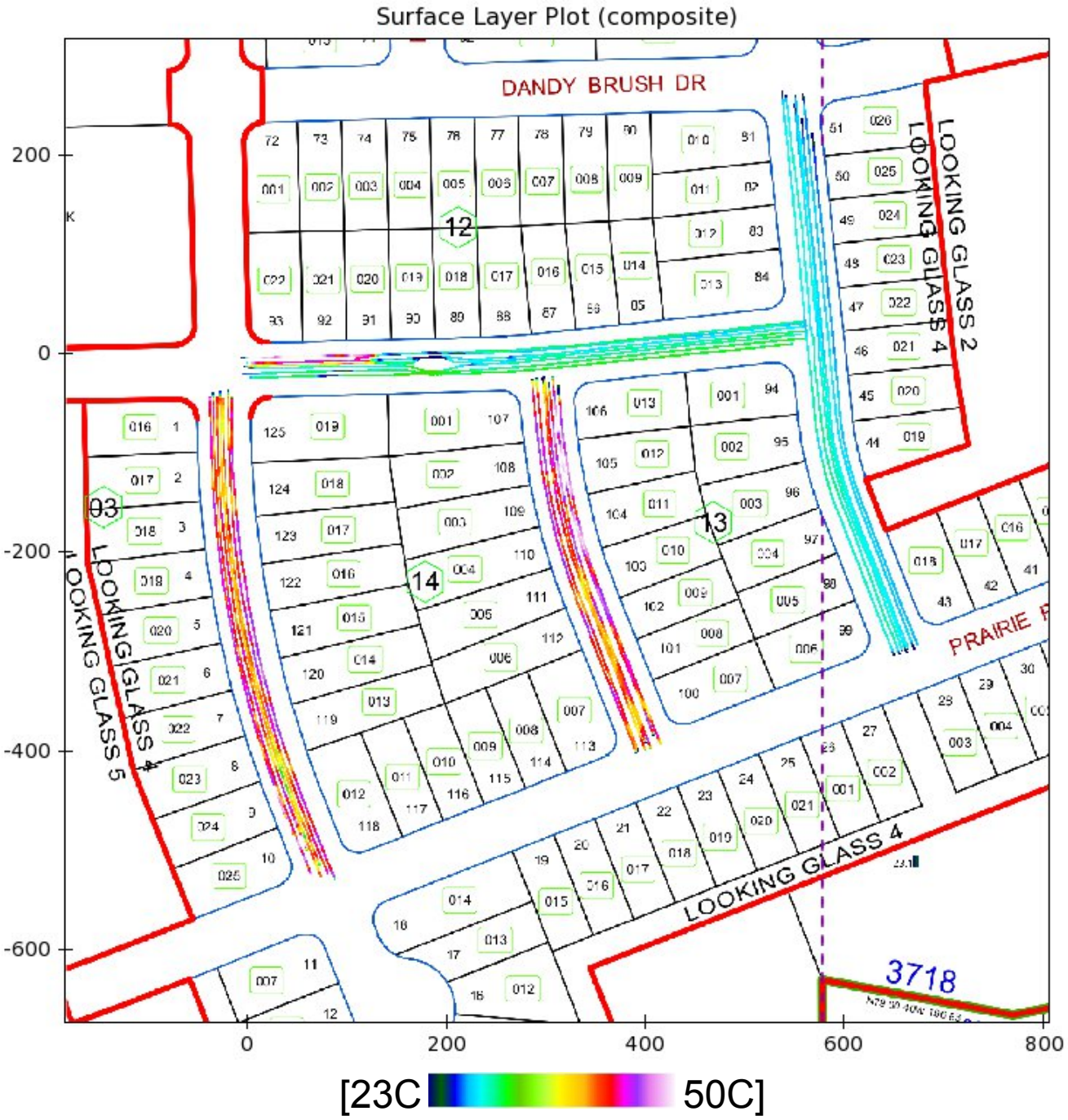
# Push Cart System Temperature Maps

⇒Useful on rollers to indicate proper window for compaction

⇒Can indicate indicate segregation problems



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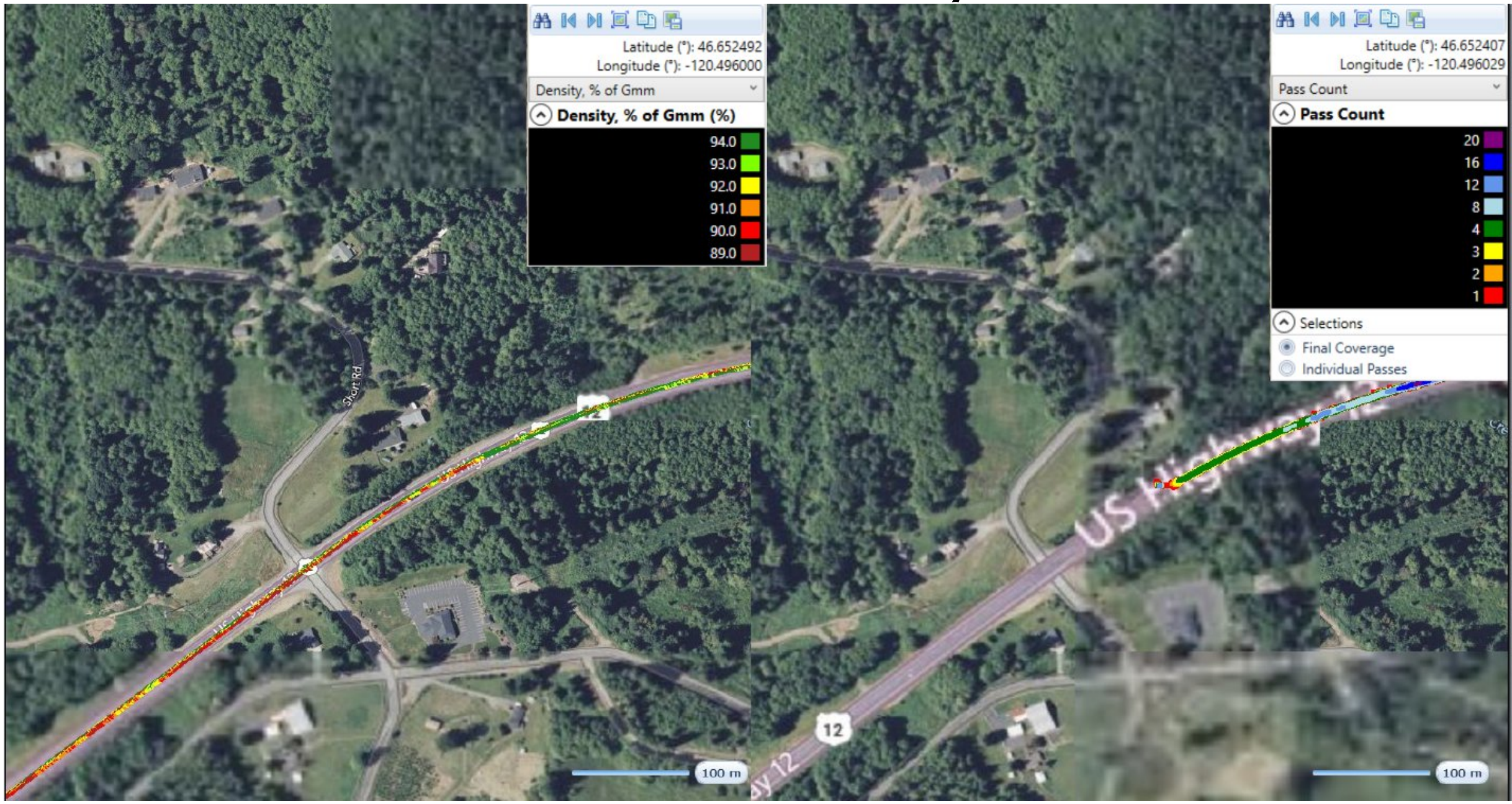
# Vehicle Mounted System



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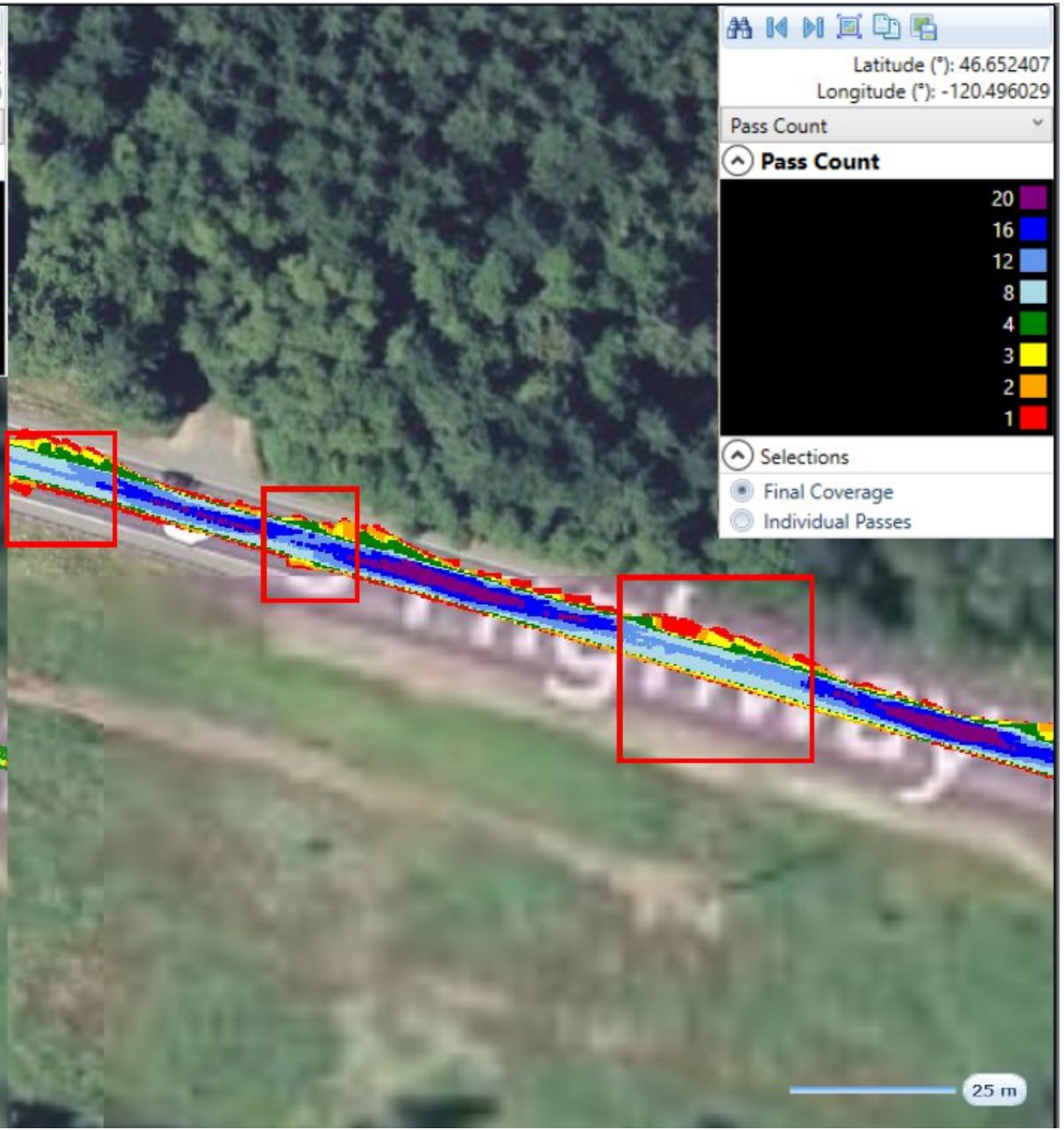

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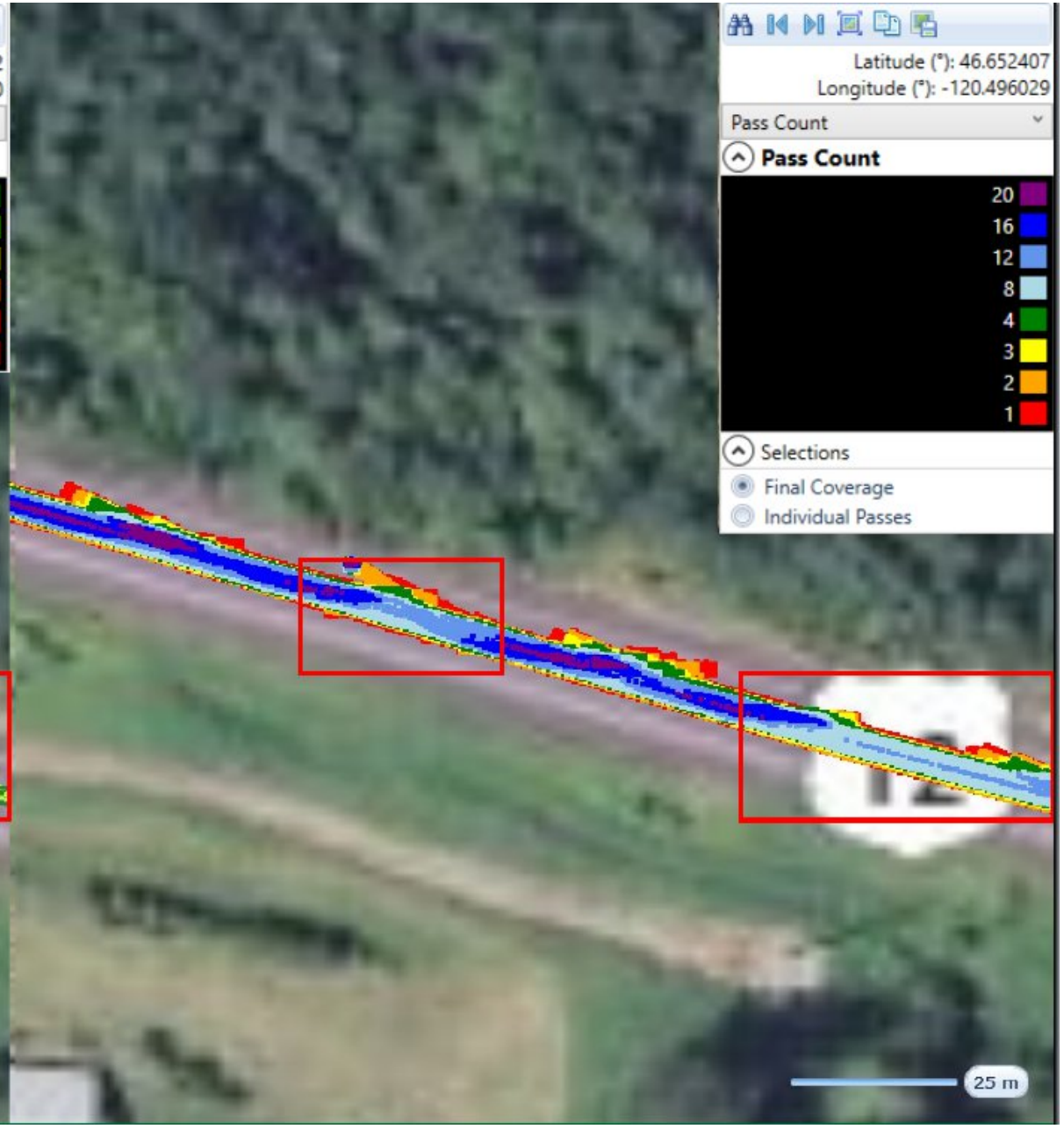
# Vehicle Mounted System

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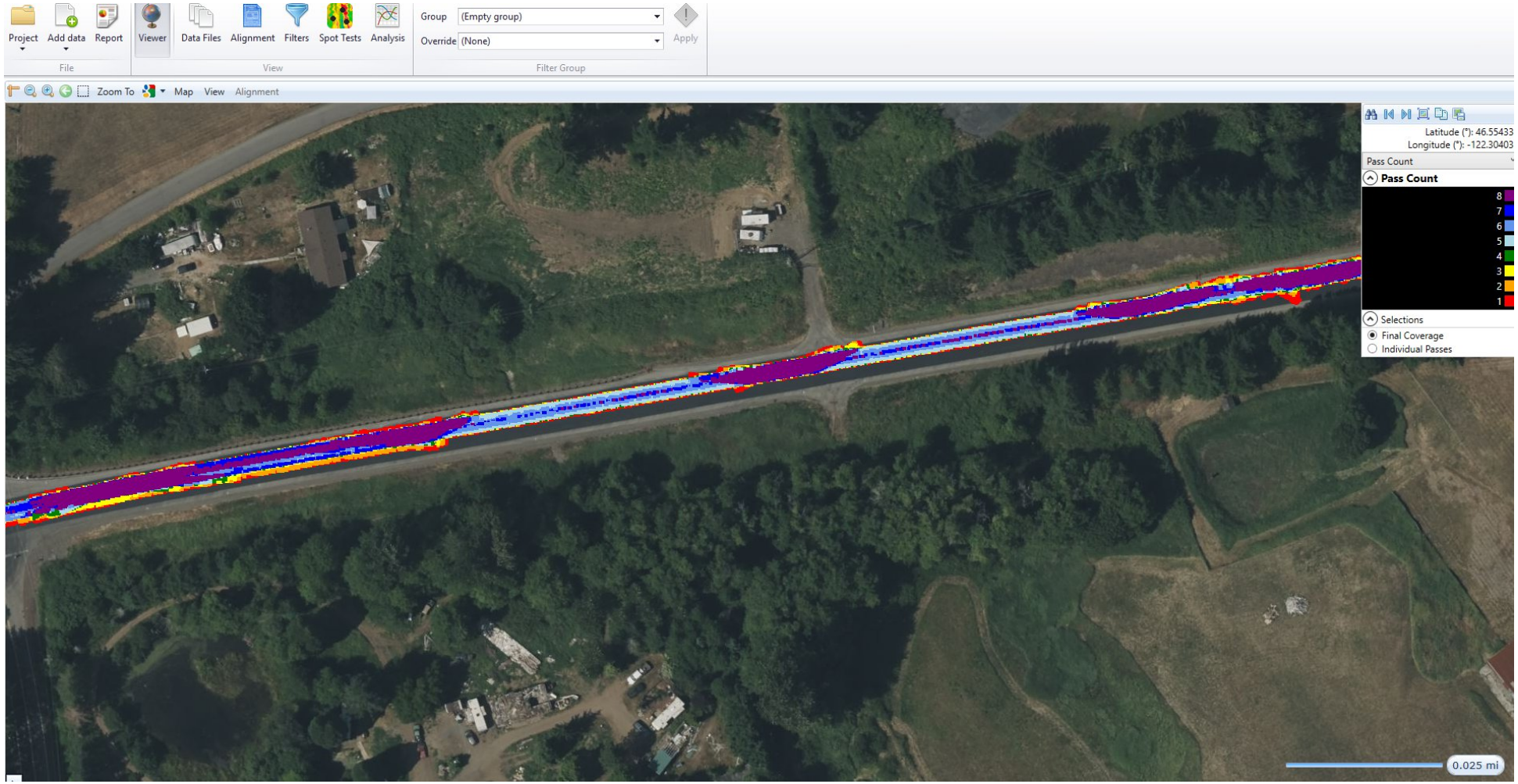
# Roller Pass Count

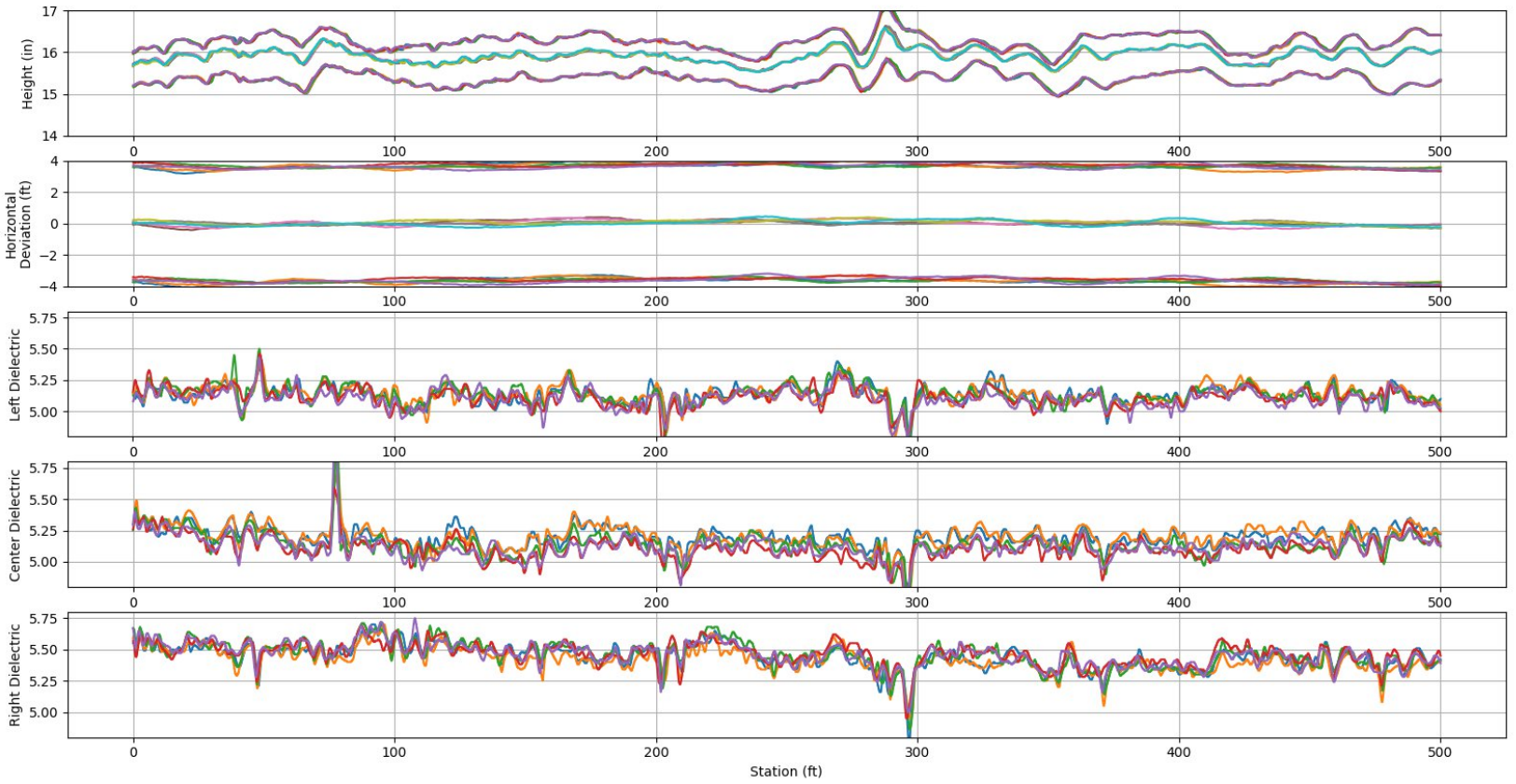
⟹ Use GPS with roller mounted system

⟹ Veta software



# Repeat Dielectric Measurement From Vehicle Mounted System

- Ten repeat lines on test track
- Less than 6” lateral position variation
- Std. dev. of mean dielectric for all runs: 0.013

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