Northeastern States Materials Engineer's Association

Project-Level Analysis of Composite Pavements Using Ground Penetrating Radar

Online
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October 26, 2021

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Acknowledgements

Lanbo Liu, PhD & James Mahoney
Connecticut Transportation Institute
Steve Norton & Leo Fontaine
Connecticut Dept. of Transportation

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Agenda

- The Need
- The Device
- Case Study No. 1 – Dowels or I-Beams
- Case Study No. 2 – Deleterious Material Under Composite Pavement
- Case Study No. 3 – Voids Under Composite Pavement
- Recommendations on Practice
- On-Going Studies

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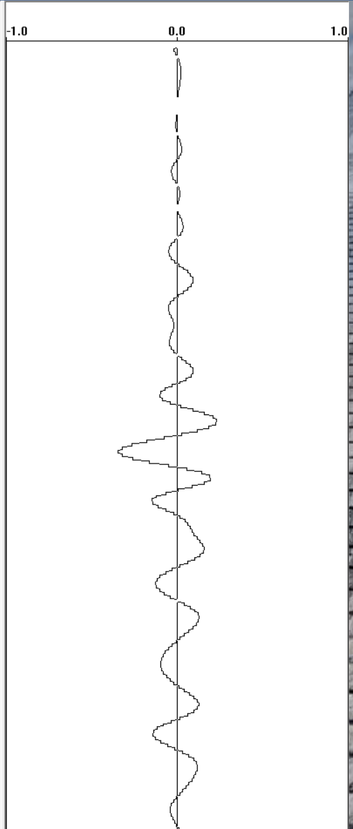
The Need

- Ground-Penetrating RADAR has been around many decades
  - Improvements to use of ‘off the shelf’ equipment
  - Improvement to resolution at shallow depths
- Composite Pavements have unknown condition without costly excavation or



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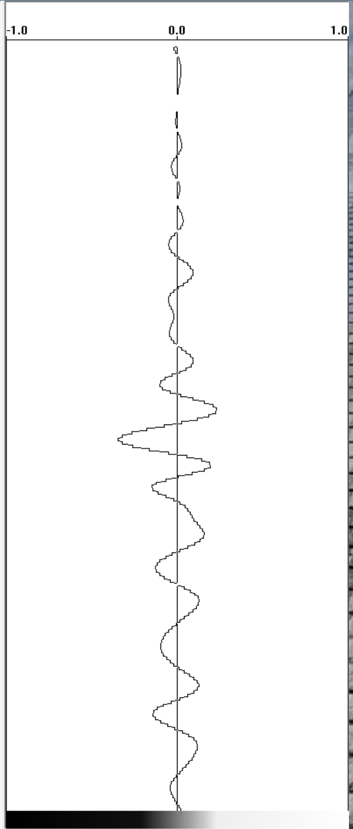
The Need

- Can we push the limits of resolution/technology to reduce need for open excavations
- Can off-the-shelf solutions provide in-the-field answers to subsurface uncertainties



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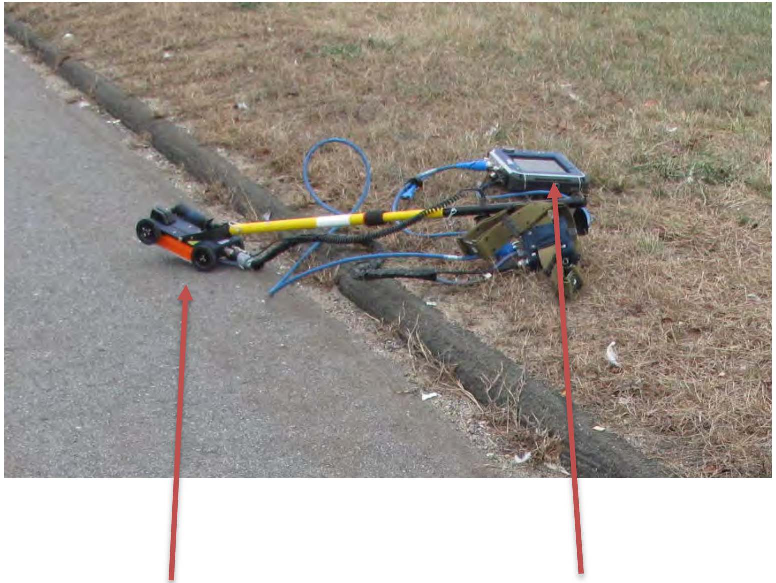
The Device

- Ground-Penetrating RADAR
  - RAdio Detection And Ranging
- Generate wide-frequency pulse, interpret difference in waves as they return to the device.
- Applications in roadways back many decades, however technologic limits existed on data collection rate and frequency of antenna



The Device

- Case Study No. 1&3 Utilized
  - 1.6 GHz (No. 1 only)
  - 2.6 GHz
- Ground-coupled, analog antennas
- 2mm scan spacing/0.0174 nano-seconds

Antenna

Data Acquisition System

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The Device

- Case Study No. 2 Utilized
  - 2.6 GHz
- Ground-coupled, analog, all-in-one concrete scanning device

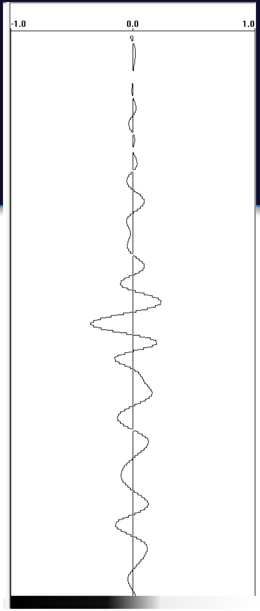
The Device

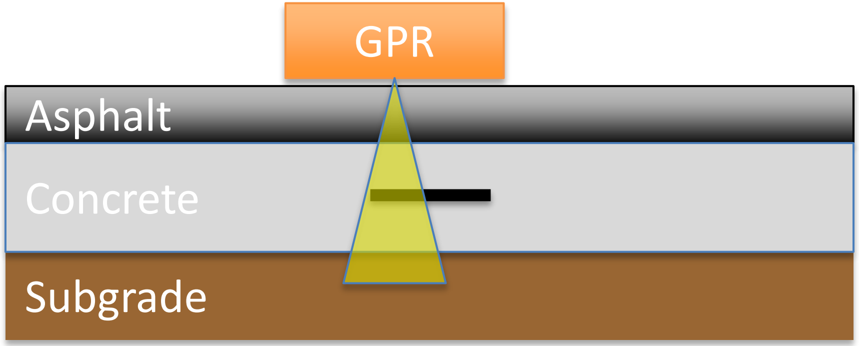
- Adapting a 3D Concrete Survey to Composite Pavements (Adding a layer to penetrate and interpret)

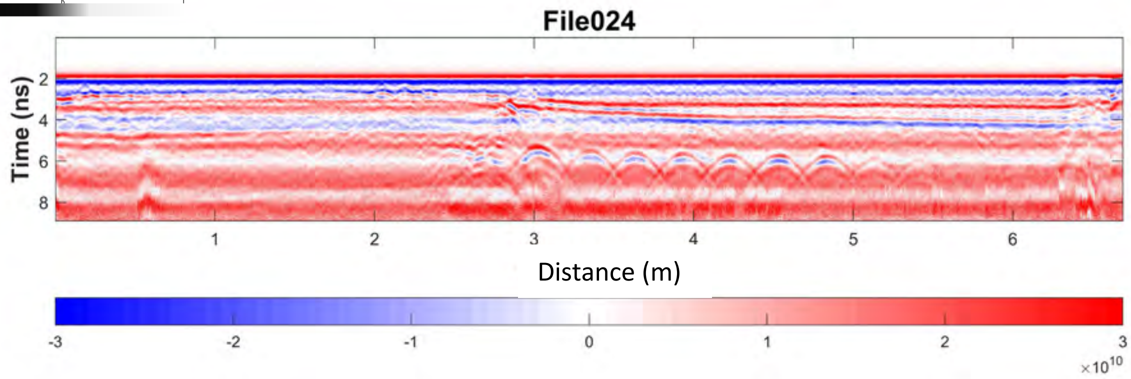
Photo Source: GSSI

The Device

- Lower frequencies ➔ deeper penetration, but limited clarity at shallow depths
- Higher frequencies ➔ shallower penetration, but higher clarity
- Ground-Coupled systems are slower to use
  - can't operate at highway speed
  - preserve energy lost at air/surface interface

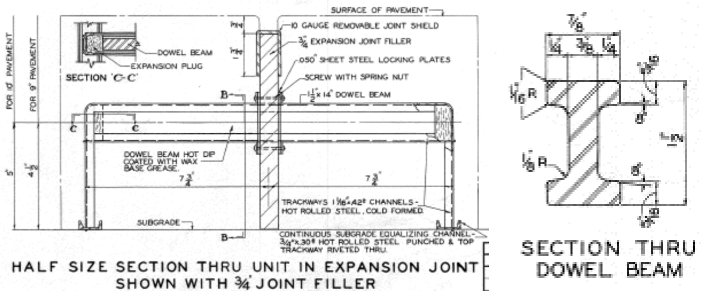






Case Study No. 1: Differentiate Load Transfer Devices

- For a period of time, CT DOT permitted the use of i-beam style load transfer devices (LTDs) on Jointed Concrete pavements.
- It is unknown where these load transfer devices remain across the state, but the state desires to replace with modern dowels when encountered.



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STATE HIGHWAY DEPARTMENT

DETAILS OF
LOAD TRANSFER UNIT
TYPE "A-1"

FOR 9" & 10" REINFORCED
CONCRETE PAVEMENT

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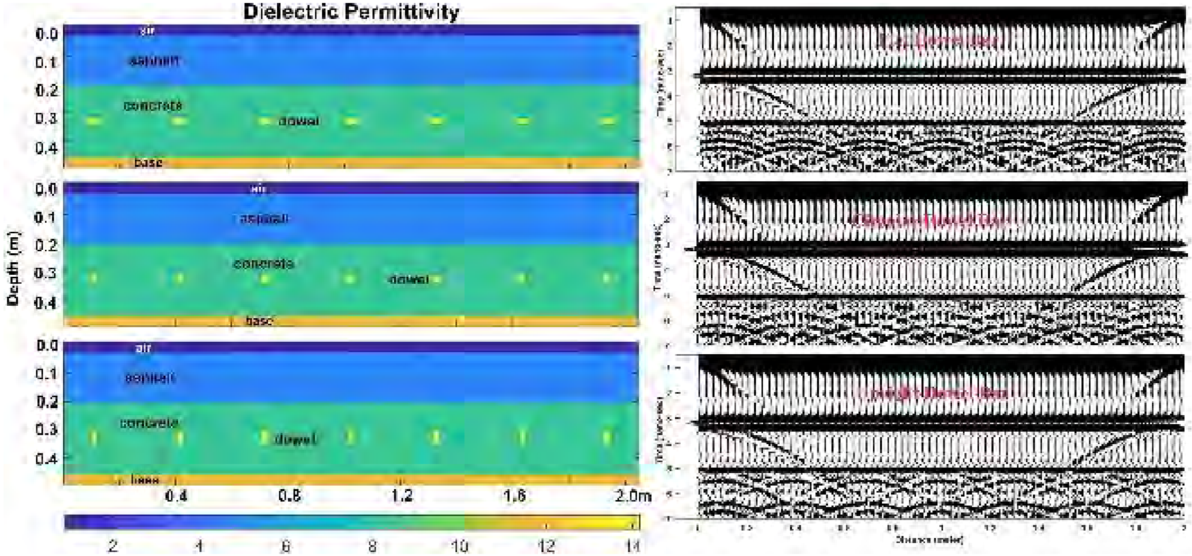
Case Study No. 1: Differentiate Load Transfer Devices

- Pseudo-Spectral Time Domain simulation performed to determine whether dowels vs. i-beams may be differentiated.



Lanbo Liu, Alexander Bernier, and James Mahoney, (2020), "Push the resolution limit: Can we differentiate the cross-section shape of dowel bars in the concrete with GPR?," SEG Global Meeting Abstracts : 180-183. https://doi.org/10.1190/gpr2020-049.1

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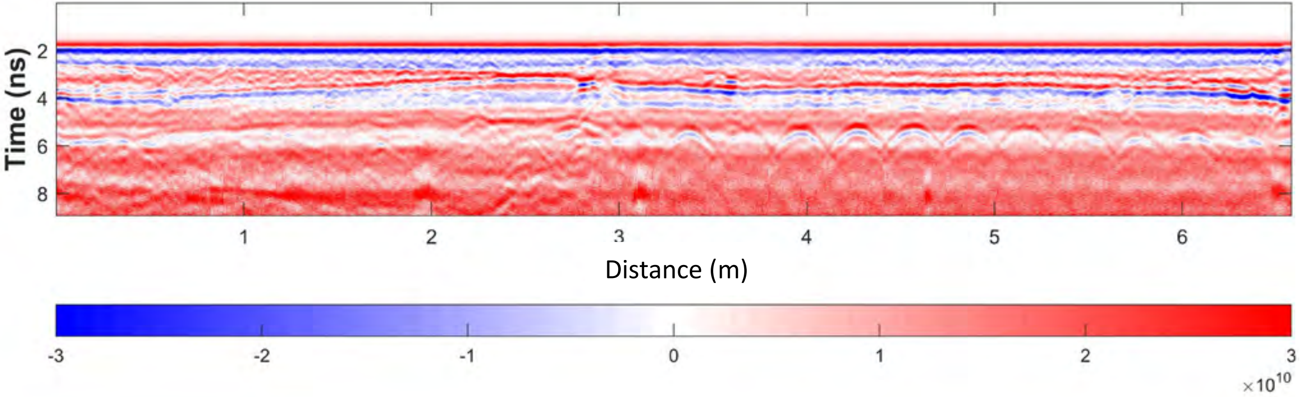
Case Study No. 1: Differentiate Load Transfer Devices

- Success!
- Field-confirmed
  - length of LTDs
  - spacing of LTDs
  - structure layer thicknesses
- Hypothesize we did encounter i-beam LTDs at some locations



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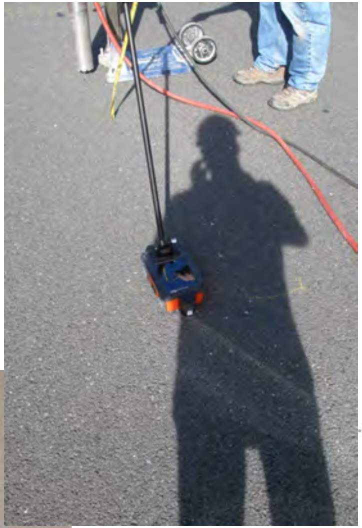
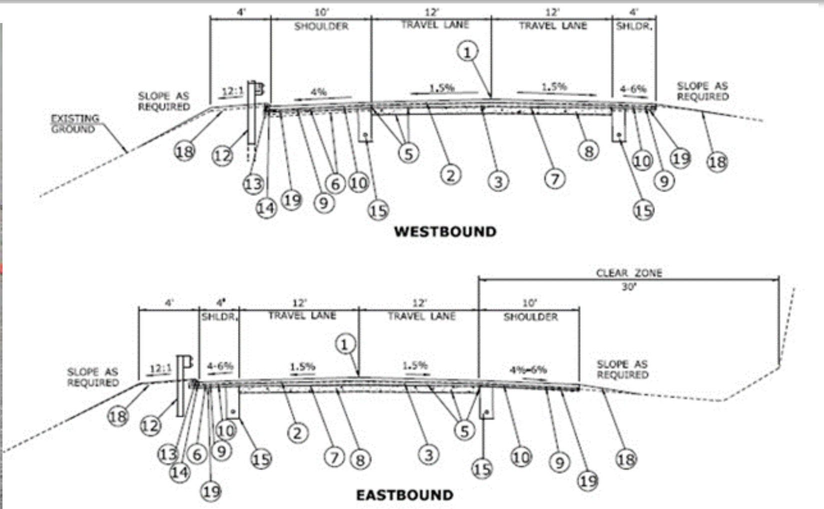
Case Study No. 2: Deleterious Material on Rubbleized PCC

- 7-9 inches HMA over PCC in design
- 2.6 GHz all-in-one Ground-Coupled GPR unit
- Surface Distresses prompted investigation

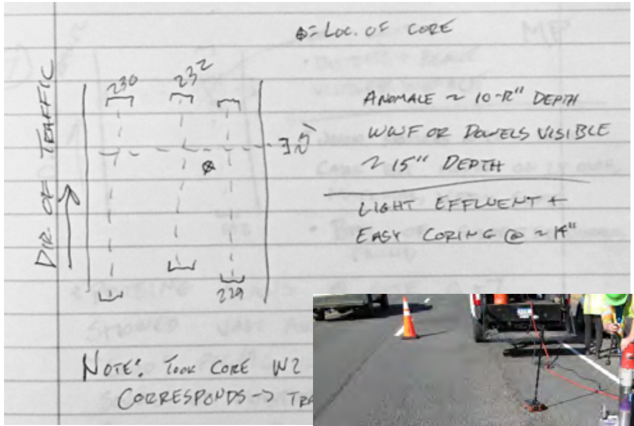


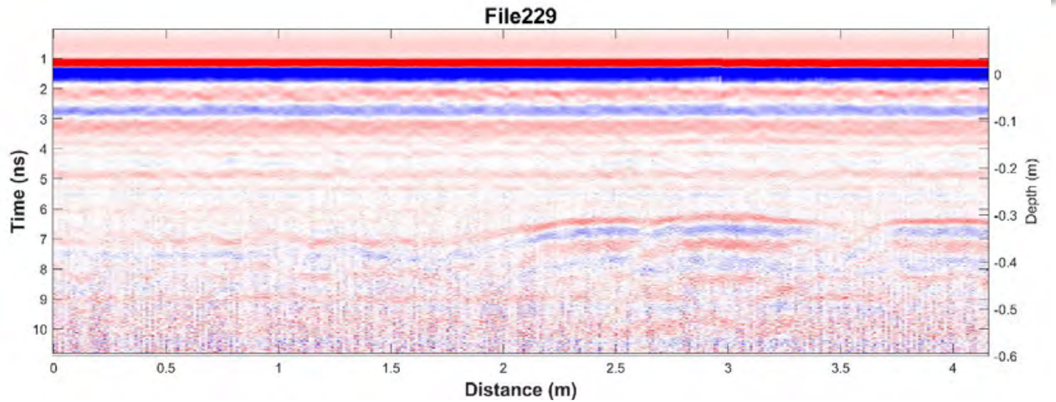


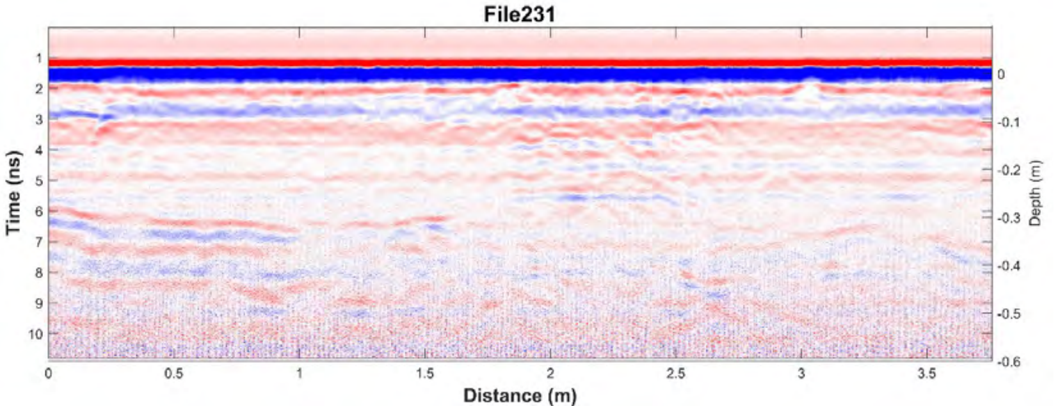
TYPICAL SECTION NUMBERING KEY

1. APPLICATION OF GRADE
2. 4" PMA S0.5 (2 EQUAL LIFTS) ON TOP OF 1 ¼" TO 2 ½" HMA S0.375 CURB TO CURB
3. 3.5" TO 5" HMA S1 (2 LIFTS) ON TRAVEL LANES
4. 2" HMA S0.5 ON TOP OF 1 ¼" HMA S0.375
5. APPROXIMATE LIMITS OF EXISTING CONCRETE PAVEMENT
6. APPROXIMATE LOCATION OF EXISTING BITUMINOUS CONCRETE PAVEMENT
7. MILL TO TOP OF CONCRETE PAVEMENT
8. RUBBILIZATION OF EXISTING CONCRETE PAVEMENT
9. MILL SHOULDERS / CLIMBING LANES FLUSH TO ADJACENT CONCRETE
10. MATERIAL FOR TACK COAT
11. TURF ESTABLISHMENT WITH 6" TOPSOIL (MAX.) IN AREAS OF EDGEDRAIN OUTLETS
12. 3-CABLE GUIDE RAILING (I-BEAM POSTS) METAL BEAM RAIL (TYPE R-B 350, TYPE MD-B 350) AS REQUIRED
13. BITUMINOUS CONCRETE PARK CURBING
14. REMOVE CURBING (REMOVAL OF B.C.L.C. WILL BE PAID FOR UNDER THE ITEM "EARTH EXCAVATION")
15. 4" EDGEDRAIN
16. 3" HMA S0.5 (1 LIFT)
17. MILL 3" - MAX.
18. PROCESSED AGGREGATE
19. 3" HMA S0.5 (2 EQUAL LIFTS) ON SHOULDERS AND CLIMBING LANES

Case Study No. 2: Deleterious Material on Rubbleized PCC







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Case Study No. 2: Deleterious Material on Rubbleized PCC

- Asphalt layer found to be thicker than original design
- ‘Pasty’ Effluent and light colored material indicative of a deleterious patch material

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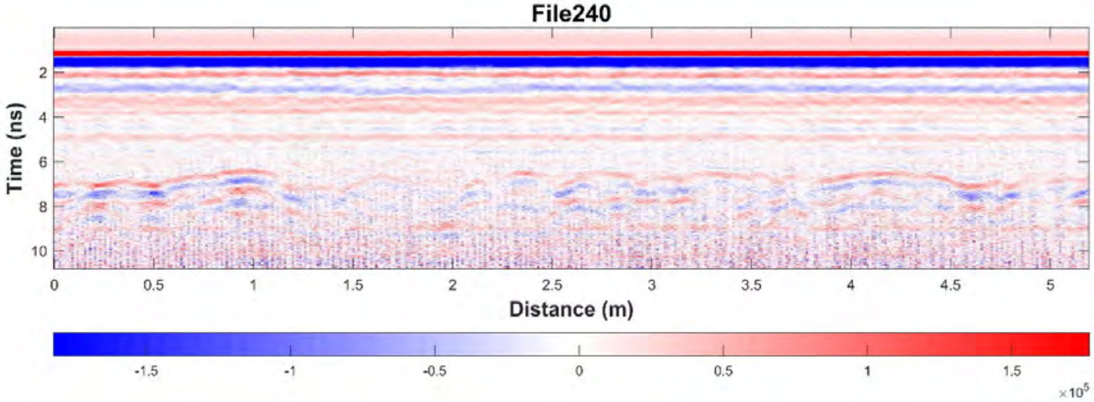
Case Study No. 2: Deleterious Material on Rubbleized PCC



- In the field, wavy subgrade signals from GPR seemed to relate to presence of patch material

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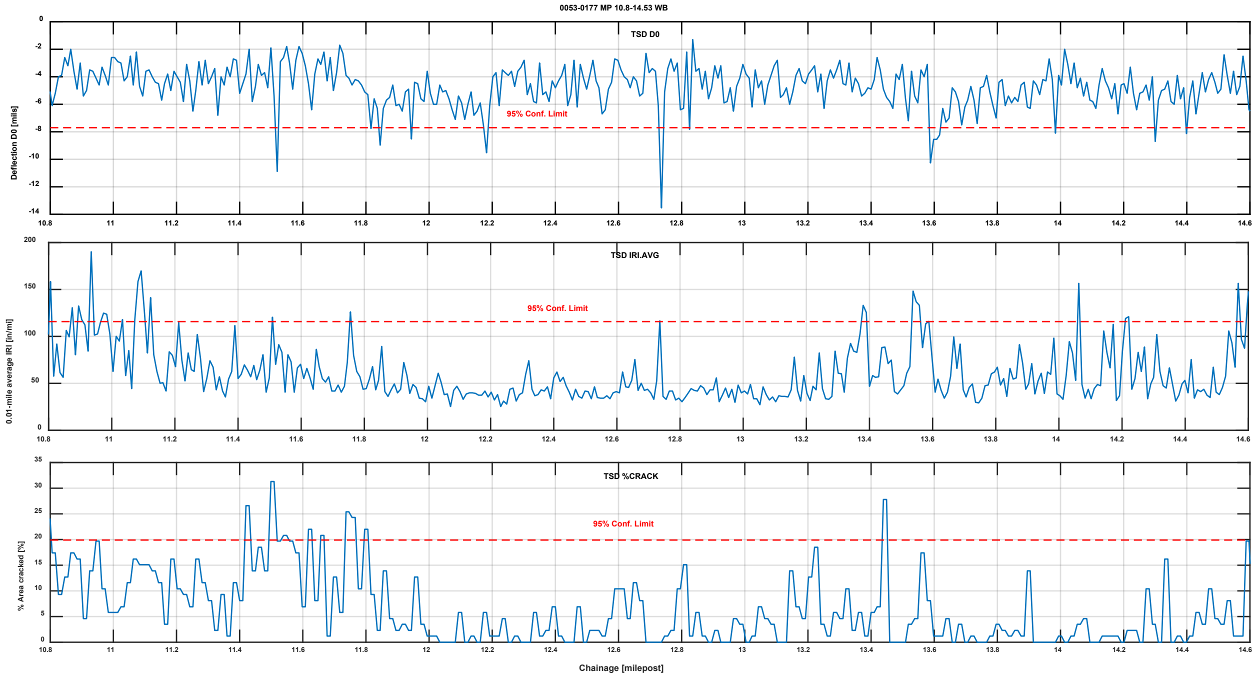
Case Study No. 2: Deleterious Material on Rubbleized PCC

- Performed analysis of Traffic-Speed Survey Devices (ARAN + iPAVE) to identify potential other sites



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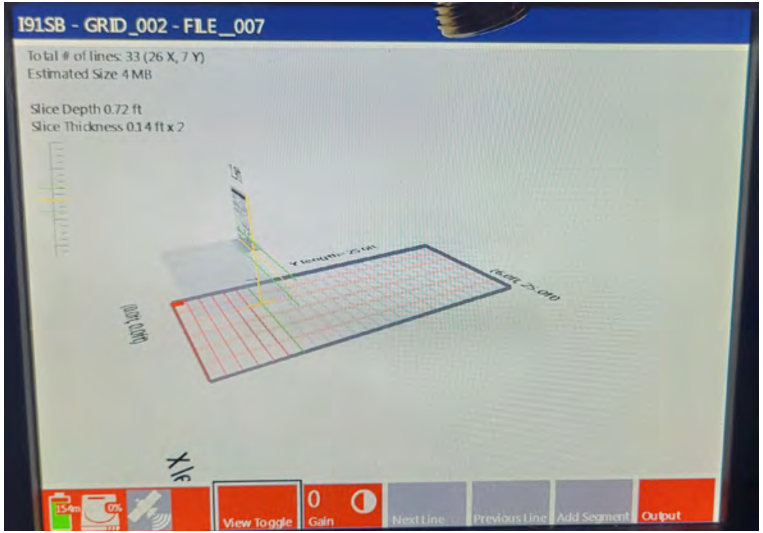
Case Study No. 3: Voids Under Composite Pavement

- Air-Couple GPR identified location void to be field-verified with Deflectometer Testing prior to repair
- Deflectometer indicated no repair necessary
- 2.6GHz Ground-Coupled brought in to see which NDT method it aligned with
- Attempted On-board 3D scanning software from Controller



Case Study No. 3: Voids Under Composite Pavement

- Laid out a 1-ft grid
- Longitudinal + Transverse

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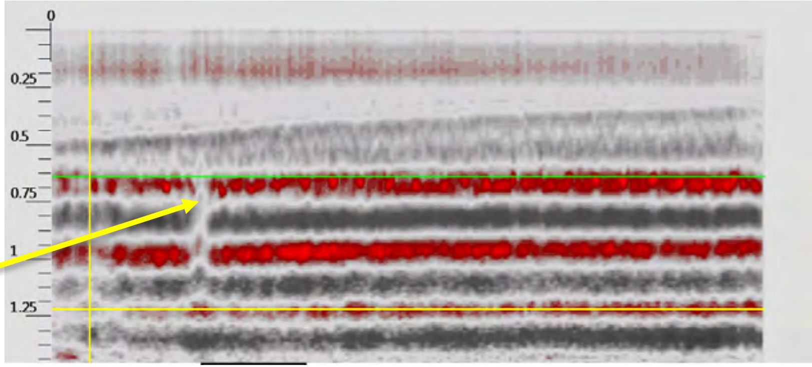
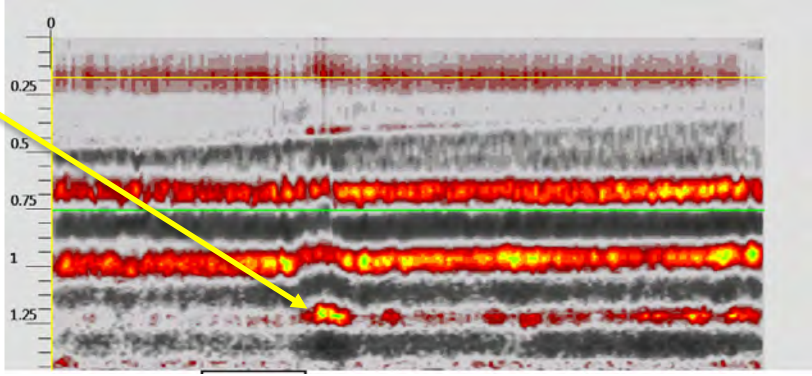
Case Study No. 3: Voids Under Composite Pavement

- Screen shots from field analysis: Panel 1
  - Seems like voids may exist
  - Unable to core/excavate to confirm
  - Asphalt layer seen to thicken (perhaps for a super elevation)

Joint

Not a Joint





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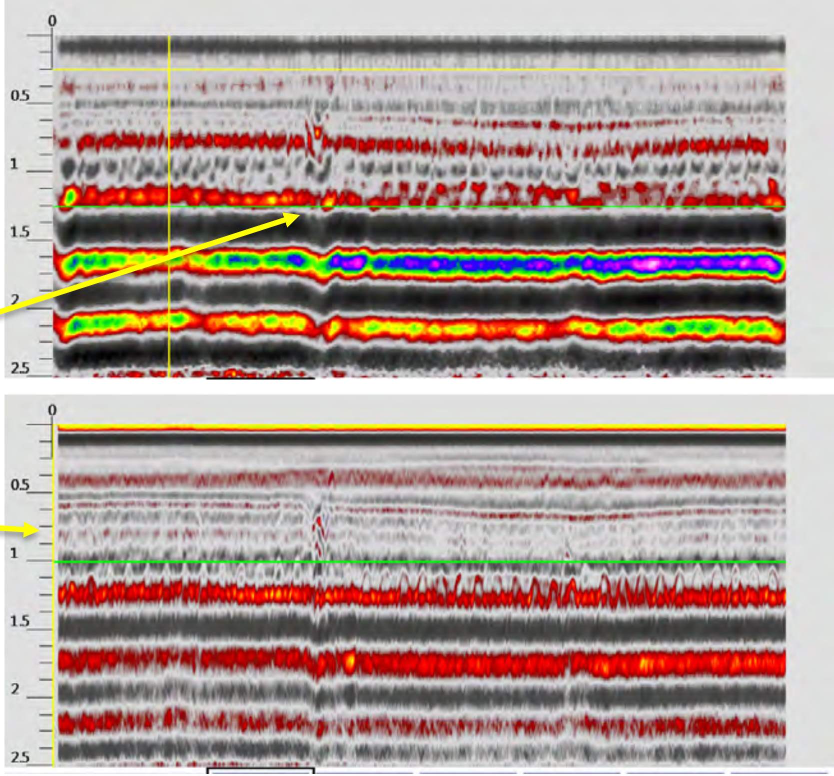
Case Study No. 3: Voids Under Composite Pavement

- Screen shots from field analysis: Panel 2
  - No visible 'deformations' of signal across the panel
- Moisture plays a role in reading reflections/scans

Joint

Welded Wire



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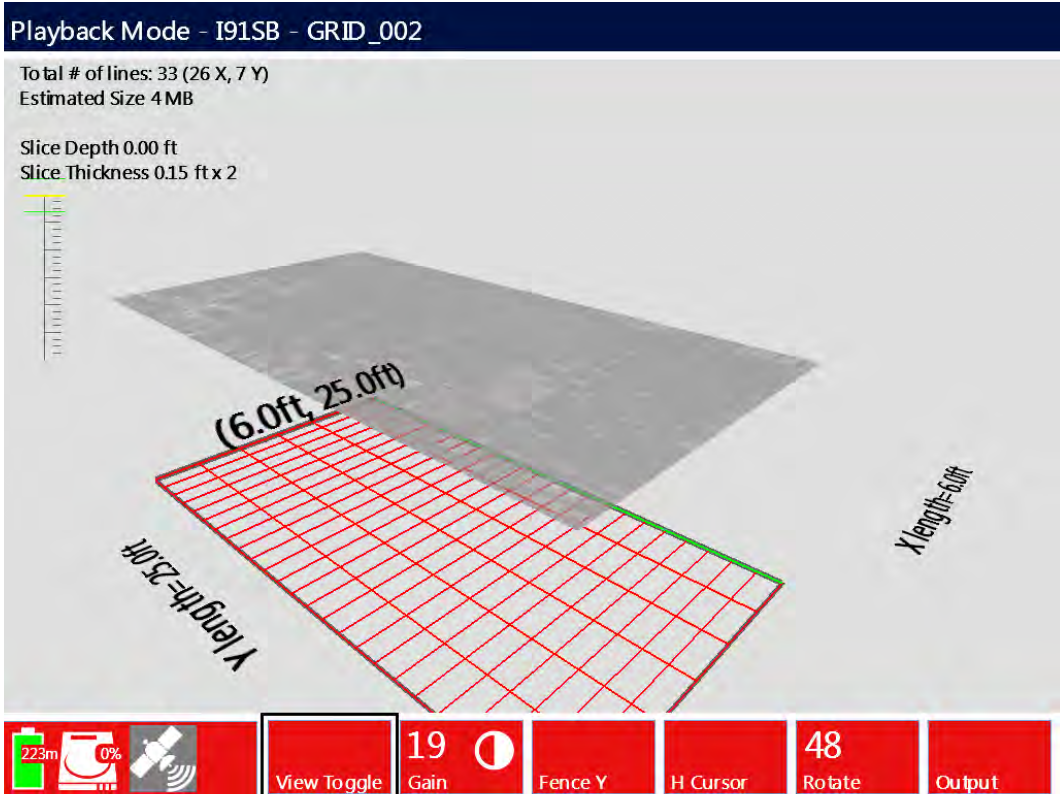
3D Scan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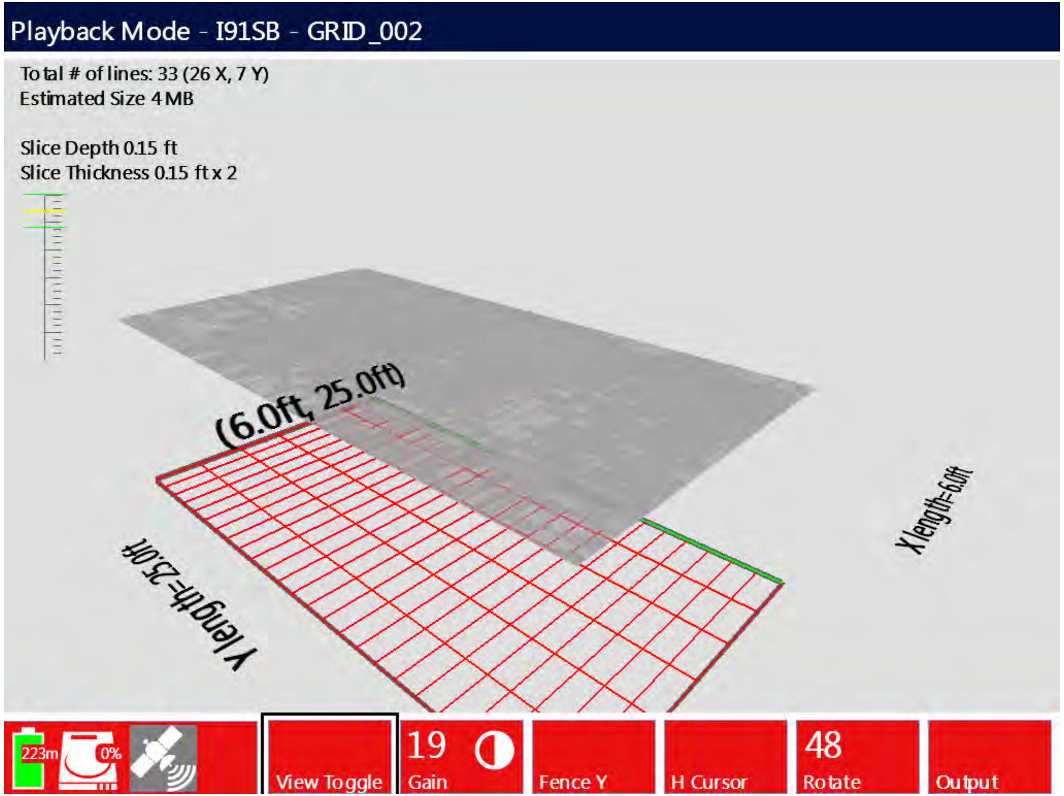
223m
0%
View Toggle
19
Gain
Fence Y
H Cursor
48
Rotate
Output

3D Scan



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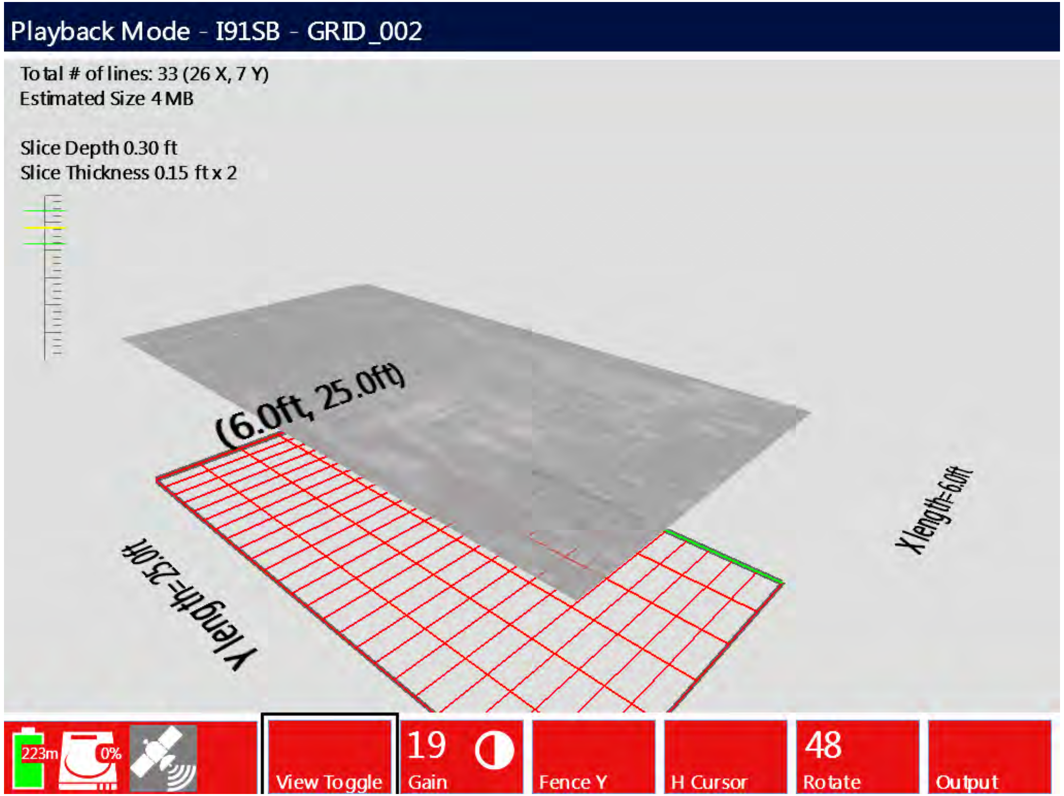
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H Cursor
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Rotate
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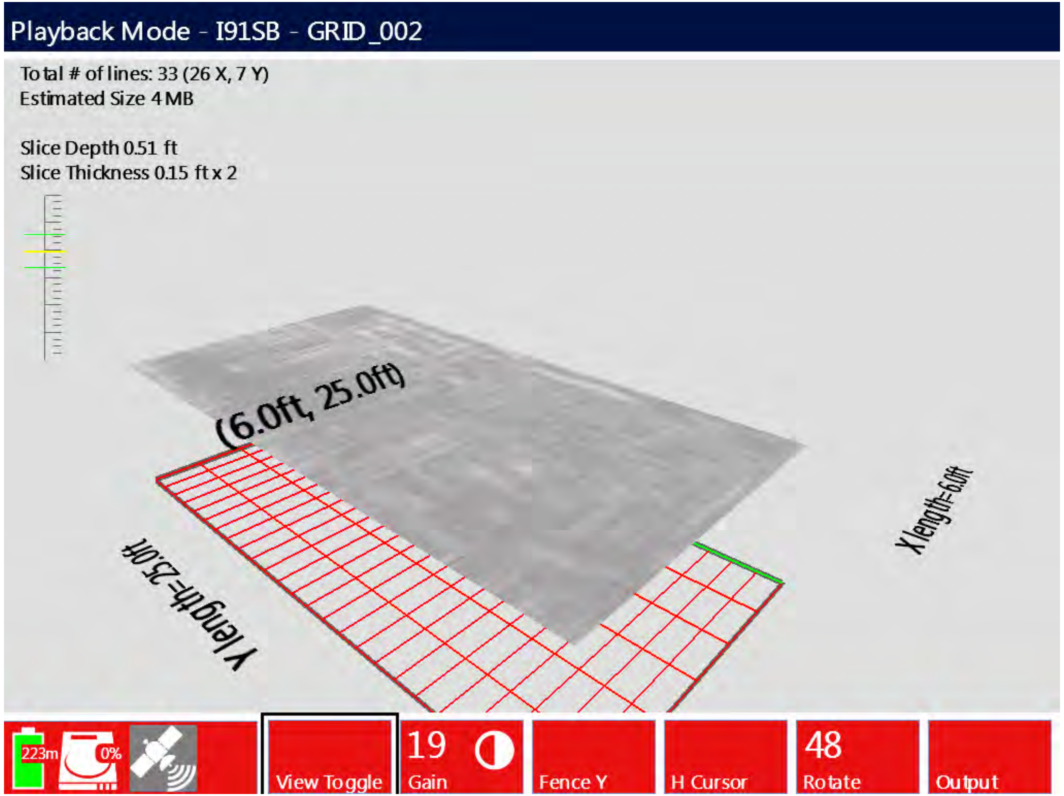
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Fence Y
H Cursor
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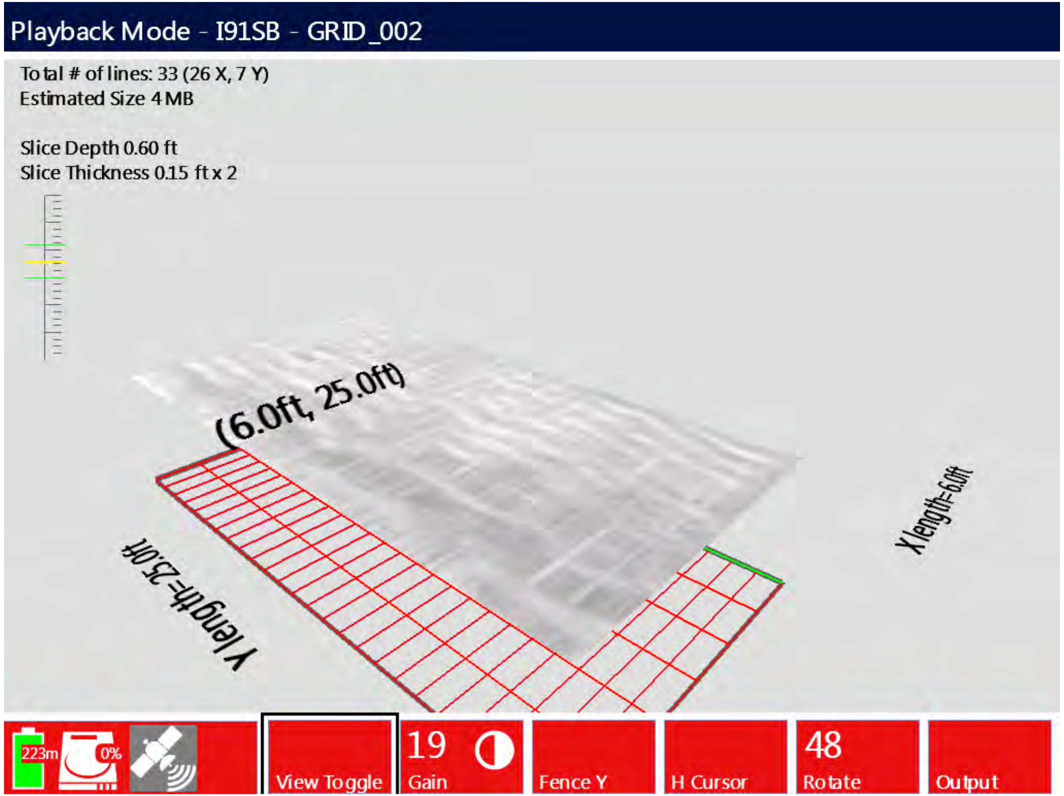
Rotate
Output

3D Scan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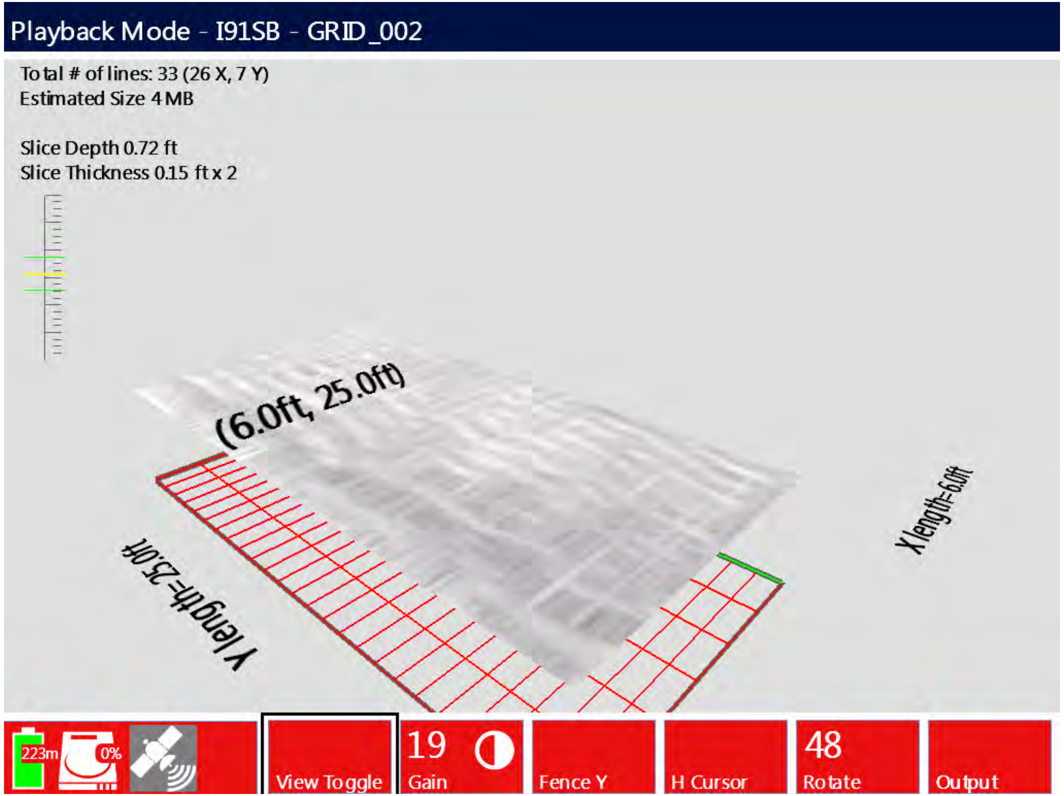
Rotate
Output

3D Scan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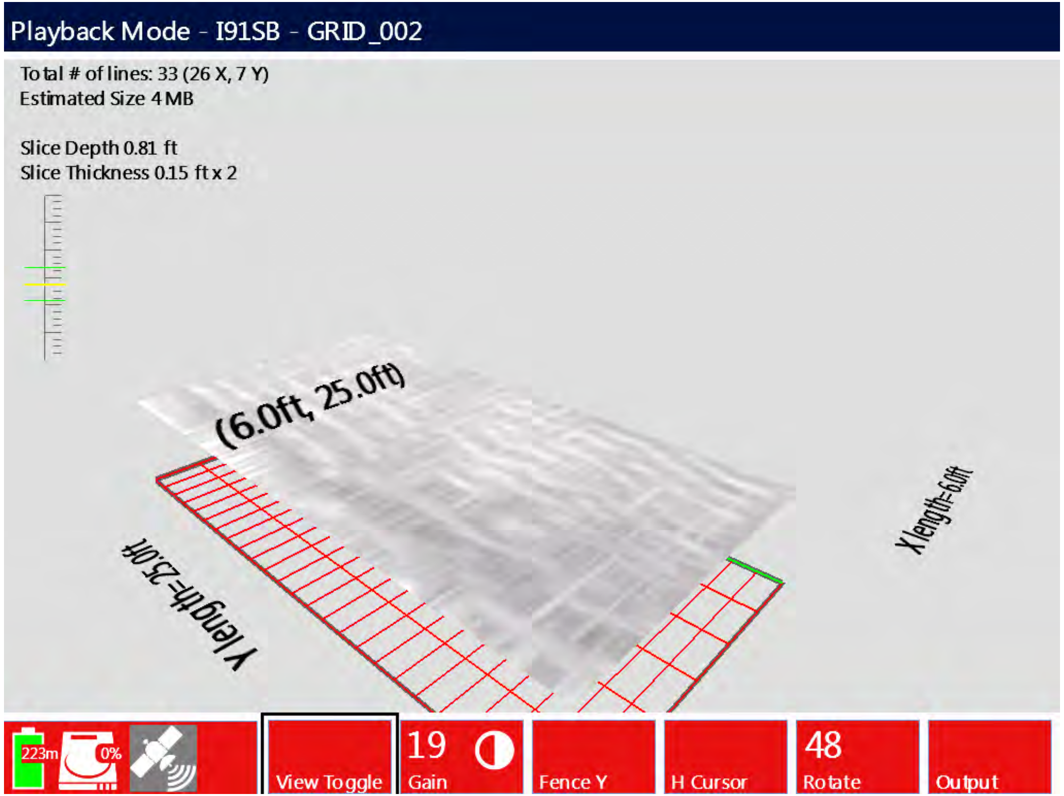
3D Scan



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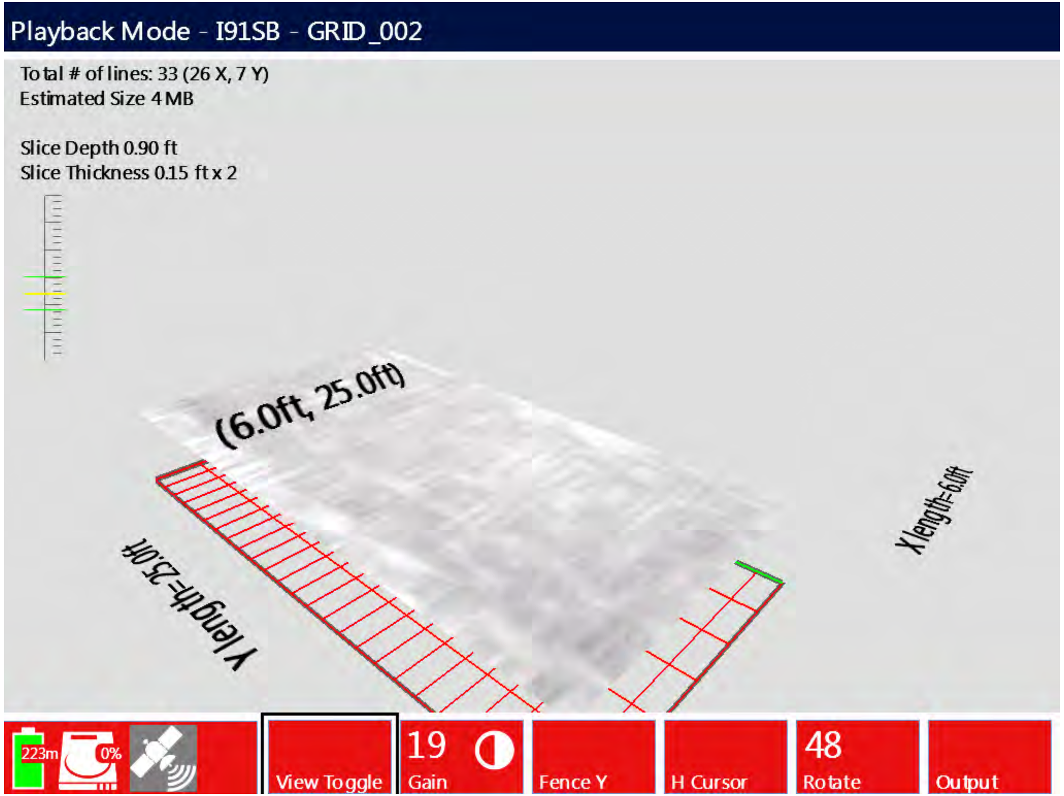
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H Cursor
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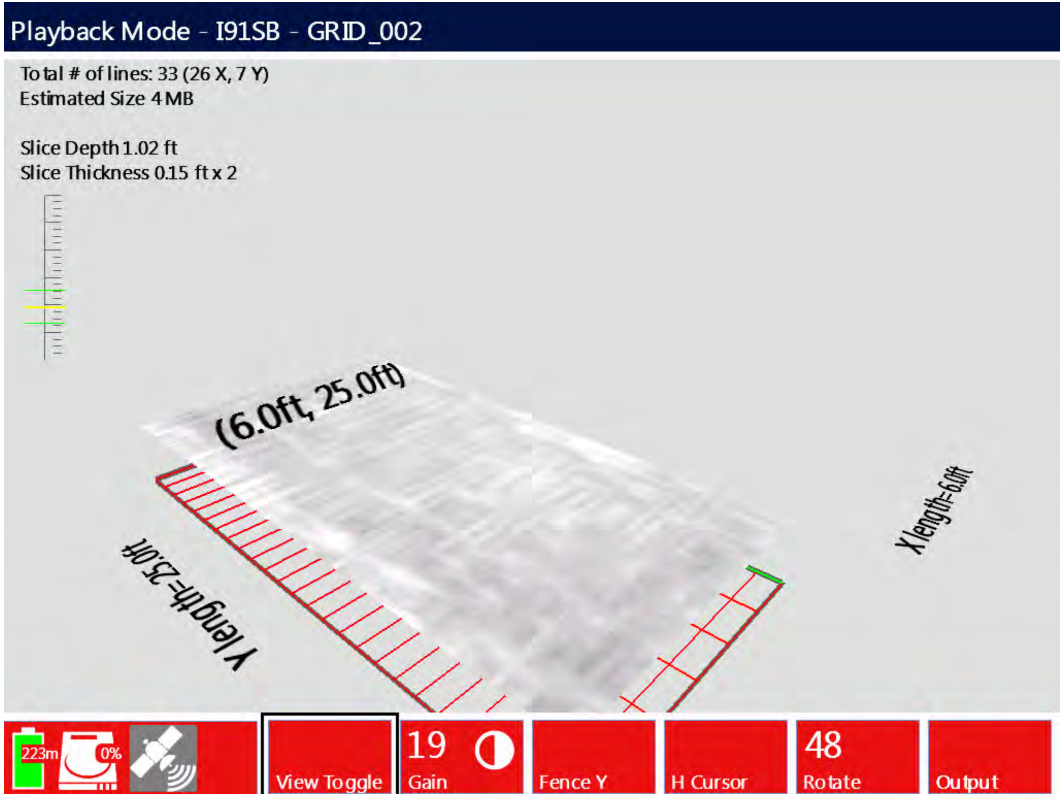
Rotate
Output

3D Scan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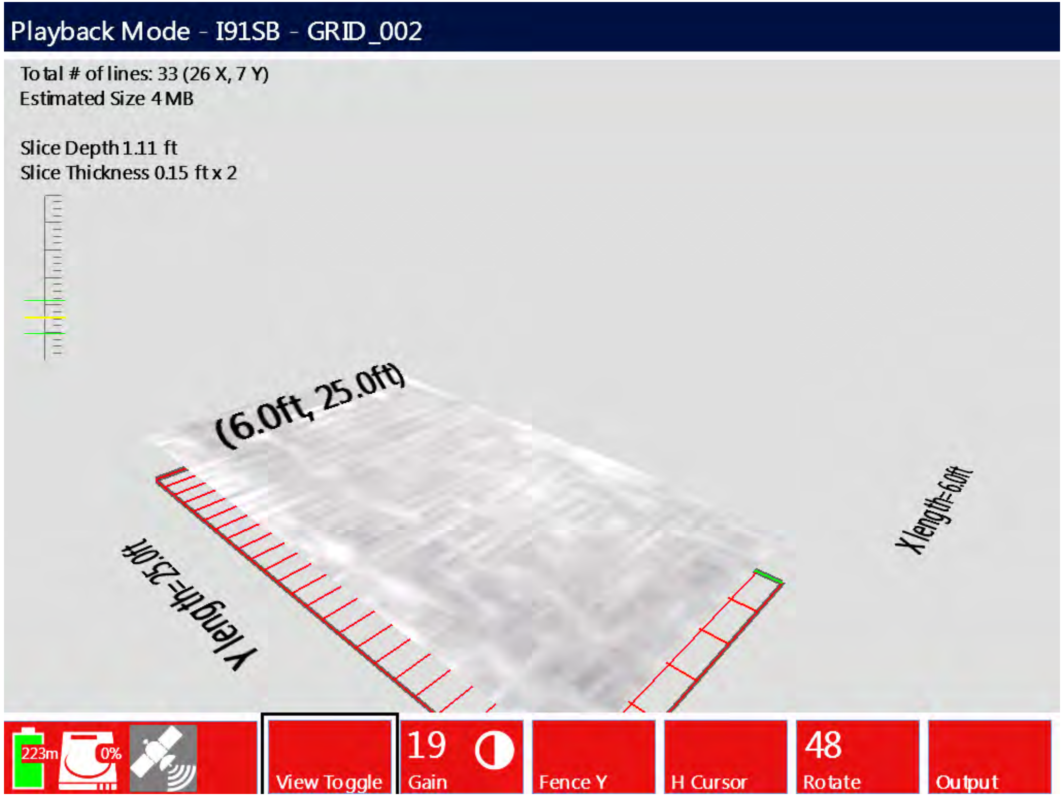

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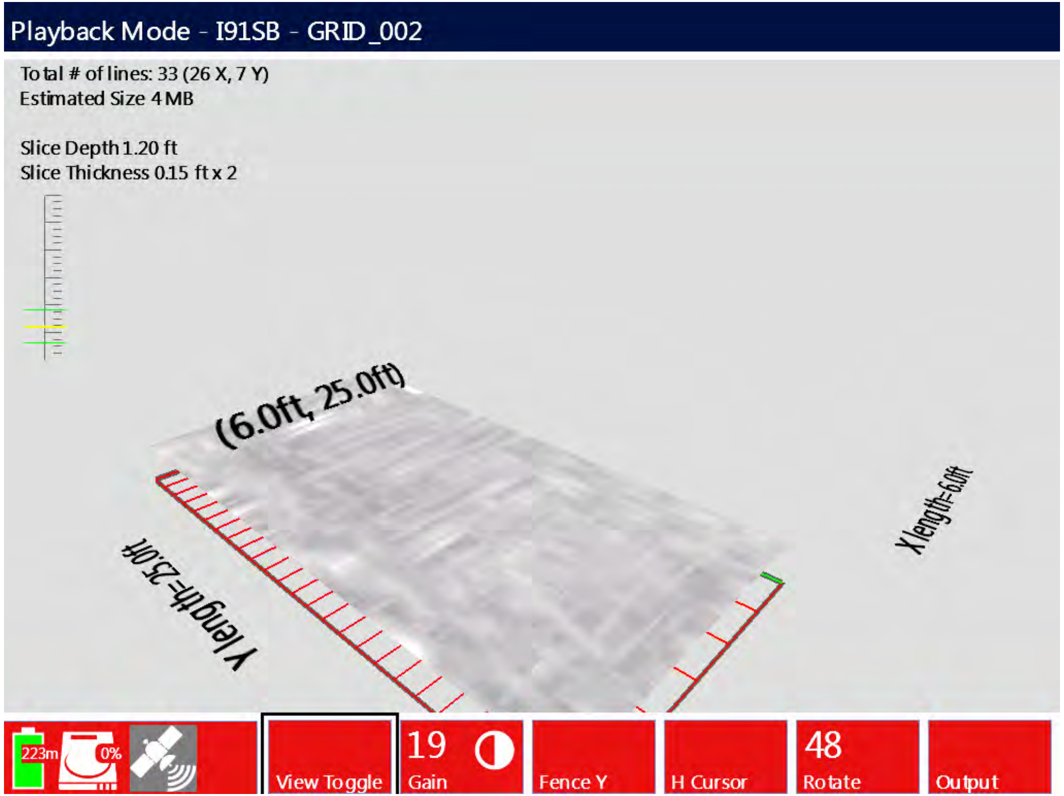

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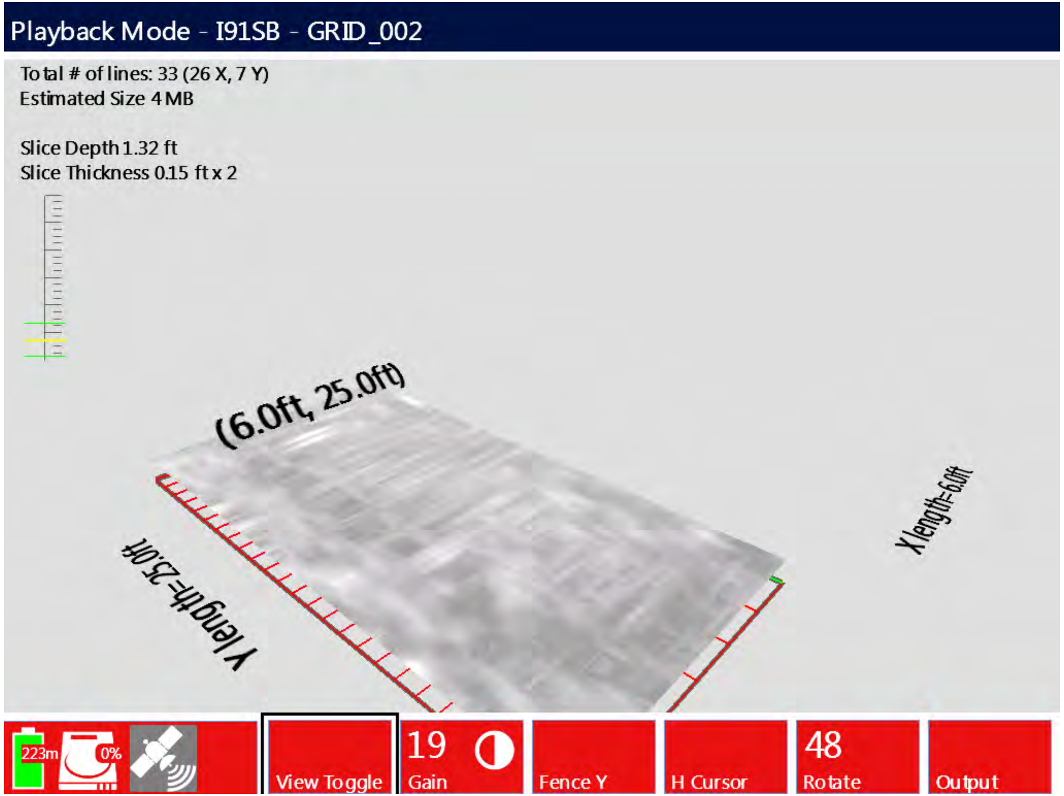
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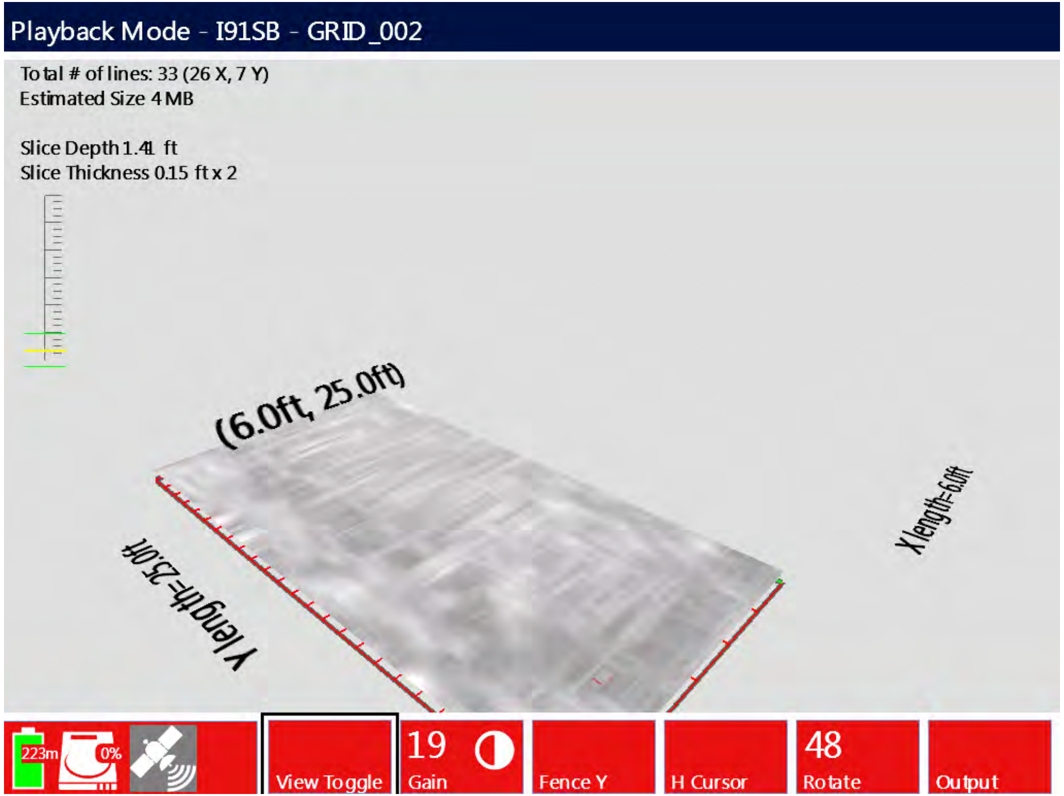

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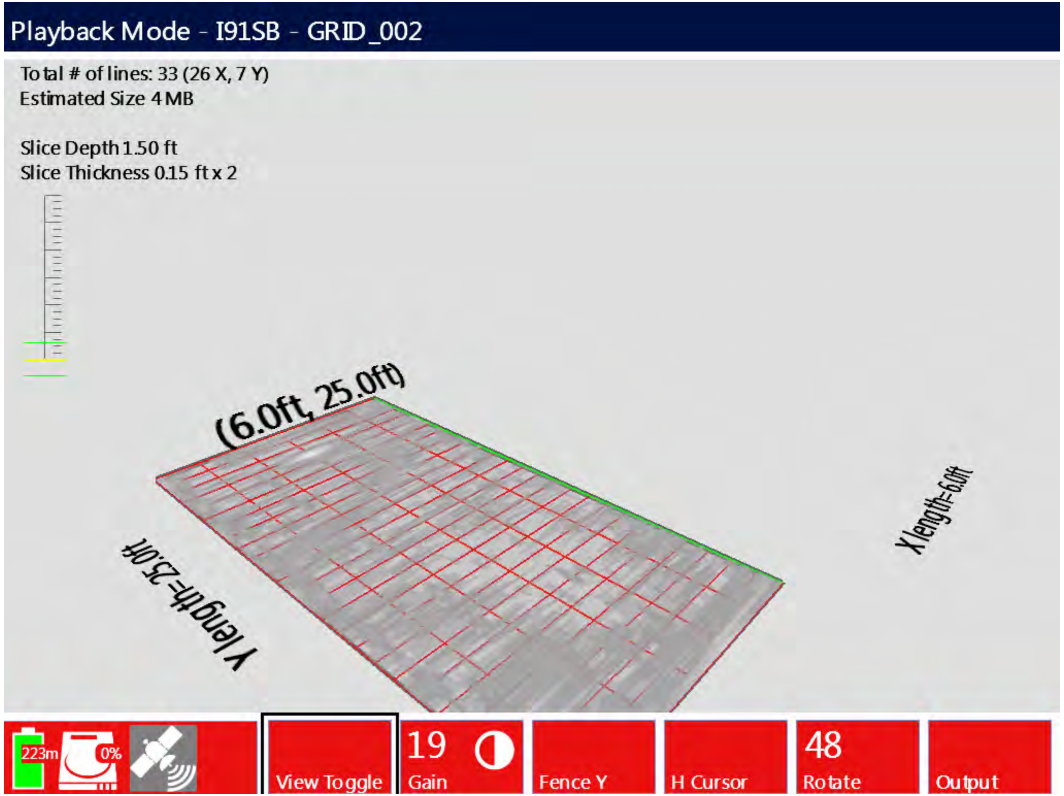
Rotate
Output

3D Scan



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223m
0%
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48
Rotate
Output

Recommendations + Improvements

- Lessons Learned Moving Forward & Future Tasks
  - Longitudinal Scans Only for void detection
  - Run 0.5 ft interval
  - Run Normal + Cross-Polarized Scans to boost clarity in presence of welded wire
  - Build laboratory mock-ups of known composite conditions
  - Truck-Mounted Scanning for longer/faster Collection
  - Ground truthing dielectric for core/scan pairings in CT

Photo Source: GSSI

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Current Studies: Pushing the limits

- Can we detect inter-asphalt layer differentials?
- Scans performed in the vicinity of a sand/skim layer
- Cores and test-pits performed as well
- Currently analyzing GPR data for possible identification
- Challenge: Sensitivity of the equipment to detect change in resistivity between different densities of material and accounting for noise of measurement

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Questions?

Thank You!

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