# Sediment Volume Search Sonar: System & Dataset Development

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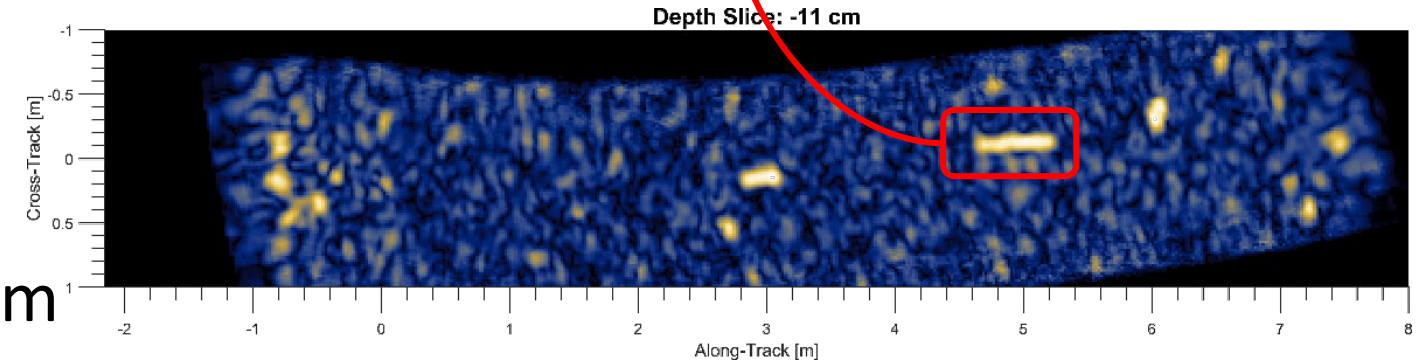
# Acoustic surveys for remediation of unexploded ordnance

- Historical military activities have resulted in unexploded ordnance (UXO) in marine environments
- These items present a difficult environmental remediation problem due to challenges with underwater sensing


**The SERDP munitions response program develops and demonstrates technologies addressing these issues for both terrestrial and underwater remediation sites**

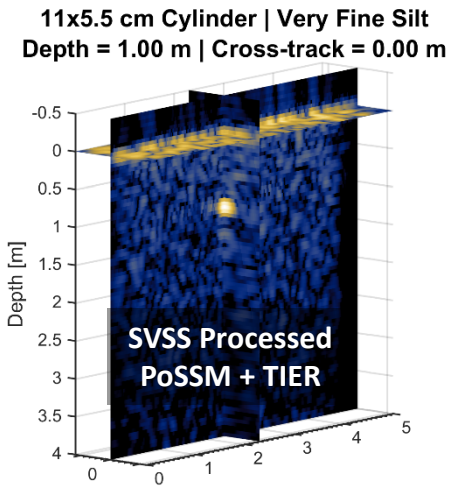
# Sediment Volume Search Sonar

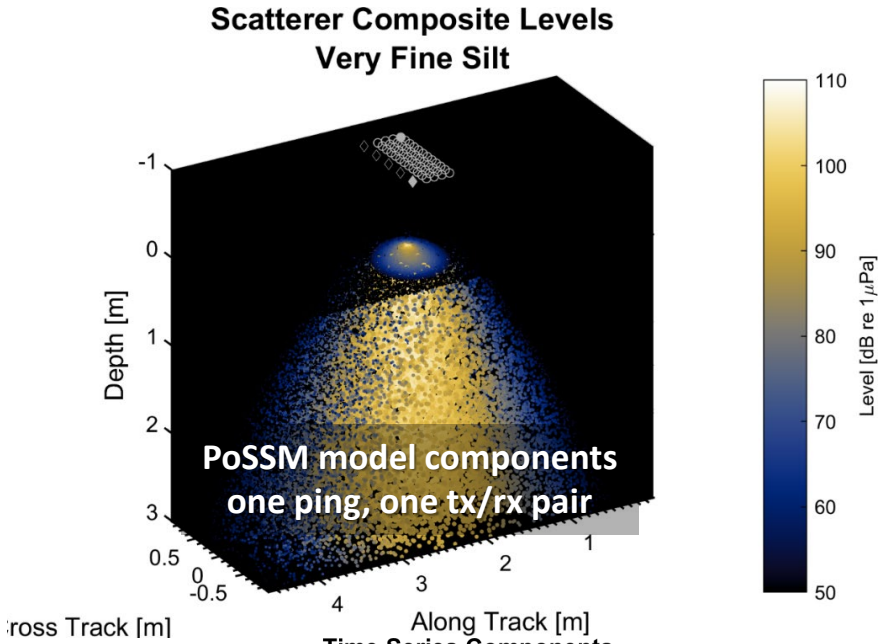
- Develop a sensor and platform for detailed UXO surveys in very shallow water
- Technology development focused project
  - Surface craft and sonar system for very shallow water
  - Sonar system design and signal processing for buried UXO imaging
- Developing custom sonar hardware tailored to problem

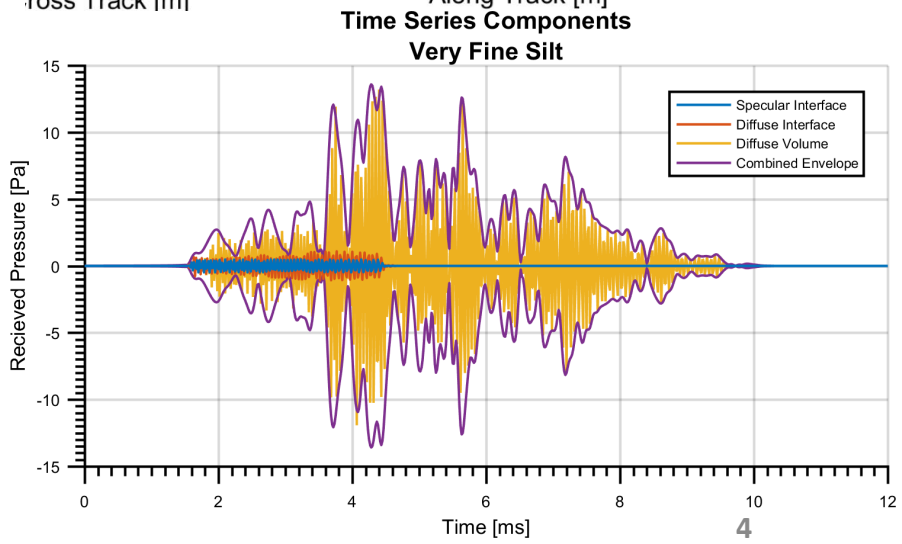


# Modeling and simulation was used in the design of the SVSS sensor

- Hybrid approach utilizing independent models for the environmental and target scattering
  - ARL/PSU: Point-based Sonar Signal Model (PoSSM)
  - APL-UW: Target in Environment Response (TIER)
- Present model/data comparison for environmental scattering



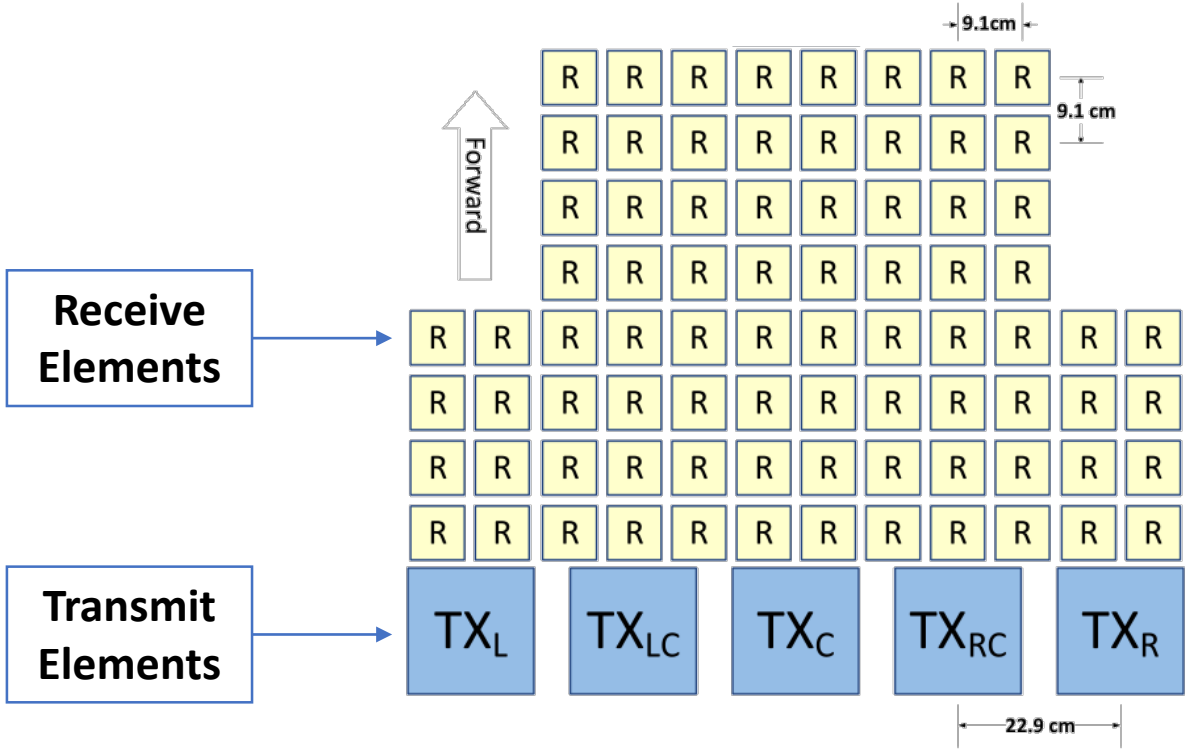





S. G. Kargl et al., "Scattering From Objects at a Water-Sediment Interface: Experiment, High-Speed and High-Fidelity Models, and Physical Insight," IEEE J. Oceanic Eng., 2015.
D. C. Brown, S. F. Johnson, and D. R. Olson, "A point-based scattering model for the incoherent component of the scattered field," J. Acoust. Soc. Am., 2017.

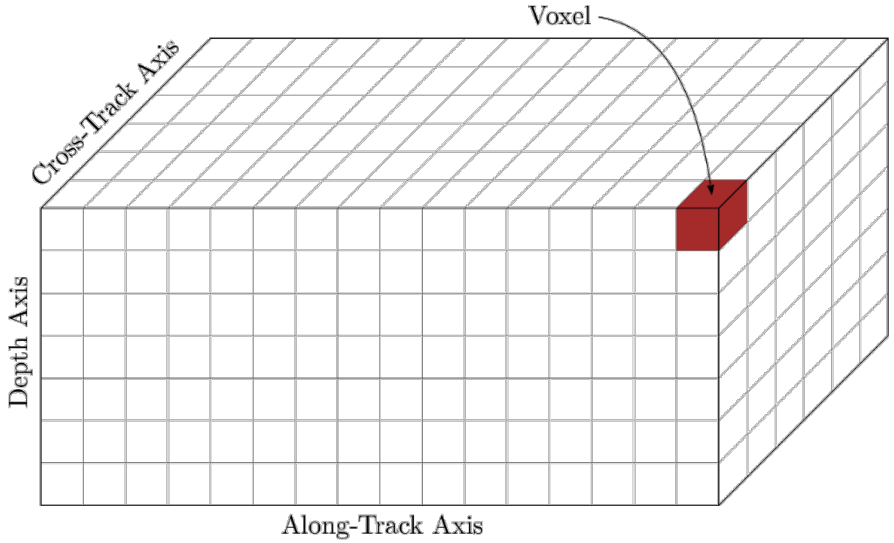
# SVSS Sonar Hardware and Array Configuration

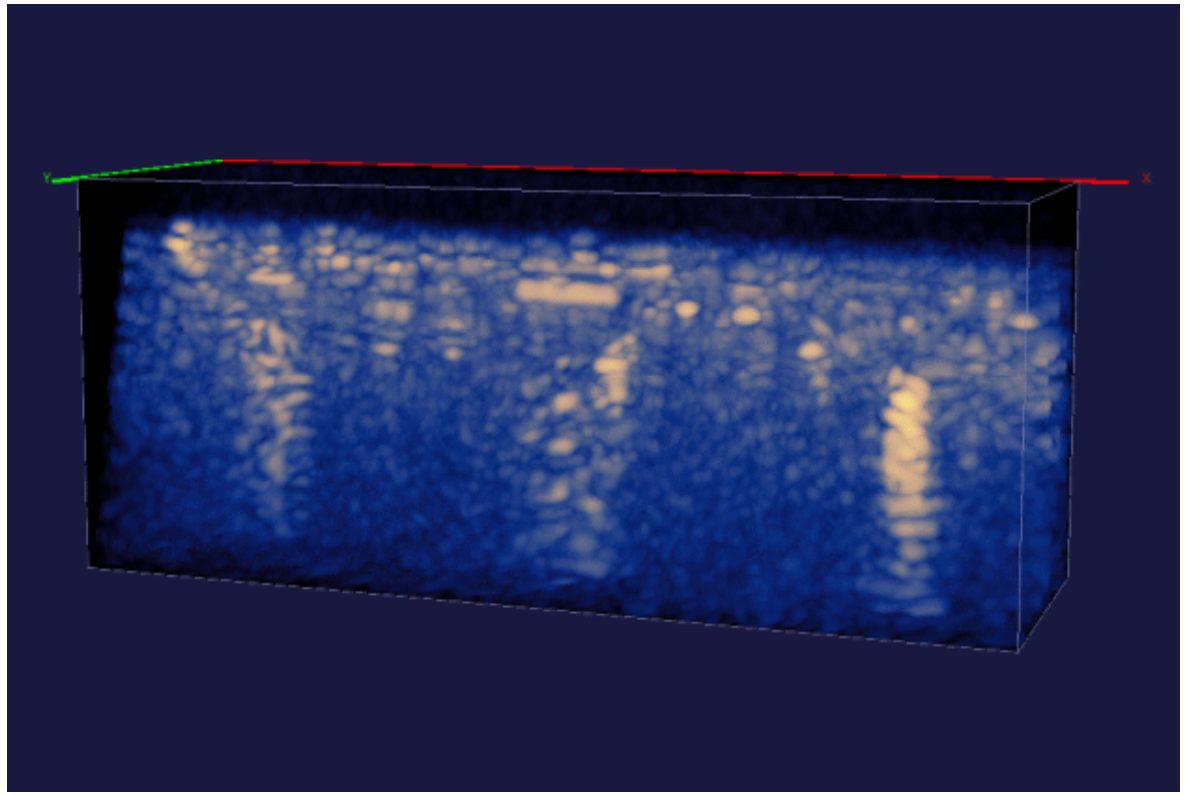



**Two-dimensional synthetic aperture allows formation of three-dimensional sonar imagery**

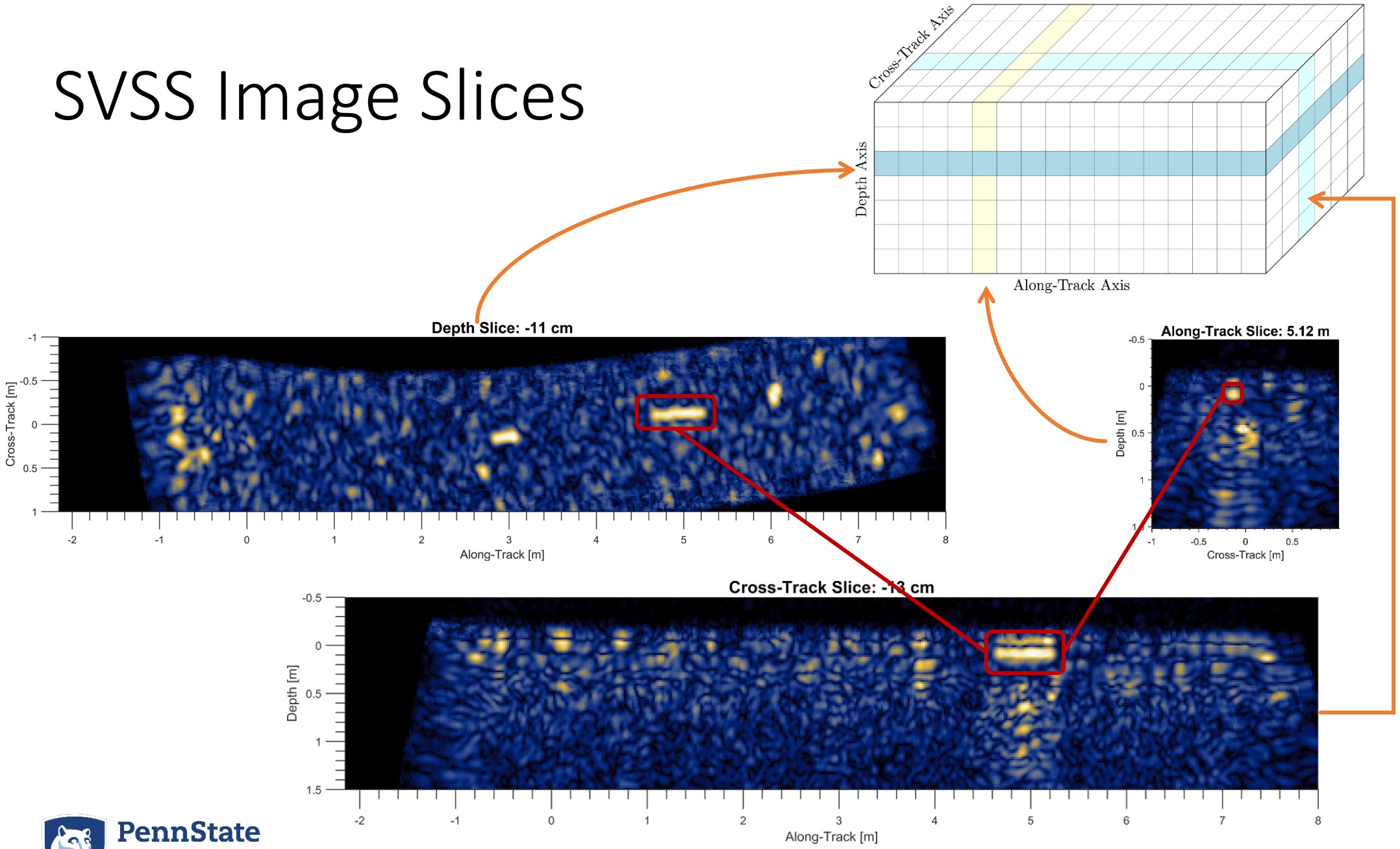
# The SVSS creates three-dimensional imagery

- Visualization techniques
  - 3D Viewer
  - Slices
  - Projections



# SVSS Image Slices

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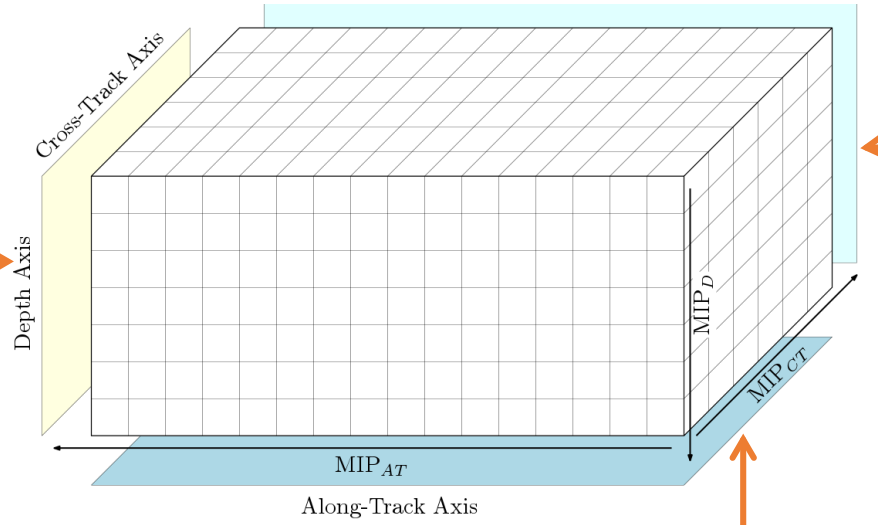
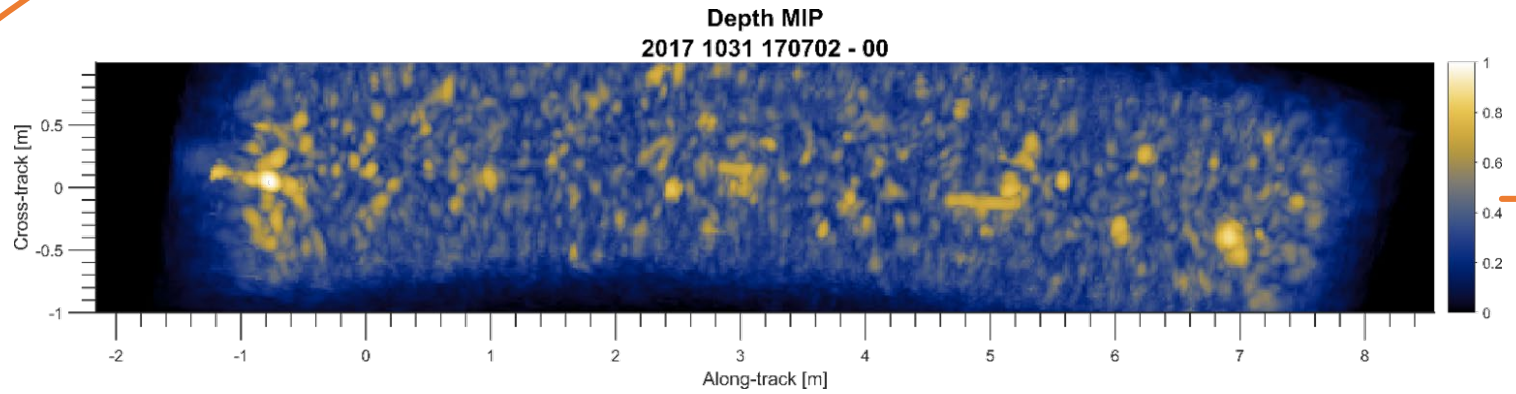
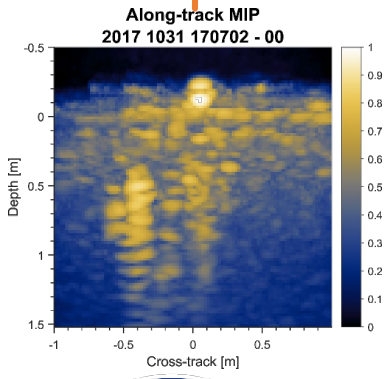
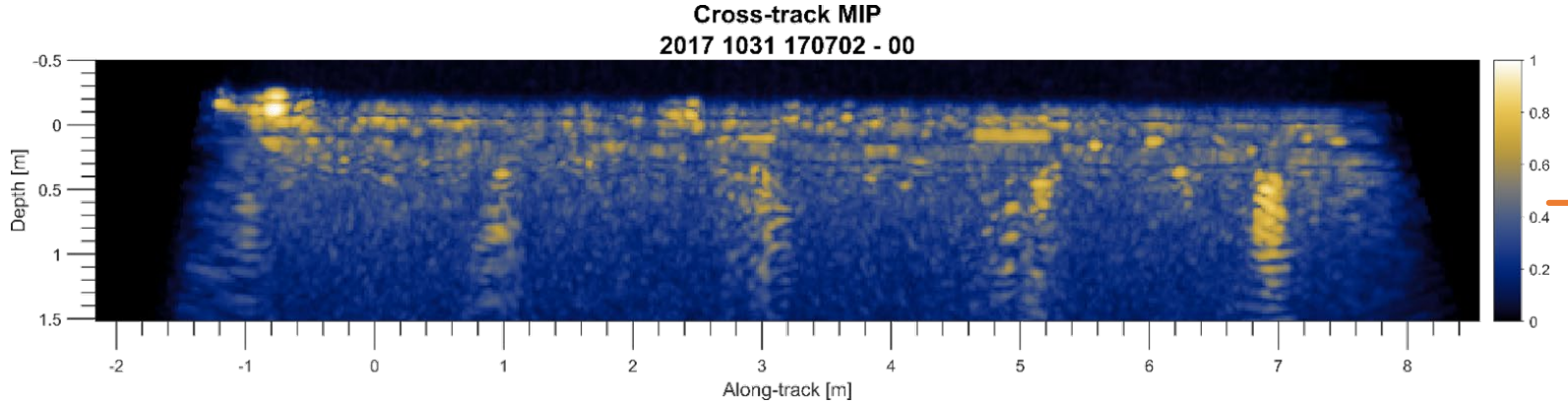
# Maximum Intensity Projections (MIPs)

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# Engineering test bed development

T05 Flat Up — 2 m — T05 Cores Up

2 m

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P01 T05D0 | P02 T04D0 | P03 T04D1 | P04 T04D2 | P05 T04D3 | P06 T04D4 | P07 T04D5 | P08 T04D6 | P09 T04D2 | P10 T04D2 | P11 T04D2 | P12 T04D2 | P13 T04D2 | P14 T05D0 | |
| P15 T05D0 | P16 T06D0 | P17 T06D1 | P18 T06D2 | P19 T06D3 | P20 T06D4 | P21 T06D5 | P22 T06D6 | P23 T06D2 | P24 T06D2 | P25 T06D2 | P26 T06D2 | P27 T06D2 | P28 T05D0 | |
| P29 T05D0 | P30 T07D0 | P31 T07D1 | P32 T07D2 | P33 T07D3 | P34 T07D4 | P35 T07D5 | P36 T07D6 | P37 T07D2 | P38 T07D2 | P39 T07D2 | P40 T07D2 | P41 T07D2 | P42 T05D0 | P85 T25D2 |
| P43 T05D0 | P44 T19D0 | P45 T19D1 | P46 T19D2 | P47 T19D3 | P48 T20D0 | P49 T20D1 | P50 T20D2 | P51 T20D3 | P52 T21D0 | P53 T21D1 | P54 T21D2 | P55 T21D3 | P56 T05D0 | |
| P57 T05D0 | P58 T08D0 | P59 T08D1 | P60 T08D2 | P61 T08D3 | P62 T08D4 | P63 T08D5 | P64 T22D0 | P65 T22D2 | P66 T01D0 | P67 T01D1 | P68 T01D2 | P69 T01D3 | P70 T05D0 | P86 T00D3 |
| P71 T05D0 | P72 T03D0 | P73 T03D1 | P74 T03D2 | P75 T03D3 | P76 T23D0 | P77 T23D1 | P78 T23D2 | P79 T23D3 | P80 T15D0 | P81 T17D0 | P82 T12D0 | P83 T24D0 | P84 T05D0 | |

**Two separate engineering test beds developed with munitions, clutter, and science objects**

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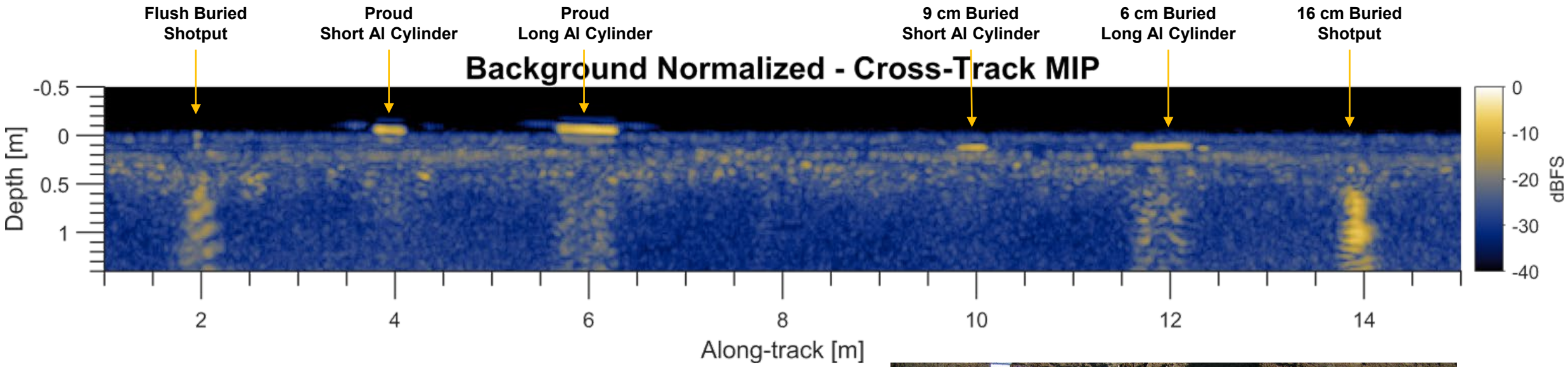


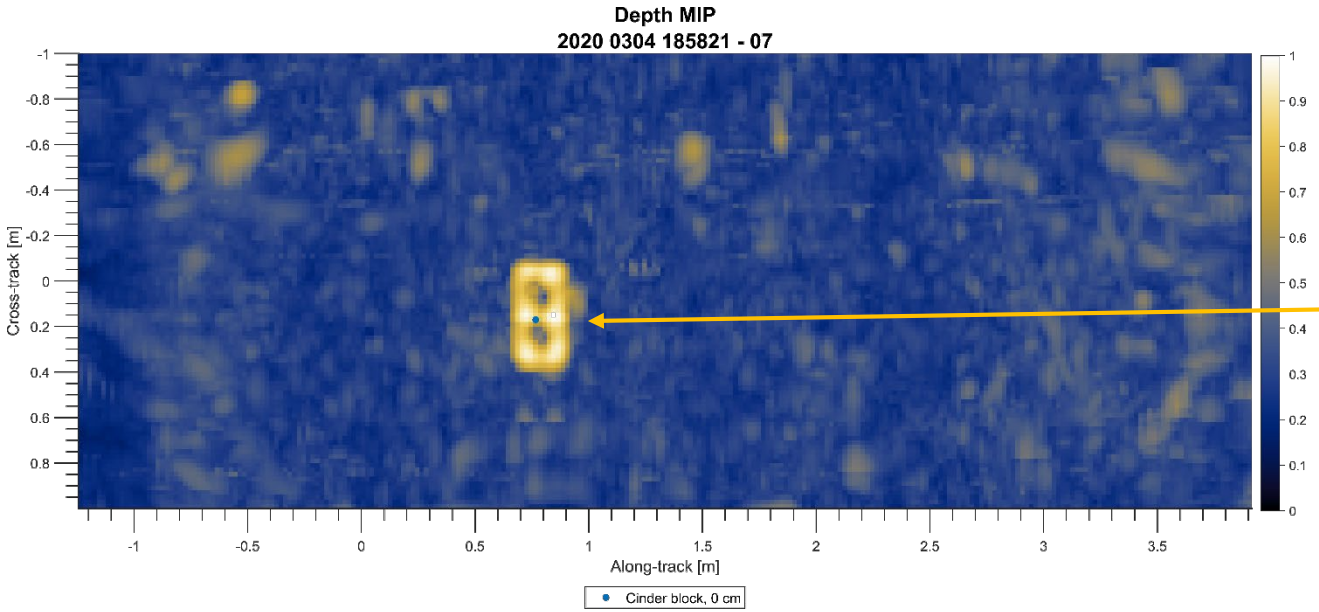



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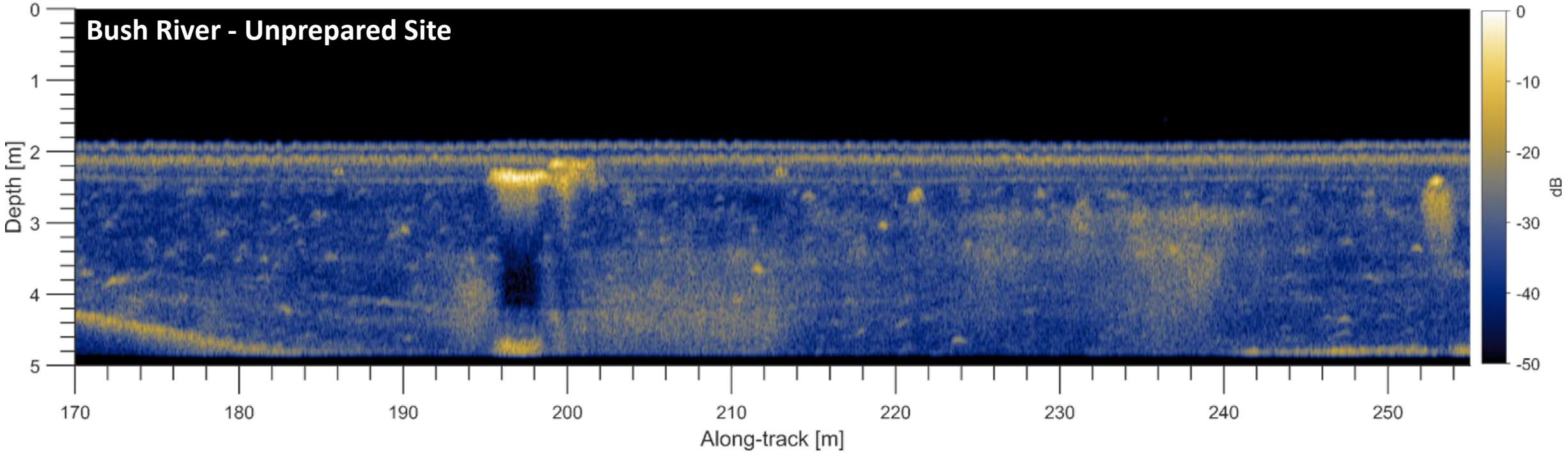
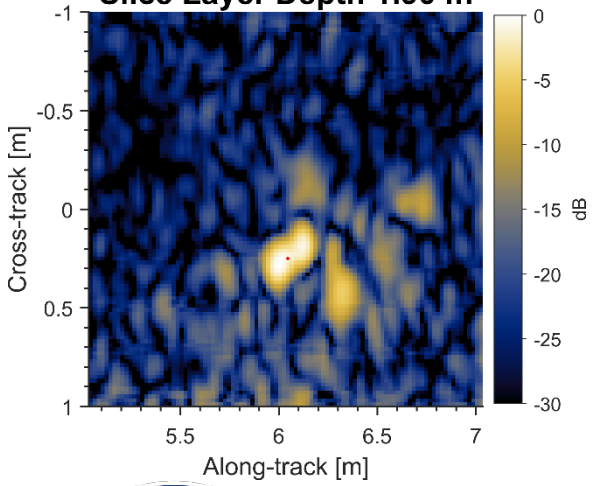
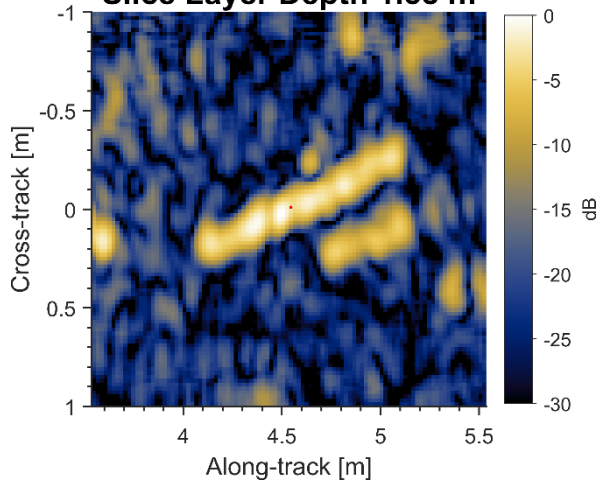
# Bush River Test Site Sub-Bottom Profile



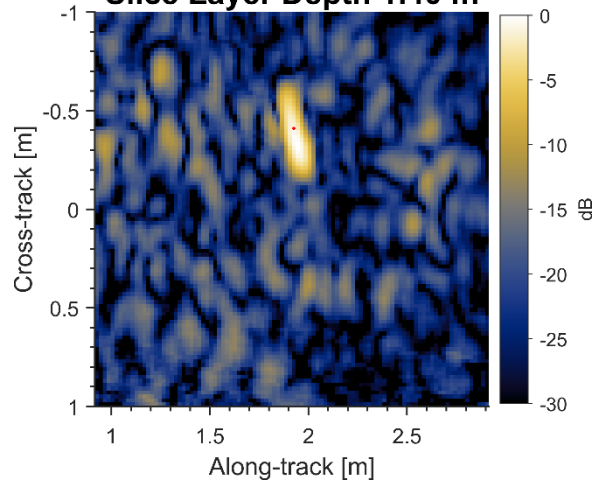

**Contact 226**
**Slice Layer Depth 1.90 m**



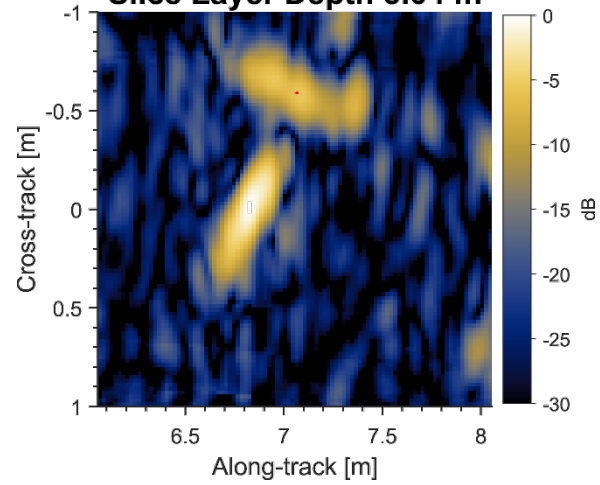

**Contact 238**
**Slice Layer Depth 1.58 m**




**Contact 478**
**Slice Layer Depth 1.40 m**




**Contact 496**
**Slice Layer Depth 3.04 m**

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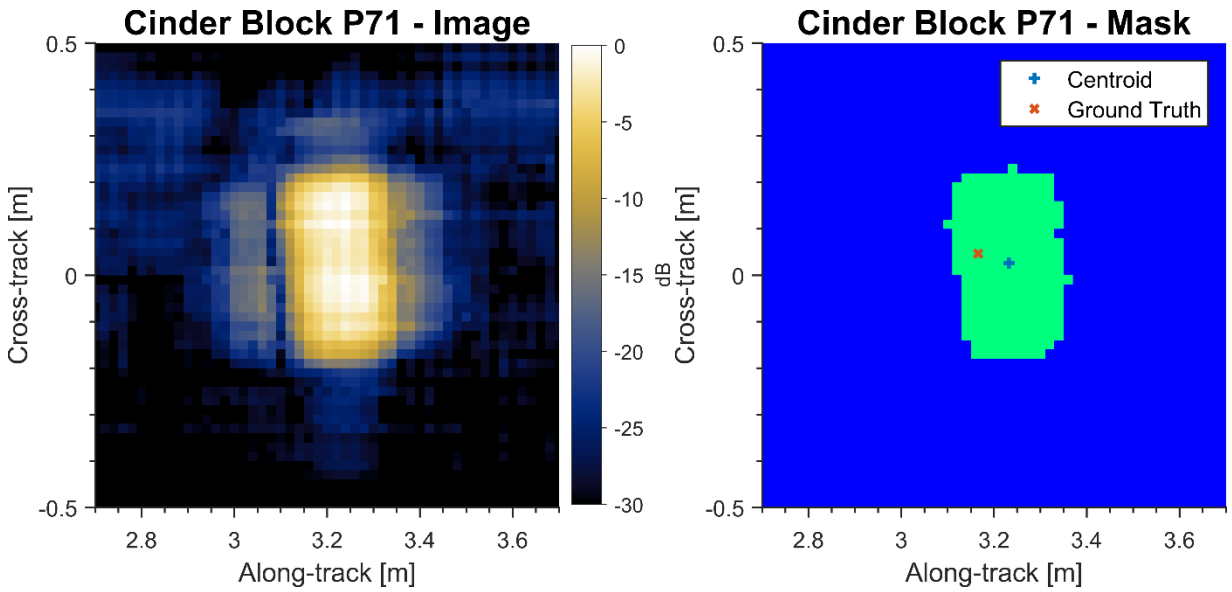
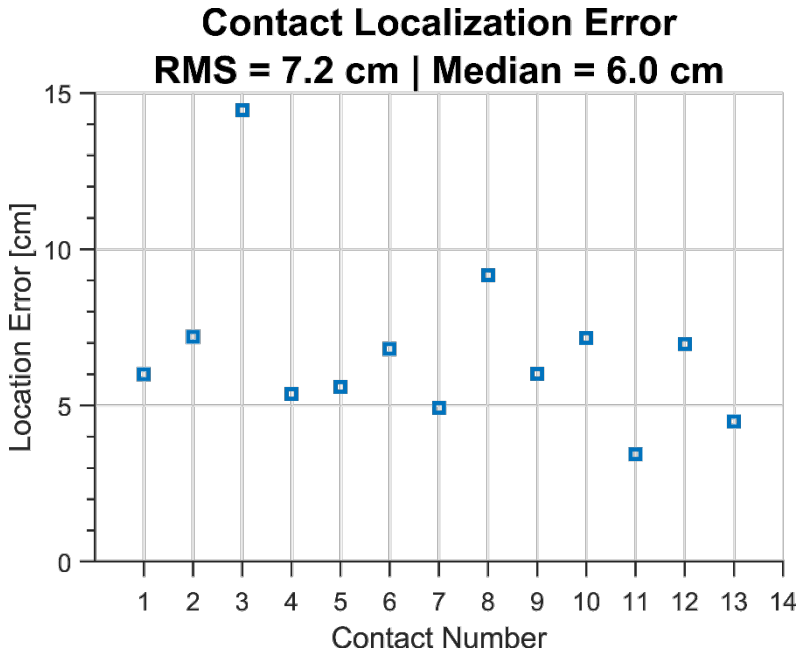
# Accurate Target Geolocation

- Proud cinder blocks were analyzed to quantitatively assess target localization
- Manual selection of depth slice
- Automated centroid calculation
- Localization error “within a shovel head”

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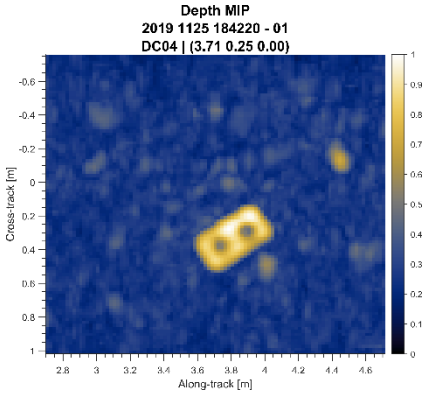
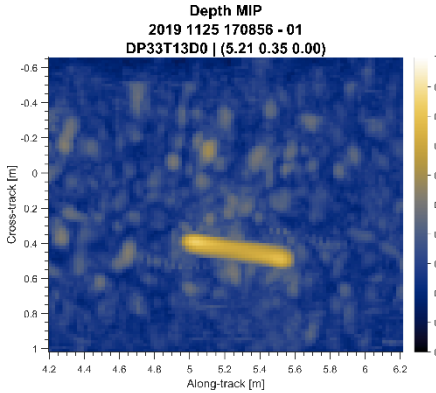
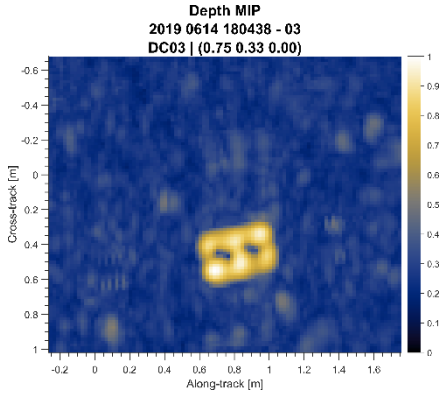
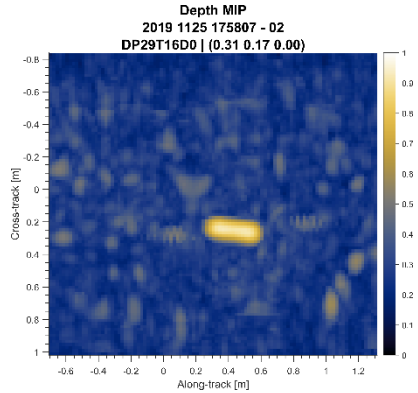
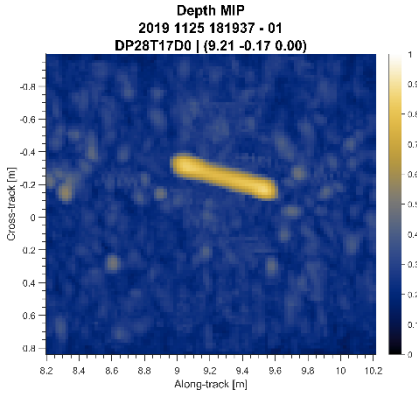
# Field experiments have produced labeled datasets suitable for training machine learning systems

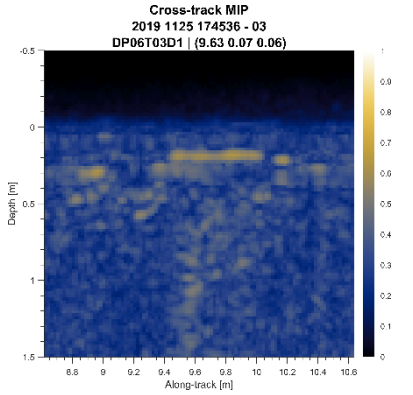


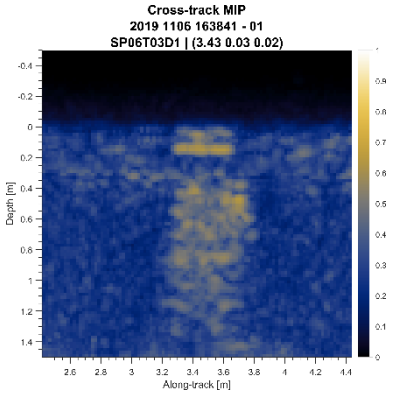



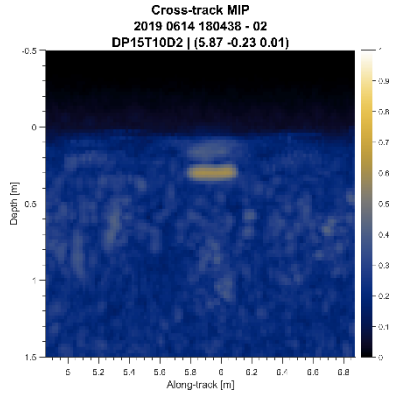



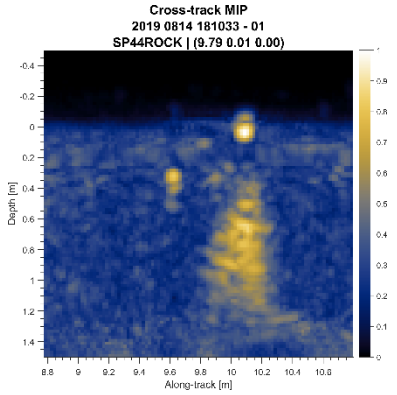



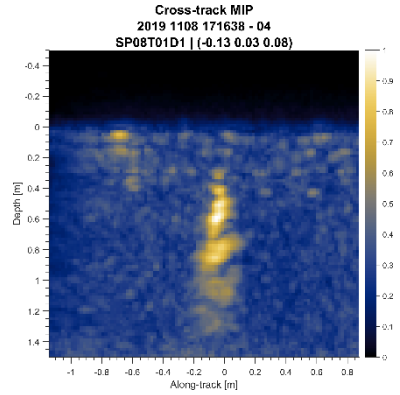




**SVSS datasets provided to collaborators at Arizona State University and Penn State University**
**>1000 Labeled 3D image Cubes**

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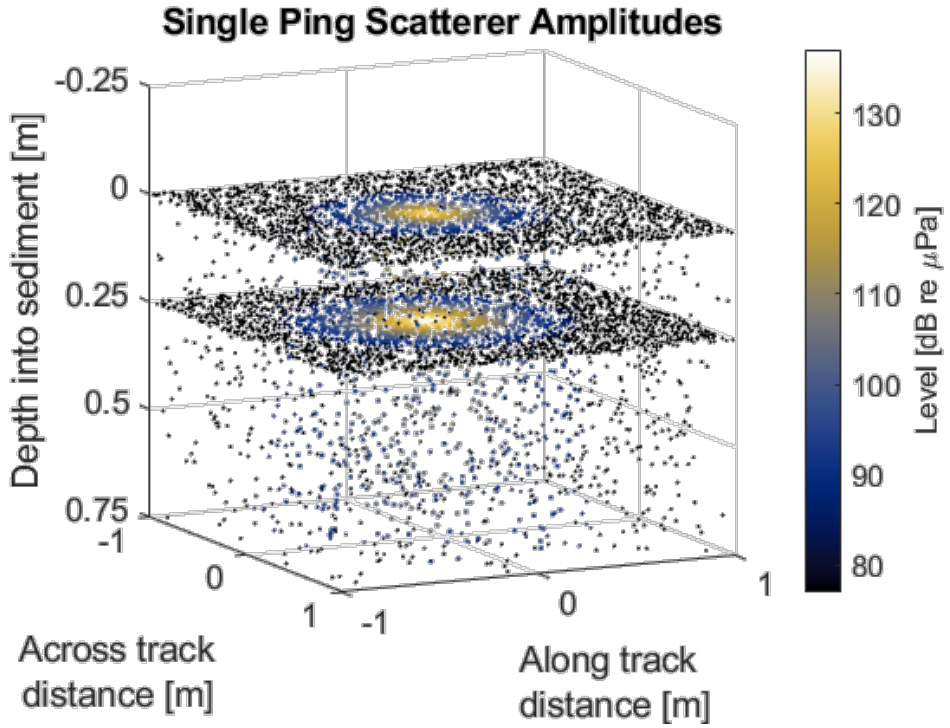
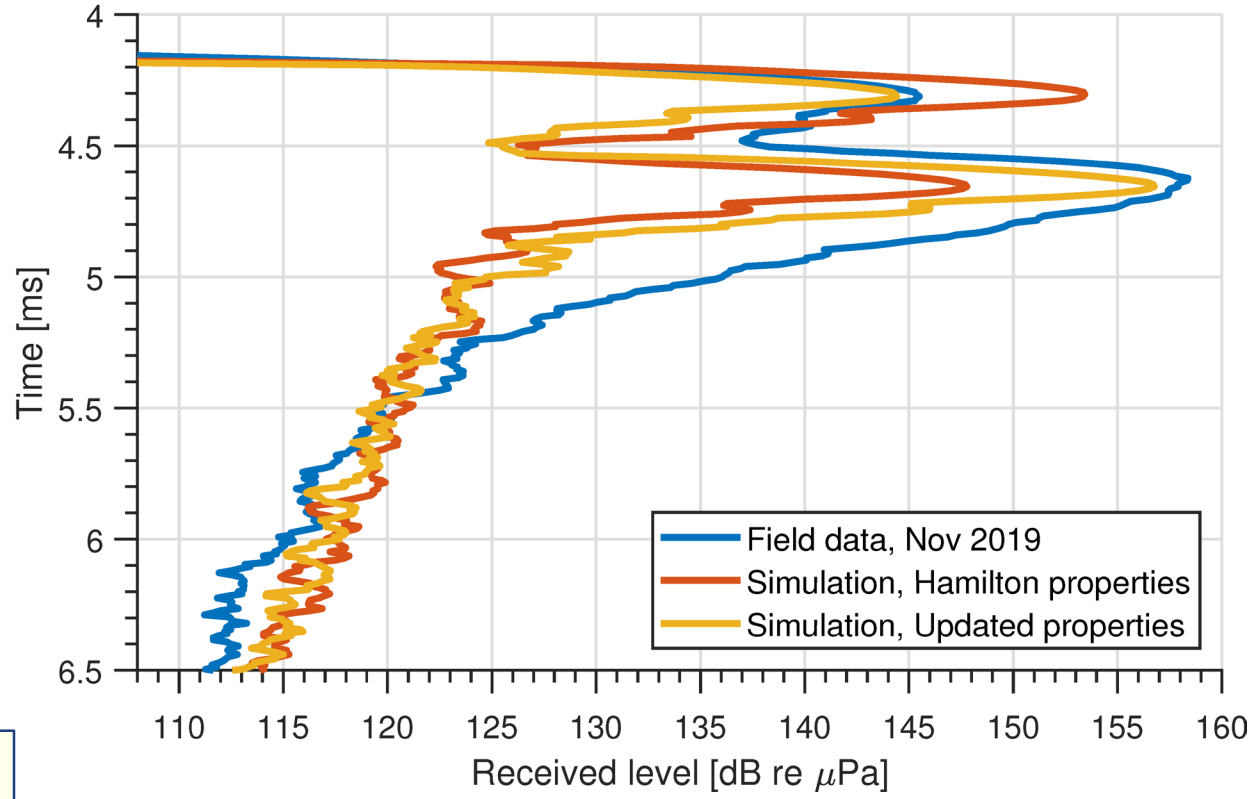
# Backup

# Model/data comparison shows reasonable agreement for A-scan levels




**Updating scattering models with estimates of in situ sediment properties improved agreement**

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