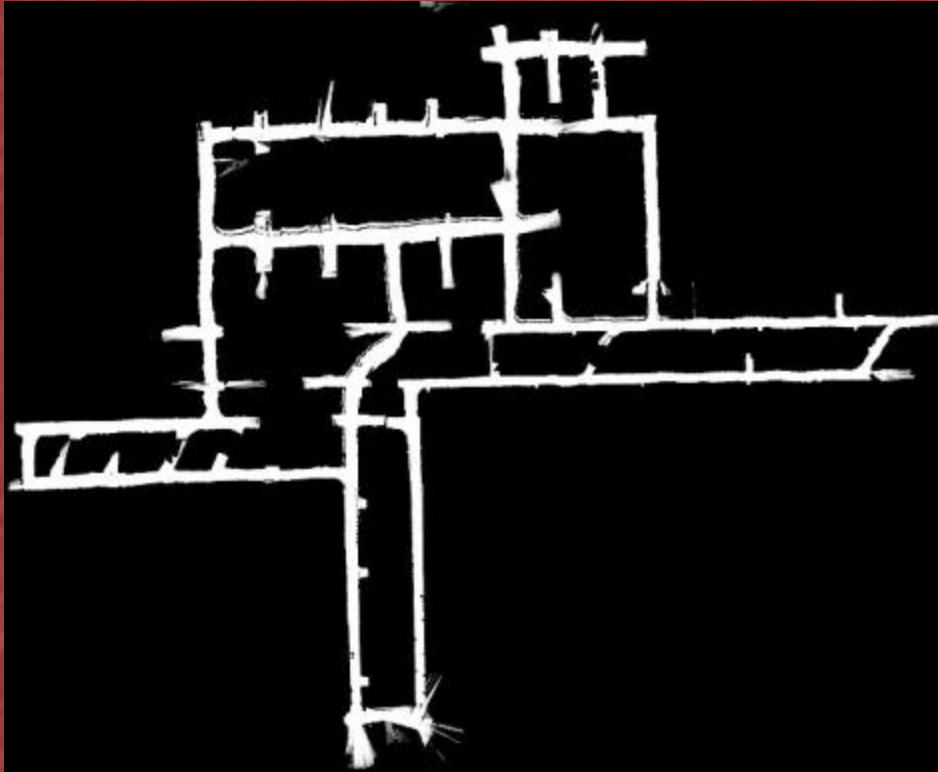
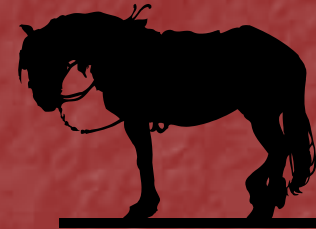


Robotic Mapping and Exploration of Abandoned Mines



Robotically Generated Mine Map



Workhorse
Technologies



- Workhorse Technologies, LLC - Service Provider for Mine Mapping
- Carnegie Mellon University – Premiere Robotics Research

Mine Mapping Results from Boreholes



- Wet and Dry Ferret
- Early Results
- Lots Branch, Boone County, WV
- Riola Mine, Georgetown, IL
- Ore Mines, Oklahoma
- Future Borehole Robots



Ferret 3

Pan Axis

- Lowers into 6" borehole
- Pan and tilt motion
- 150ft range laser sensor
- Automated scan & data collection
- Camera & lights

Laser & Laser Tilt

Camera & Camera Tilt



Wet Ferret

- 5" borehole deployable
- Profiling sonar
- Readily deployed
- 300ft sensor range
- Magnetic sensor orientation
- Submersible to great depths

Tether

Support Frame

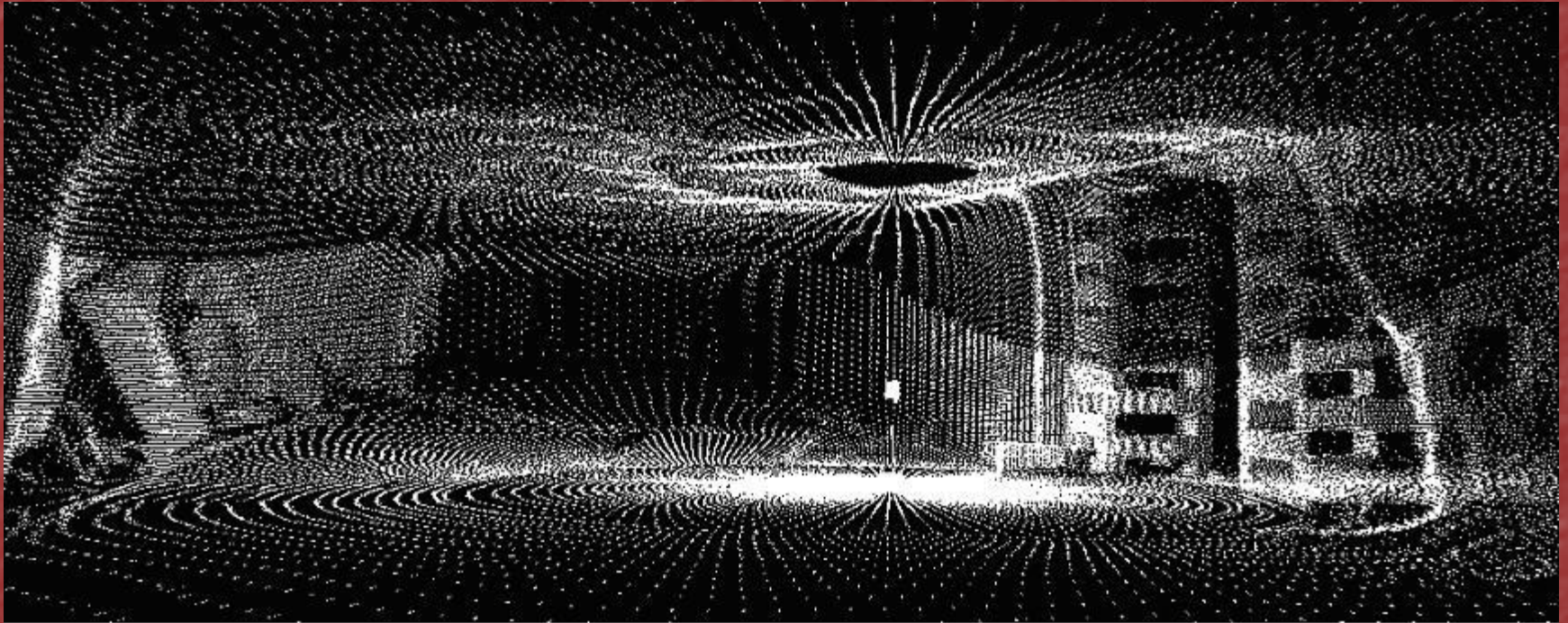
Sonar Profiling Unit

Underwater Camera

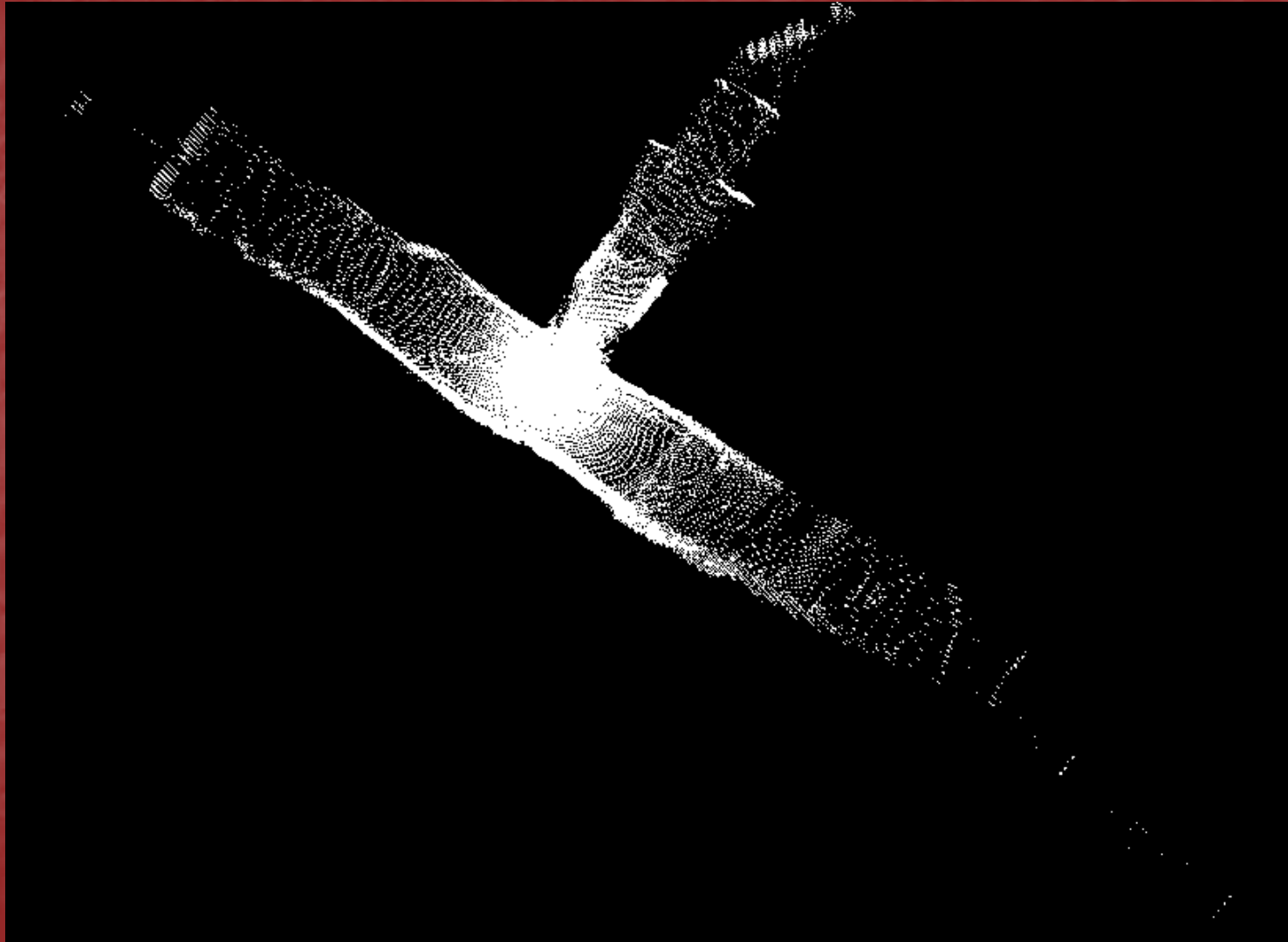
Compass



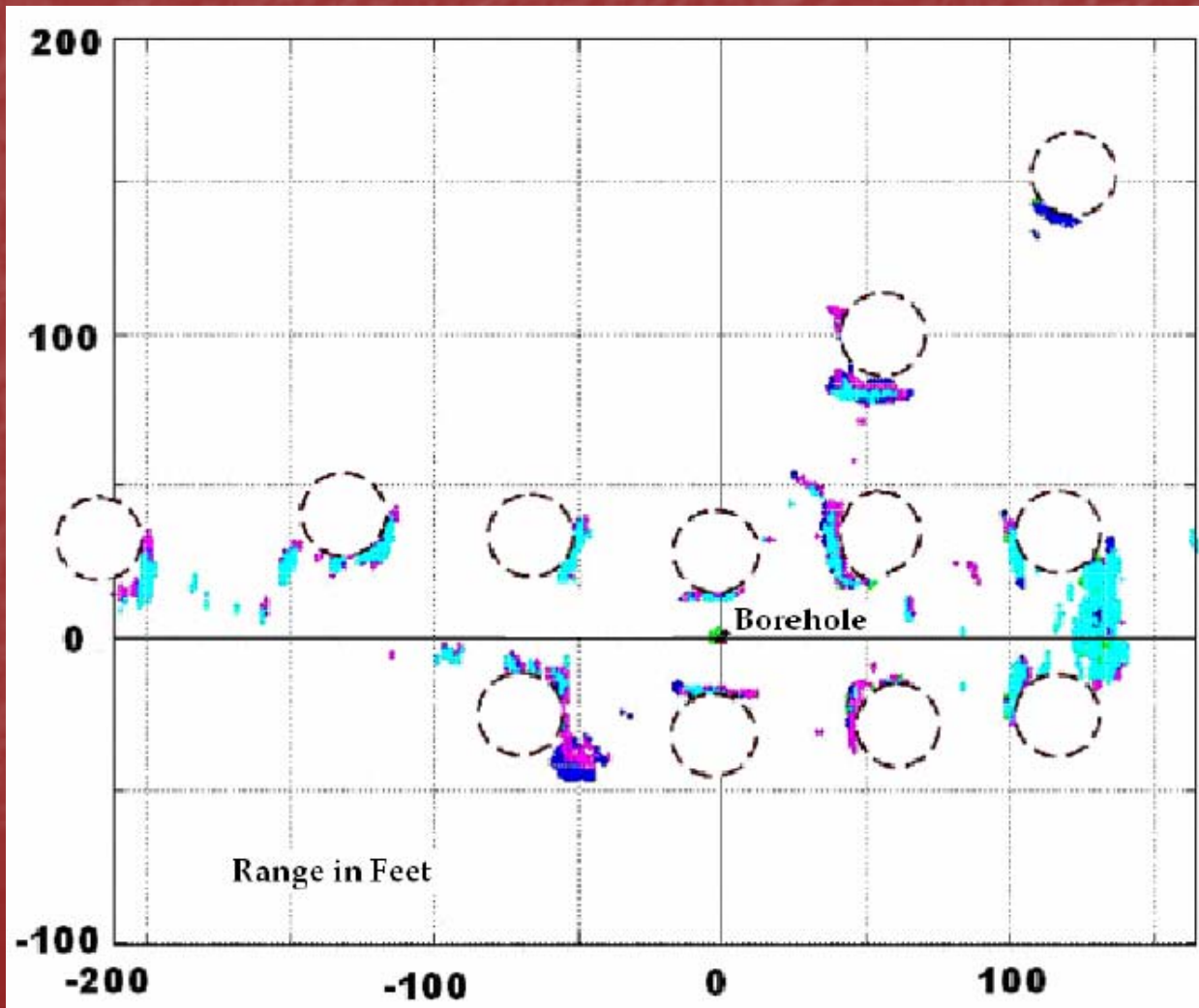
Laser Model from a Single Borehole In Coal



T-intersection in a Coal Mine



Map of Submerged Pillars in a Limestone Mine

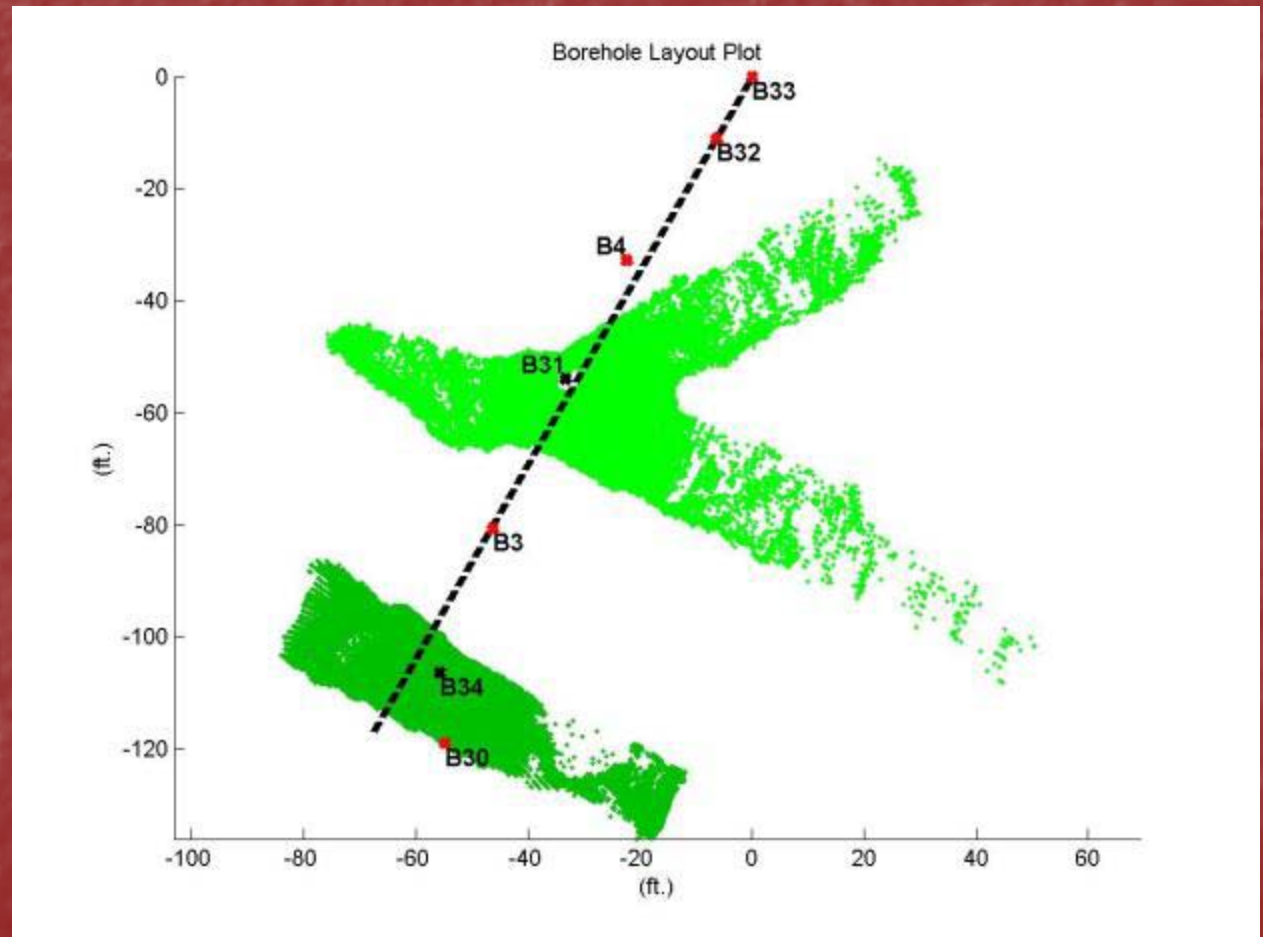


Coal Mine Lots Branch WV

Models collected from abandoned dry coal mine through 4 boreholes using Ferret 3 Laser

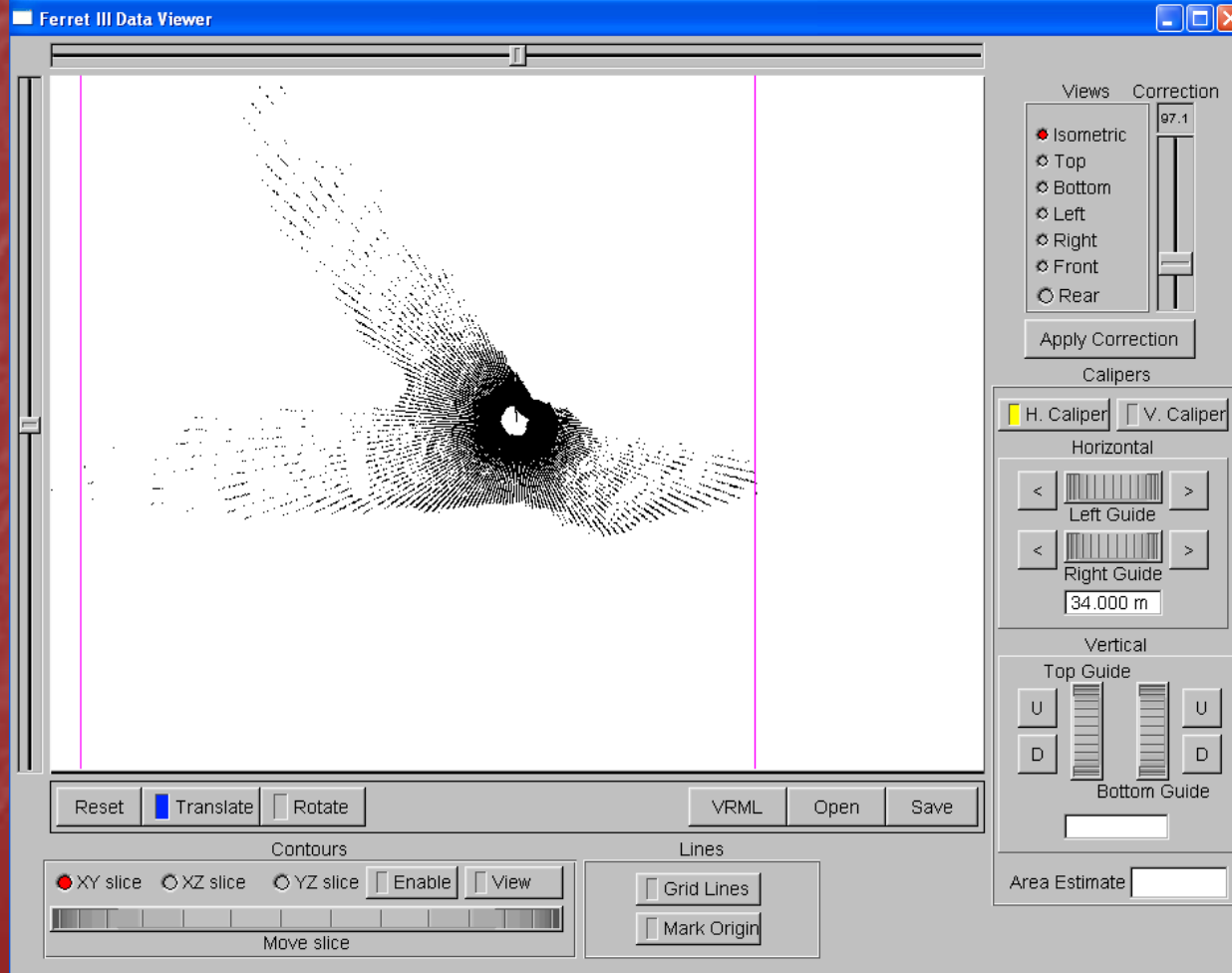
For D'Appolonia, Monroeville, PA

Drilling verification task on Geophysical Demonstration Projects for MSHA

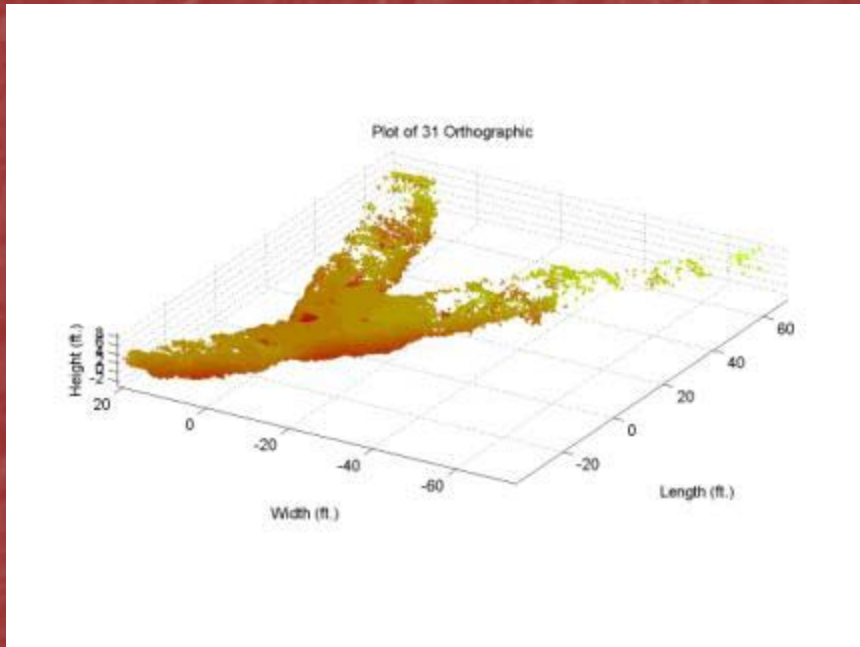


Plan View for boreholes 31 and 34

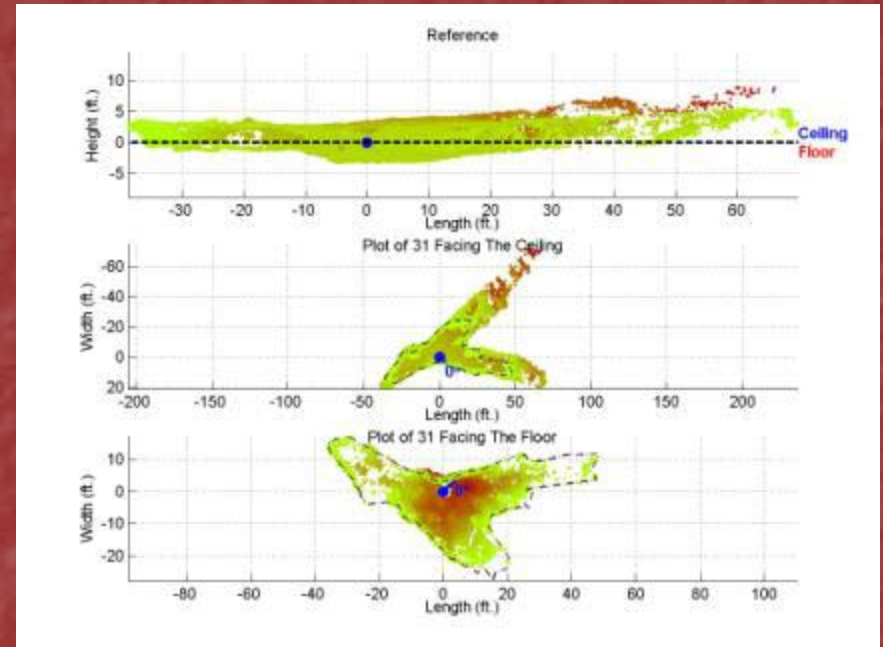
Field viewer for laser data



BH 31 Plots, Lots Branch, WV

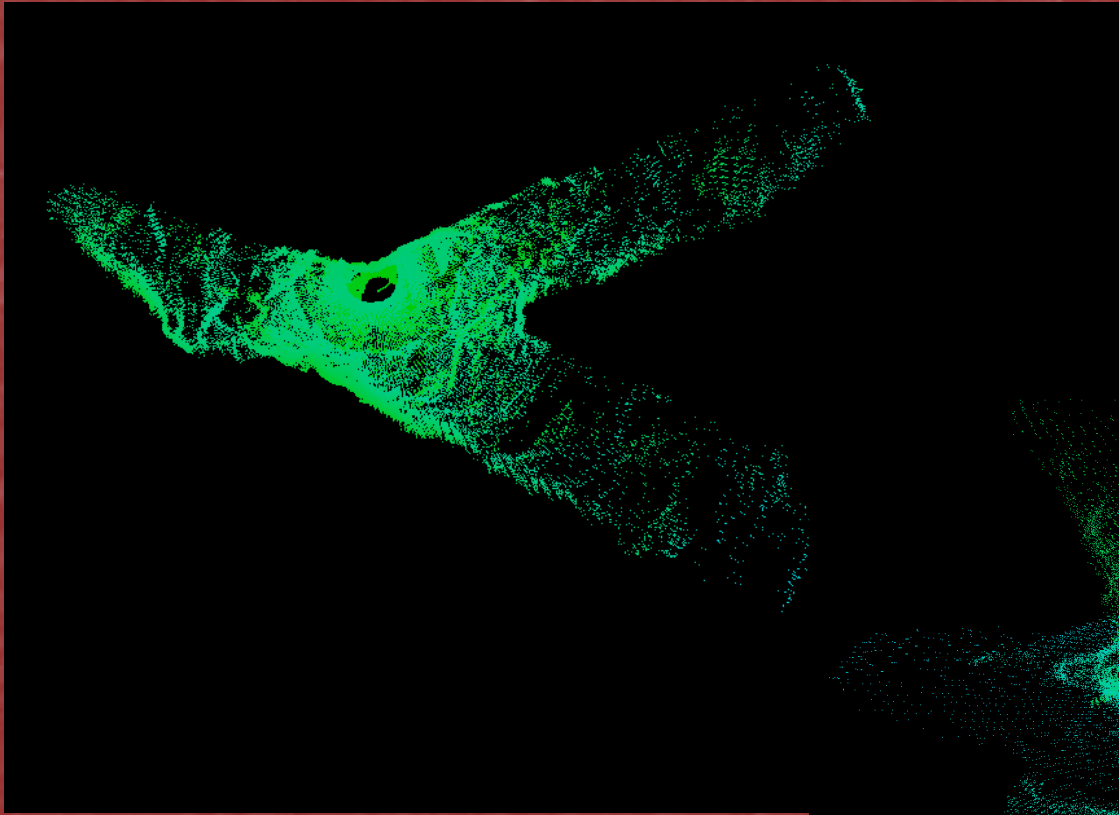


Orthographic View

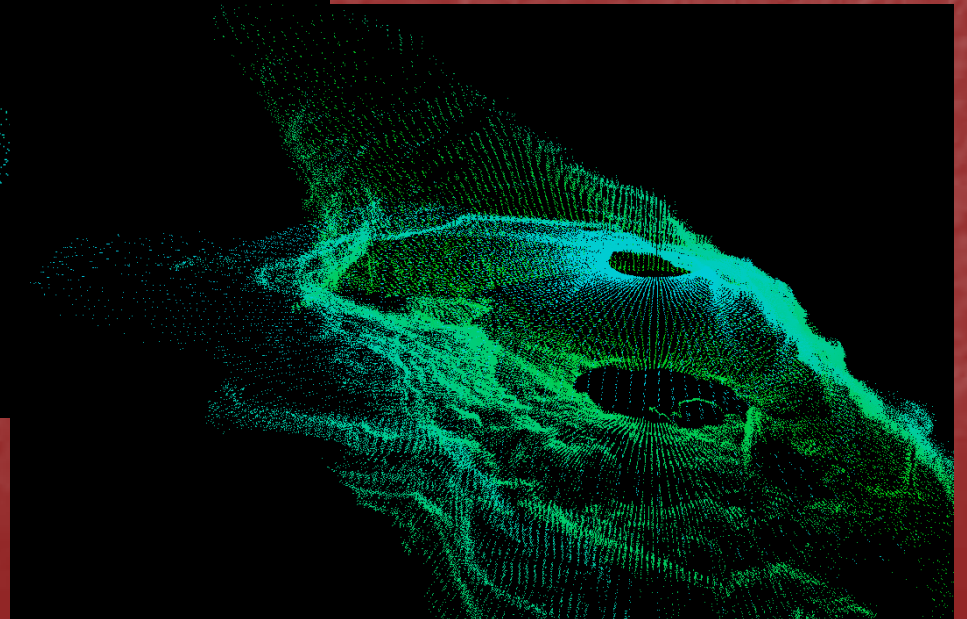


Sectional View

VRML files Lots Branch, WV



BH #31



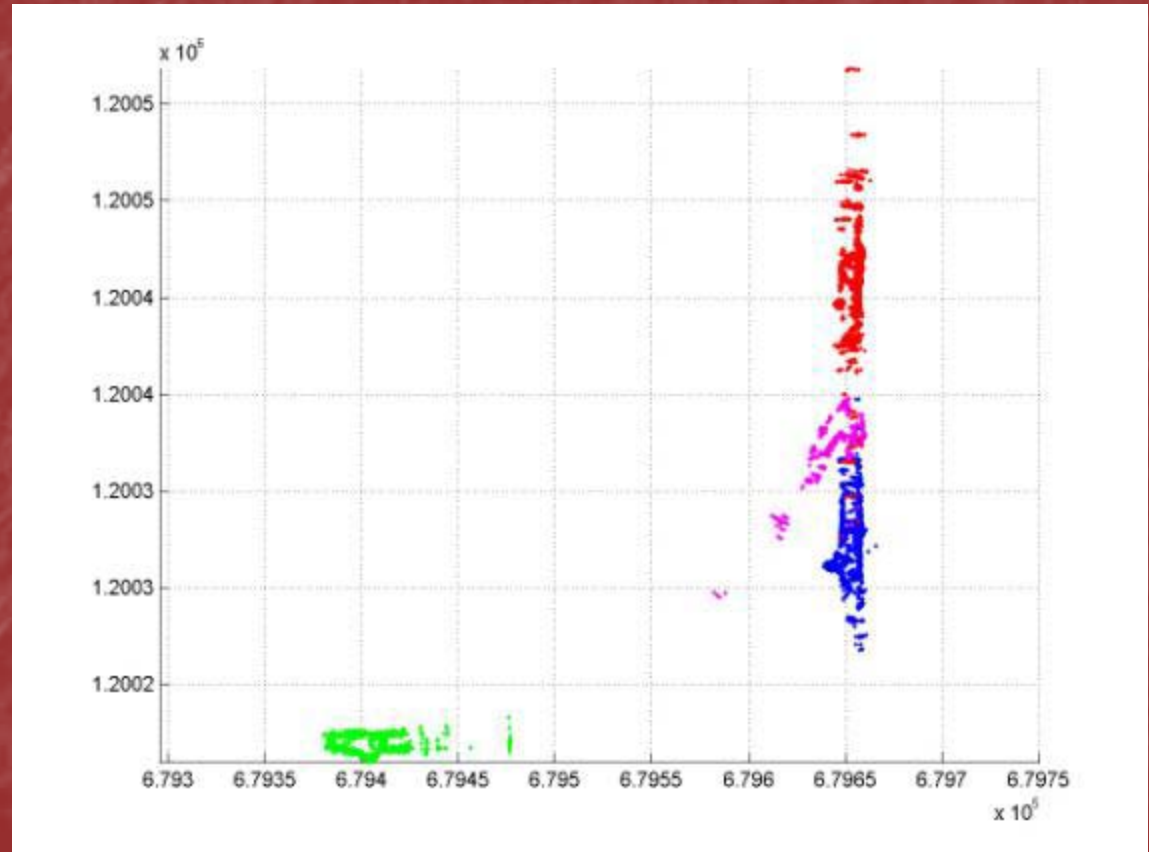
BH #25

Riola Mine, Illinois

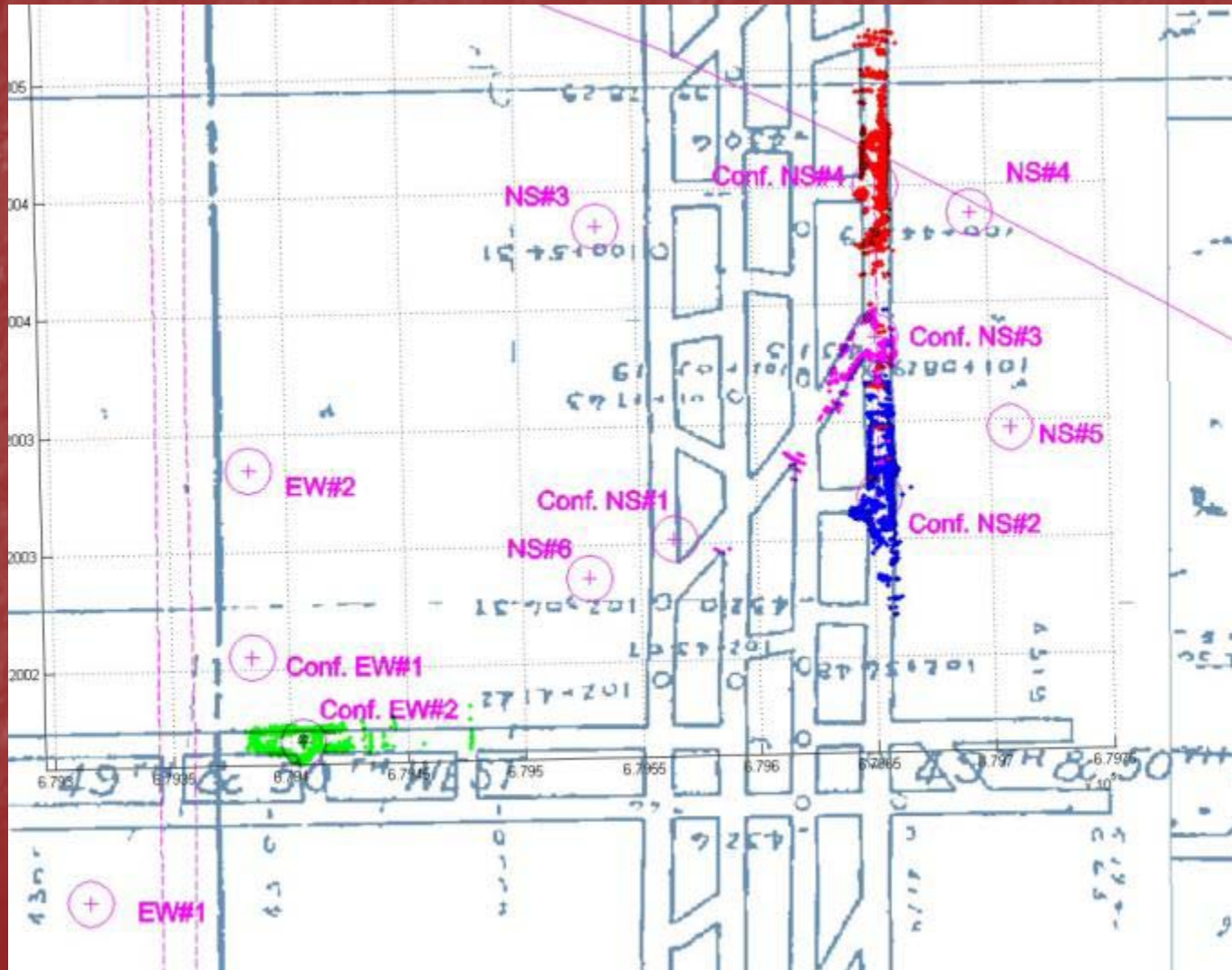
Models collected from 4 boreholes in flooded coal mine using Wet Ferret Sonar

For Blackhawk a division of Zapata Engineering

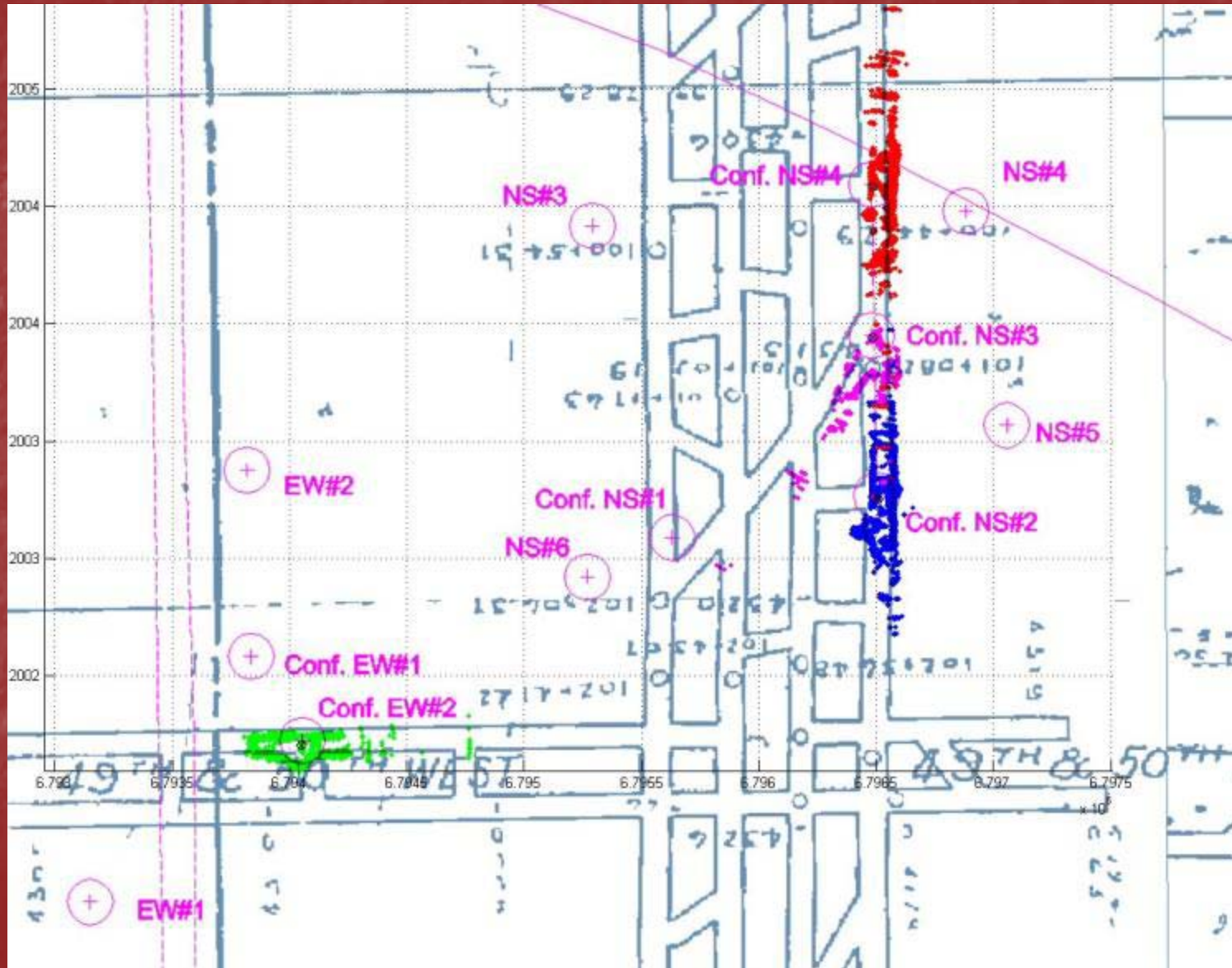
Drilling verification task on Geophysical Demonstration Projects for MSHA



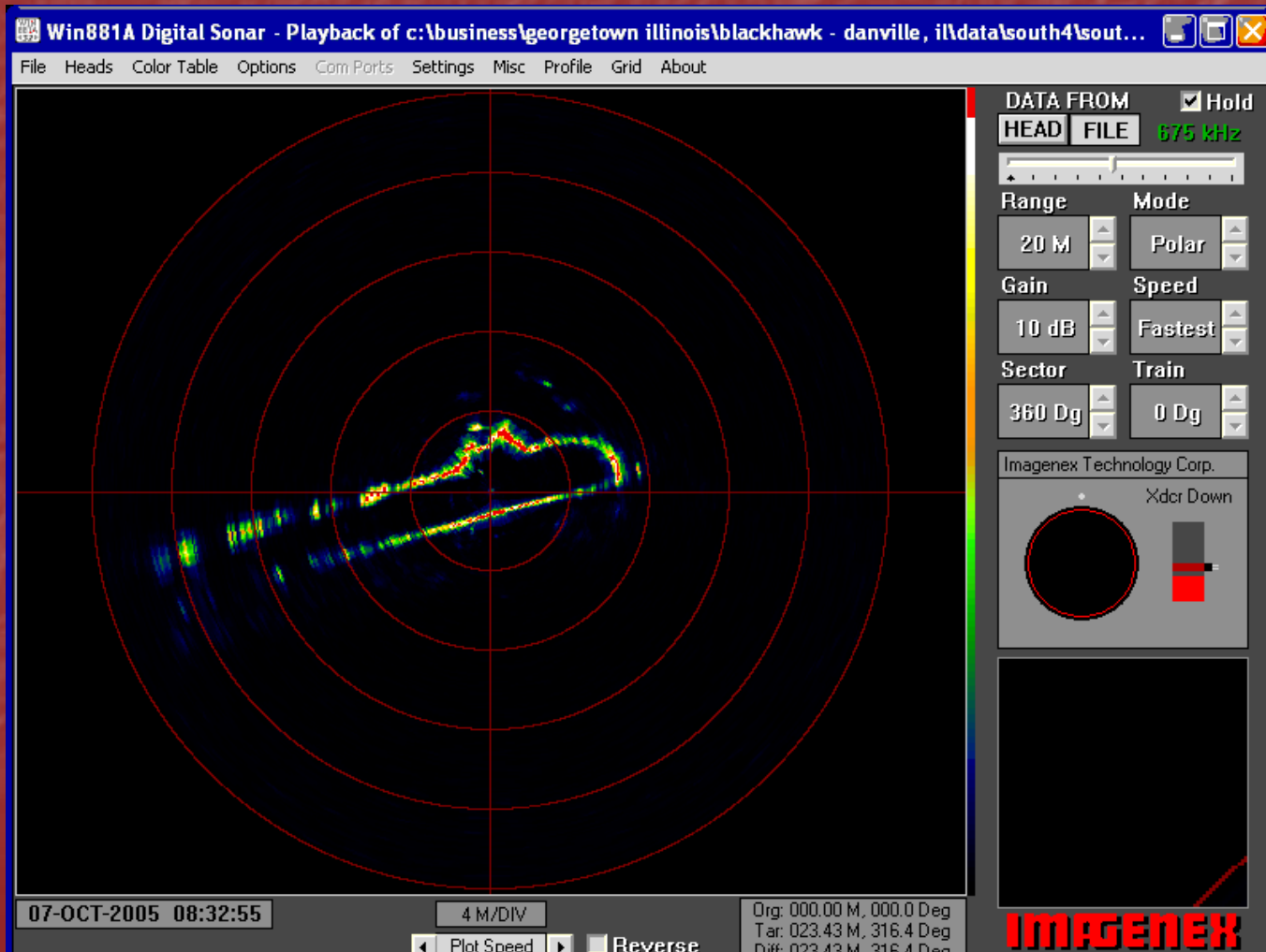
Match with Map, Riola Mine, Illinois



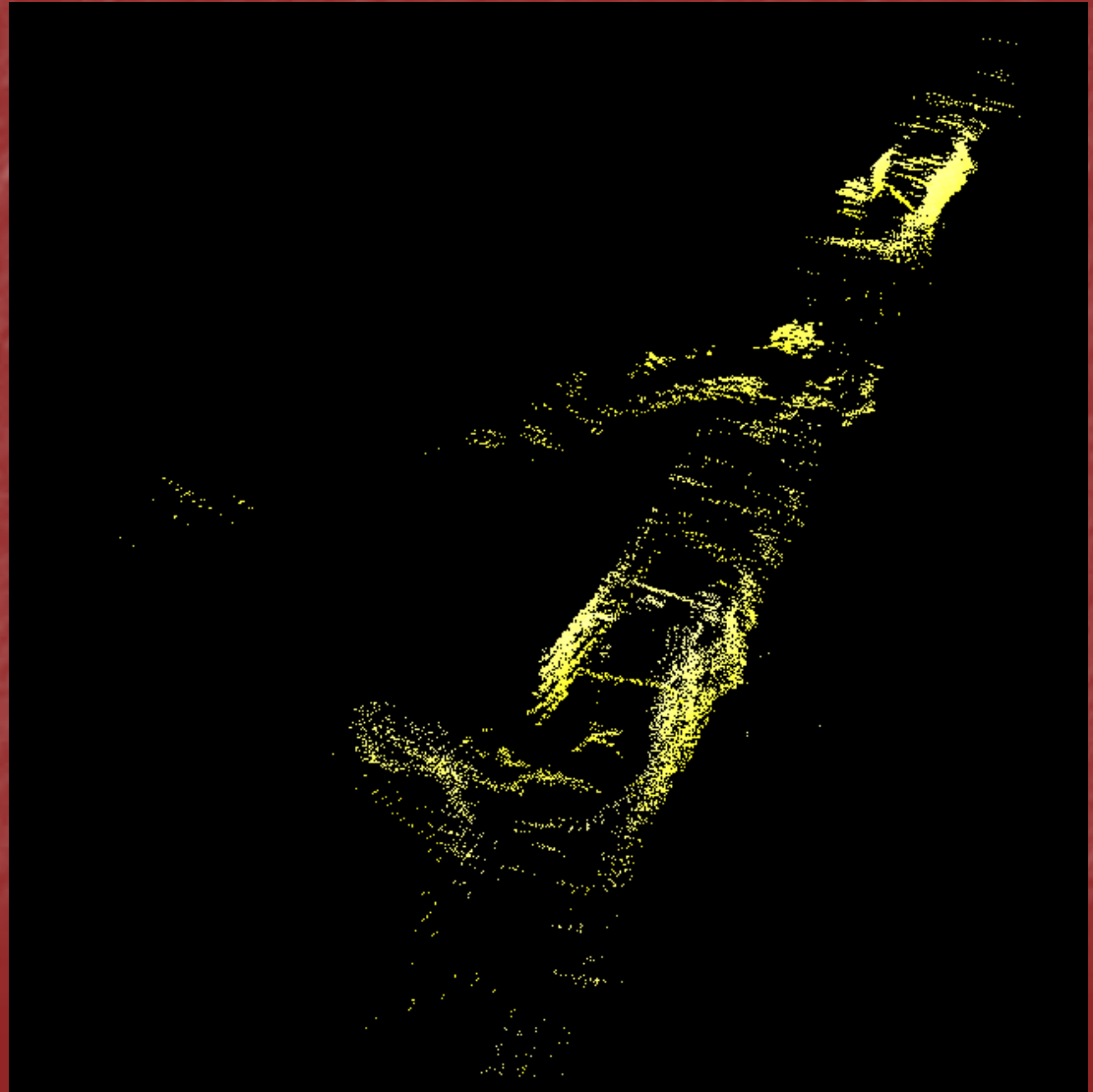
Ground truth plot, Riola Mine, IL



Sonar scan from 1 elevation

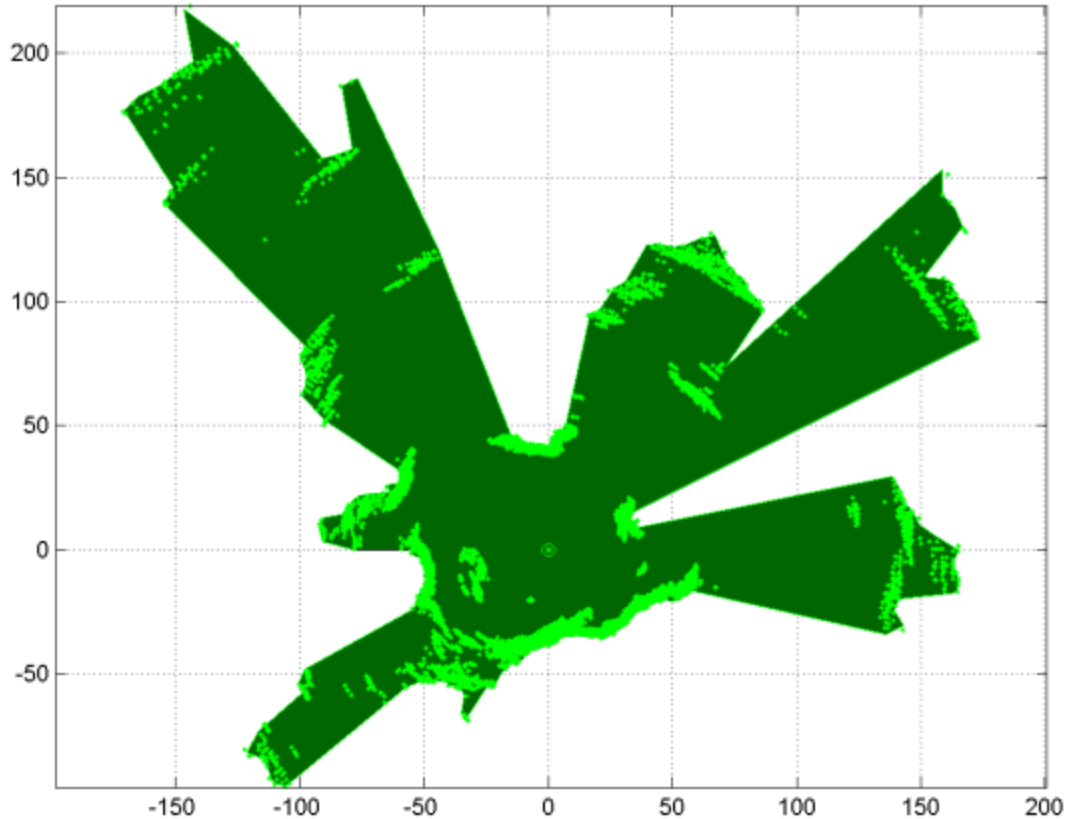


VRML view of Riola Mine, IL



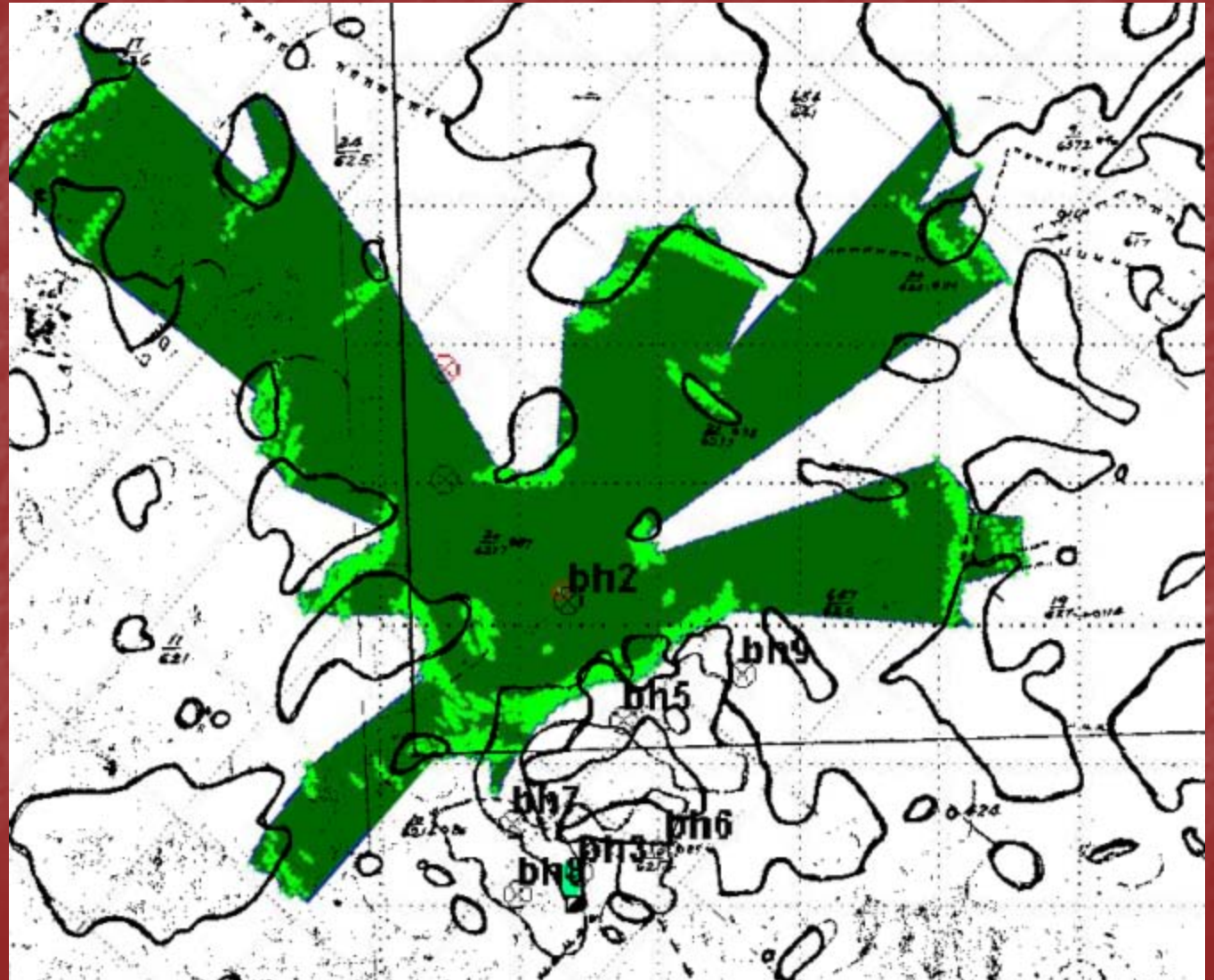
Composite model
from 3 holes

Flooded Ore Mine in Oklahoma



Sonar
Composite
Model of Mine
From 1
borehole

Ore Mine in Oklahoma

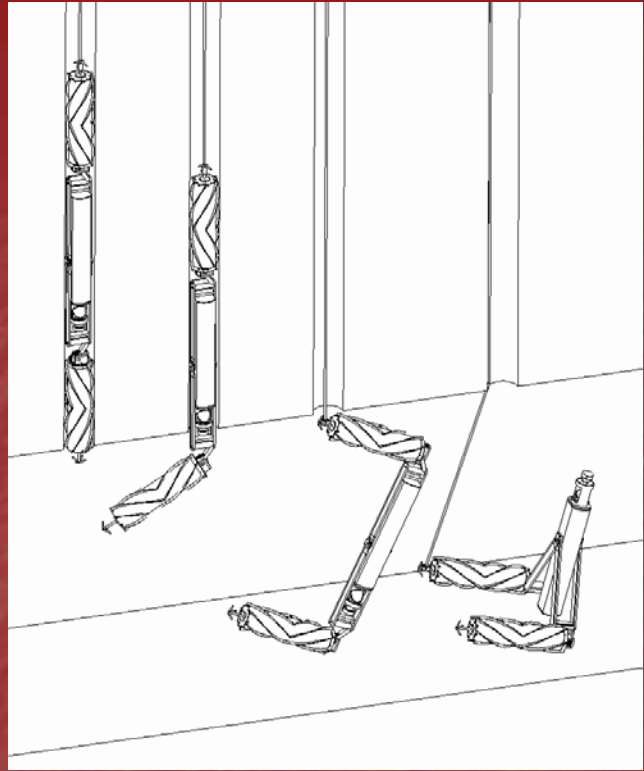


Sonar Composite
Model of Mine
From 1 borehole
overlayed and
aligned with mine
map

3" Ferret

- 3" hole
- 10 minute scan
- Sealed
- Half weight
- Half length
- 1 person deployment
- New program with PA-DEP

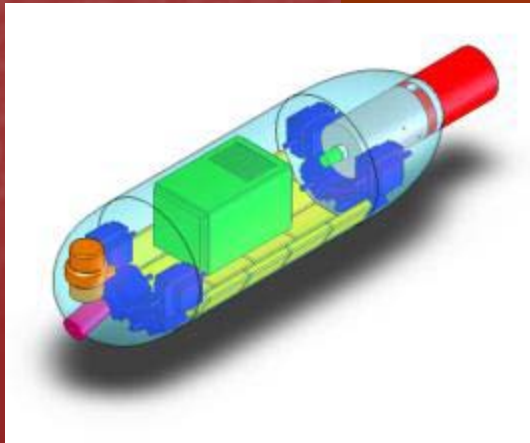
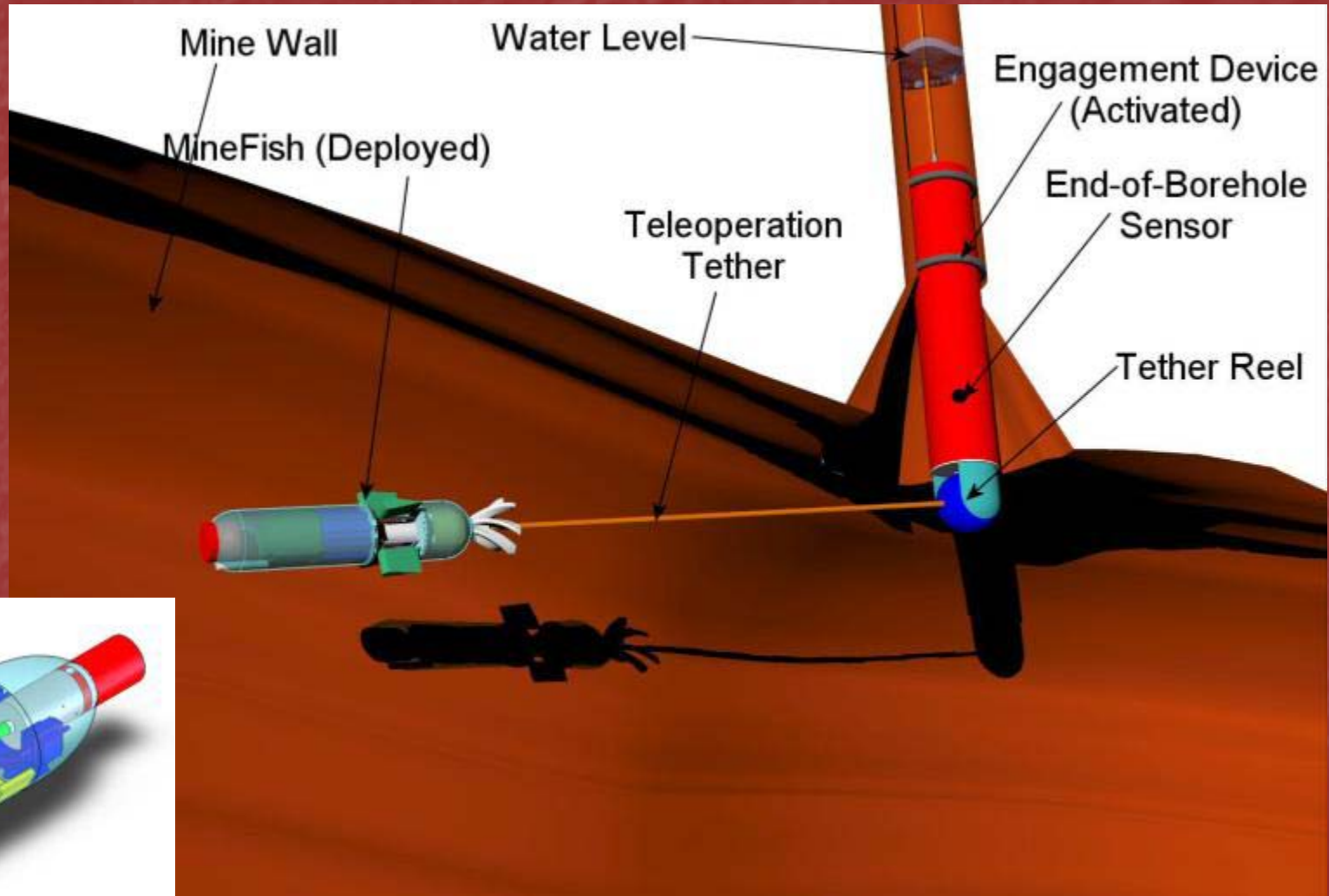
Borehole Deployed Mobile Robot



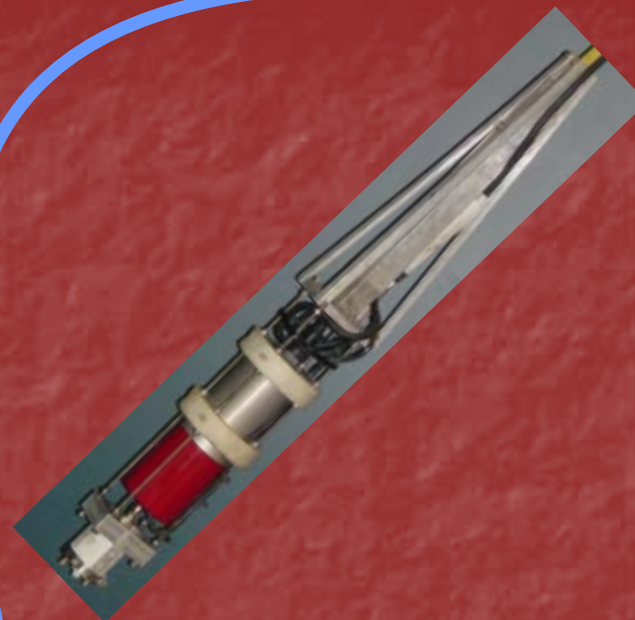
Borehole Deployed Mobile Robot (Helix)



Mine Fish Underwater Mapping Robot



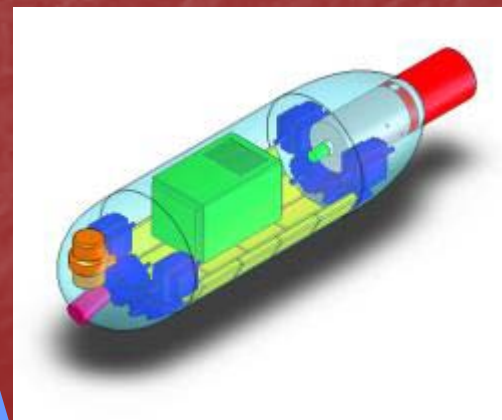
Subterranean Robot Archetypes



**Borehole
Portal**

**Static
Mobile**

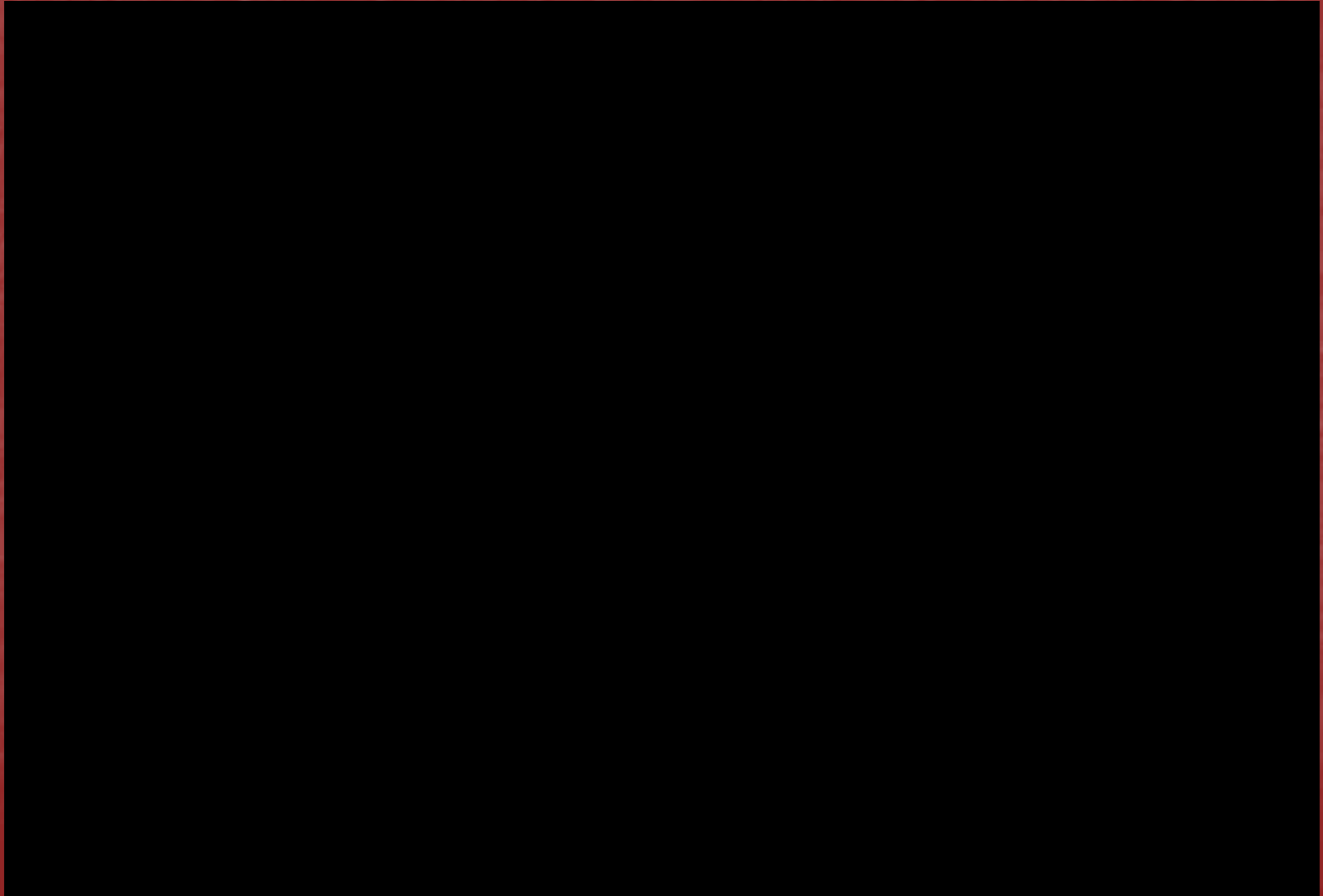
**Met
Dry**



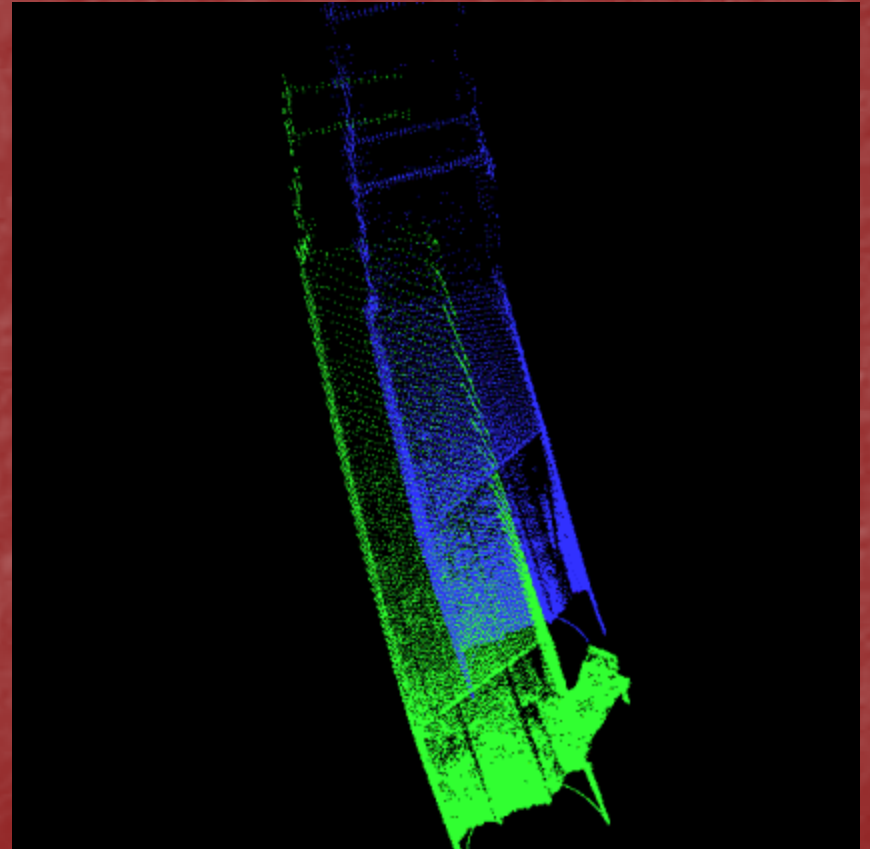
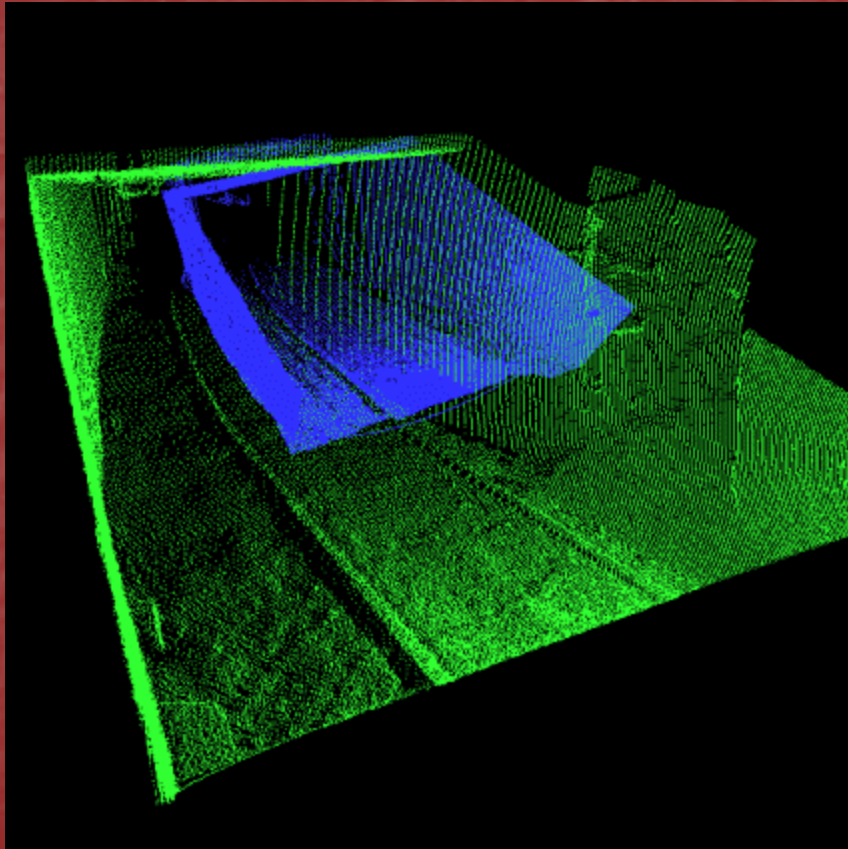
Mine Mapping w/ Mobile Robots



Mine Exploration via Portal

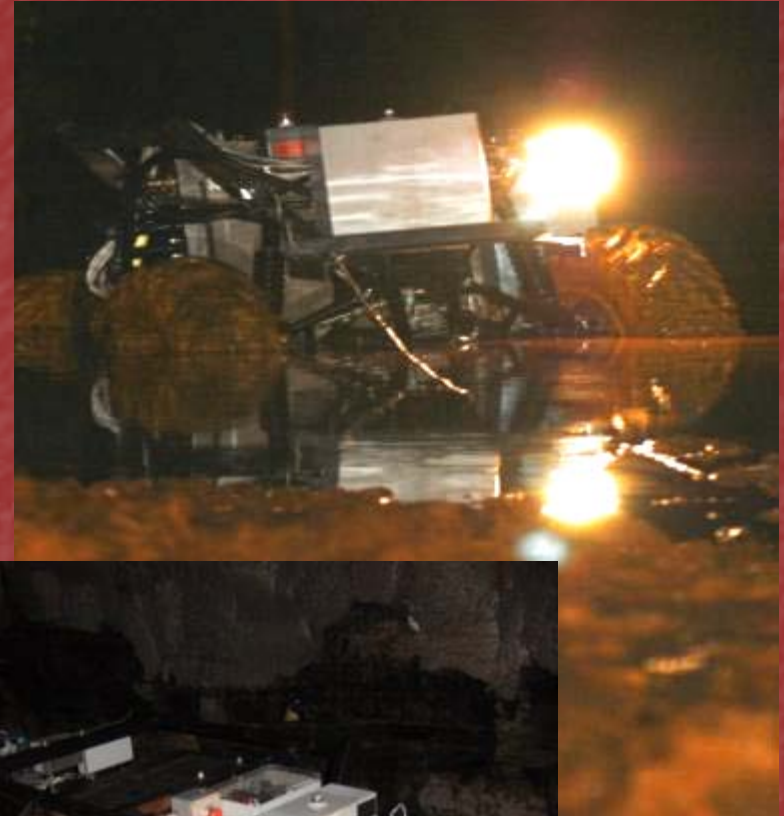


Creating 3D Maps



Groundhog

- Autonomous Mobile robot vehicle
- 4 wheel drive & steer
- 8 ft turning radius
- Battery powered
- Hydraulically driven
- 1 mile range

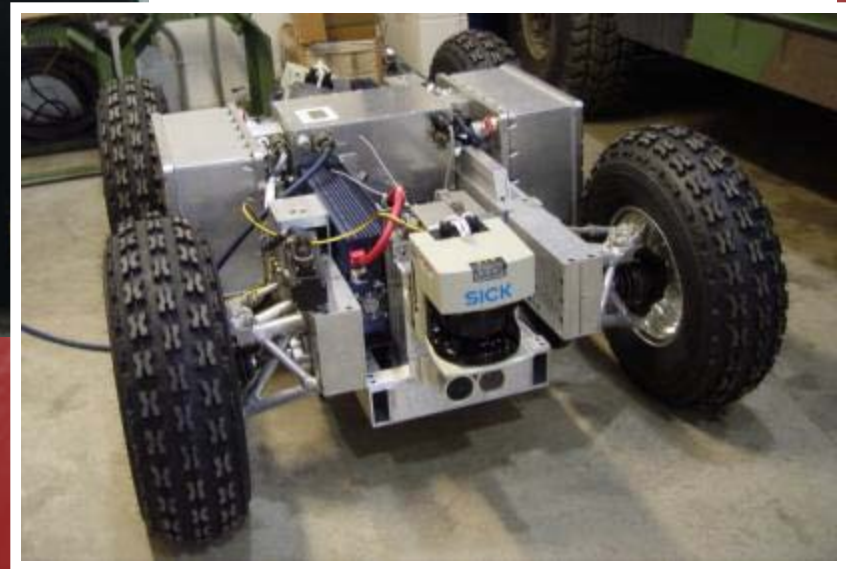
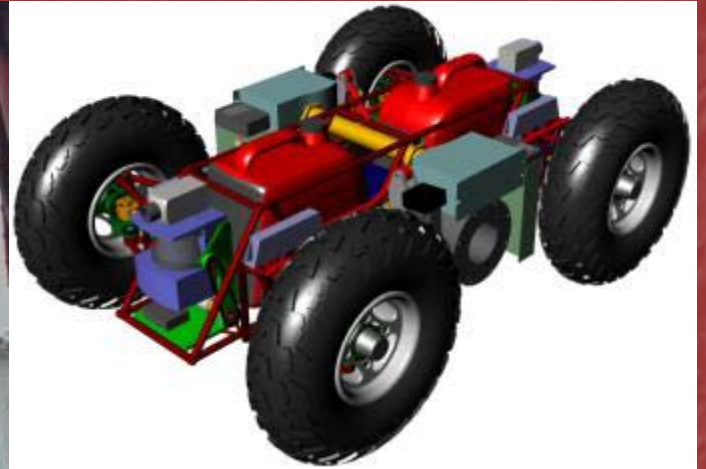


Long Traverse, Coal Mine, WV



- 2.25km of traverse
- 1.5% error
- 3D Model Creation

Cave Crawler



Continuous Laser Scanning



Real-Time Tunnel Imaging



Mine Fire Experiments





Contacts



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