Workhorse Technologies, LLC

- Service Provider for Robotic Mapping of Underground Voids

Robotically Generated Mine Map
Agenda

- Introduce Workhorse to You
- Present Void Modeling Technology
- Discuss Void Modeling Technology
- Brainstorm Application of Void Modeling Technology for You
- Actions
- Adjourn
Services Provided

- Audit Mineral Reserves.
- Abandoned Mine Investigations
- Void Modeling
- Stabilization Planning and Verification
- Borehole Surveys - Wet or Dry
- Economizing Exploratory Plans
3 hr, 1 mile Mine Mapping
Mine Void View from Borehole

Mine Roof

Borehole Breakthrough

Mine Pillar

Borehole Cuttings Cone on Bottom of Void
Map of Submerged Pillars
How do we Model Voids and Drive?

- No GPS
- No Wireless Communications
- No Sunlight, Dark Surfaces
- Inaccessible for retrieval
- Maps don’t always exist
- Toxic/Explosive atmosphere possible
- Air filled, water filled, ponded

Workhorse solutions ........
Groundhog

- 4 wheel drive & steer
- 8’ turning radius
- Laser Scanner mapping
- Hydraulics and electronics in an explosion proof enclosure
Abandoned Mine Mapping

- Uneven Floor, Deep Mud, and Water
- Environmental Sensing
Borehole Deployable Scanner

- Fit in 8” Borehole
- Lower hundreds of feet
- Laser Range Sensing
- Pan and Tilt Motion
- 3D model of void
- Correlation to prior map
- Video overlay on model
Ferret

- Long Range – Low Reflectivity Laser
- Magnetic Compass
- Video Camera & Lights
- Deployment Apparatus
- Breach Detectors
Submersible Ferret

- 6” Borehole Deployable
- Scanning Sonar
- Readily Deployed
- Long Distance Ranging
- Magnetic Compass
- Submersible to Great Depths
Software

- SLAM (Simultaneous Localization and Mapping)
- Robot Control
- Scanning Control
- Void Modeling
- Volume Estimation
- Map Correlation
- User Interface
Map Registration

- 3D Void Modeling
- Profile of Mine Collapse
- Mine Map Registration With Surface Coordinate System
- Visible Mine Structures
- Pillar & Debris Pile
Groundhog Day May 30

1500 ft Autonomous Driving and Mapping at the Mathies Mine

A great day
Groundhog Day Results

3-D Model – Navigable Passage

3-D Model - Fallen Roof
Timber Blocking the Passage

2-D Mine Map
Workhorse Could Answer ........

- What is the extent of prior mining?
- Is there remining potential?
- What volume of material is needed to backfill a void?
- Was prior void stabilization backfilled properly?
- How close is an old mine to a residence or operation?
- What is an old mine layout?
- Have the pillars degraded?
Subterranean Challenges

- Exploration Autonomy
- Communications
- Miniaturization
- Mobility
- Power
- Sensors
- Reliability
Future

- Borehole deployable driving robot
- Boat for subterranean lakes.
- Submarine for submerged voids
- Wireless communications to surface
- Radio positioning
- Autonomous exploration
- Subterranean operations
- Guiding equipment
- Thin seam mining
Helix

- Borehole deployed robot
- Fluted drive cylinders
- Laser scanner
- Climbs obstacles
- Target design for a 6” borehole
Subterranean Agenda

- Mapping
- Mining
- Safety
- Gas Storage
- Rescue
- Nuke Storage
- Infrastructure
- Combat

In

- Mines
- Caves
- Tunnels
- Bunkers
- Sewers
- Pipes
- Tanks
Next Steps Together

- Field work addressing an immediate need
- Visit Pittsburgh for live demonstration of the equipment
- Deepen government and business relationships
- Work toward a safer and more productive future in the mining industry.
Workhorse Technologies, LLC

484 West 7th Avenue
Homestead, PA 15120

Phone: (412) 979-2632
Fax: (412) 268-1338

Web: www.workhorsetech.com
E-mail: info@workhorsetech.com

- Chuck Whittaker, Operations Manager
- Ben Daud, Consultant, Business Development
  Phone: (304) 598-3292
  Cell: (304) 216-3012
- Red Whittaker, Chief Scientist
- Eric Close, President