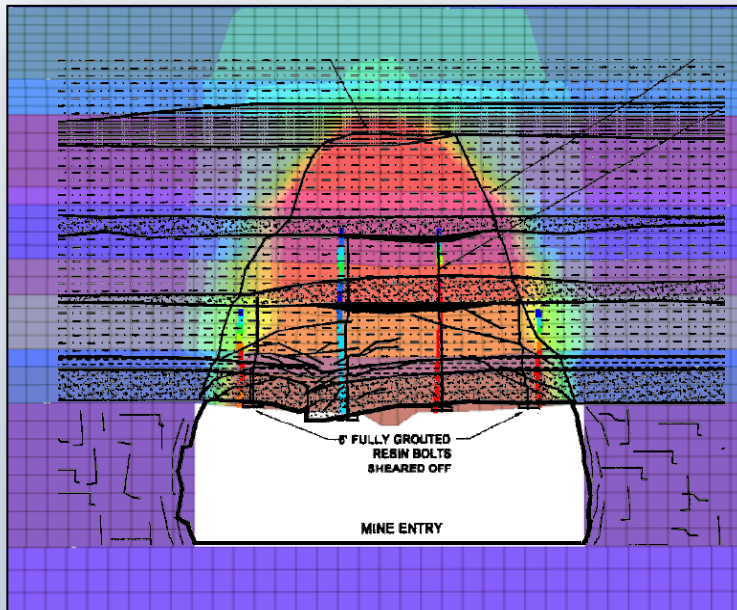


Ground Control Research Program

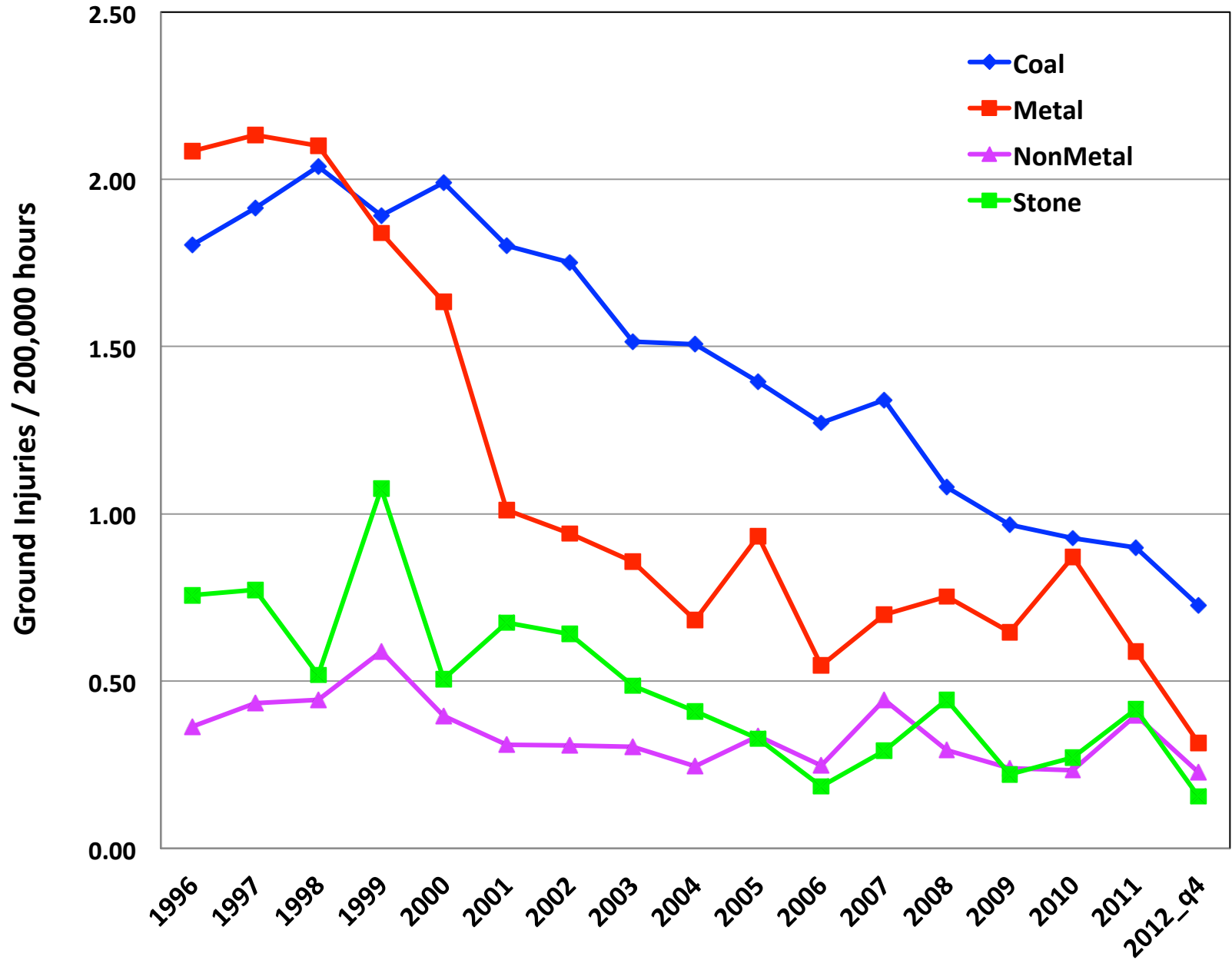


Reduce ground failure fatalities and injuries in the mining industry



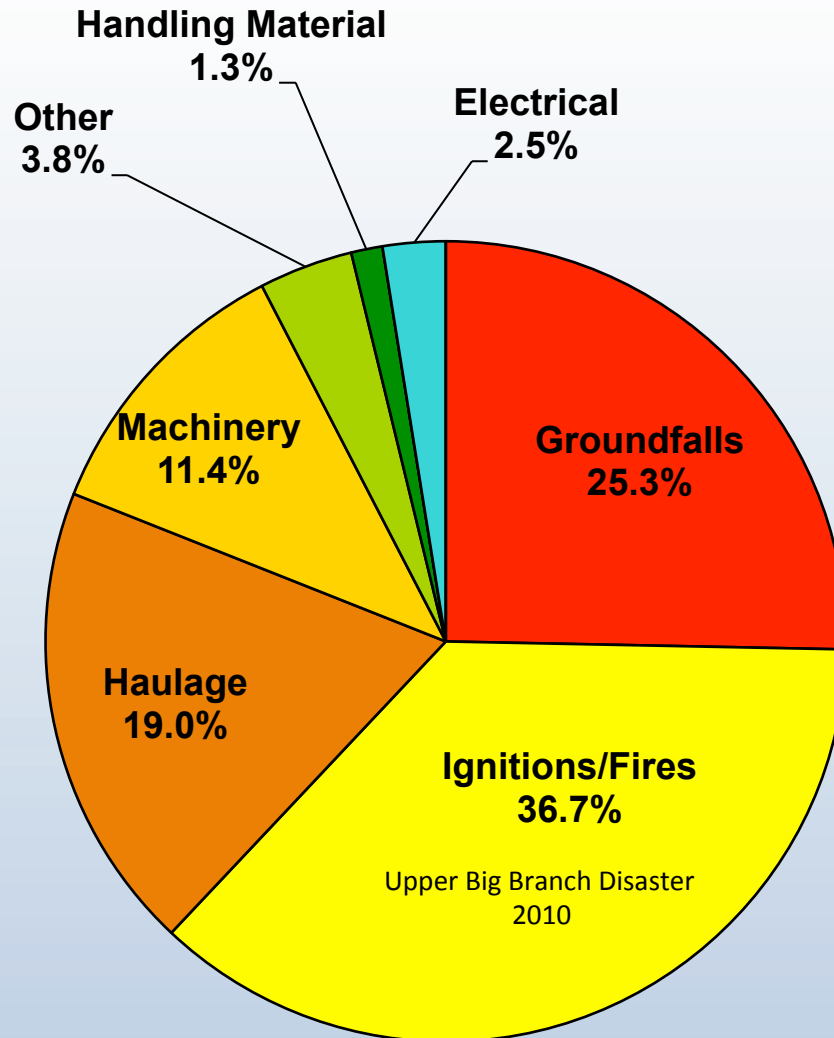
Strategic Goal

Underground Ground Fall Injury Rate by Sector (MSHA, N=18,560)



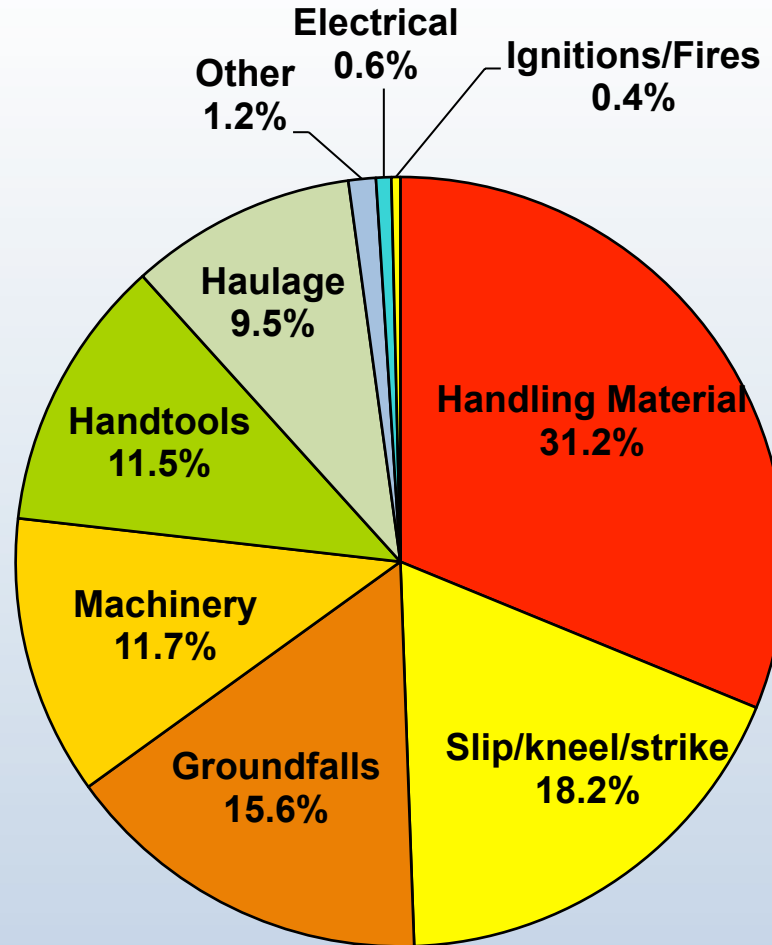


PROPORTION OF OPERATOR GROUNDFAIL FATALITIES 2008-2012^{4th quarter} (MSHA, N=79)





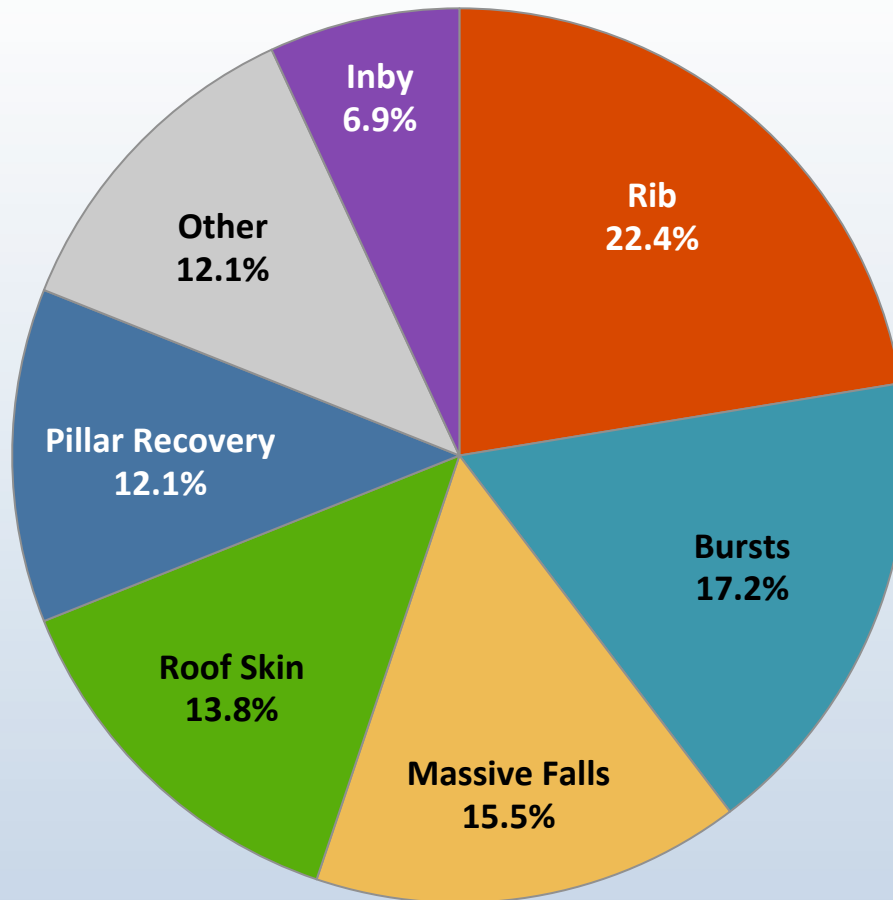
PROPORTION OF OPERATOR GROUNDFALL INJURIES 2008-2012^{4th quarter} (MSHA, N=13,907)





GROUND FALL FATALITIES 2003-2012

(MSHA, NIOSH N=58)



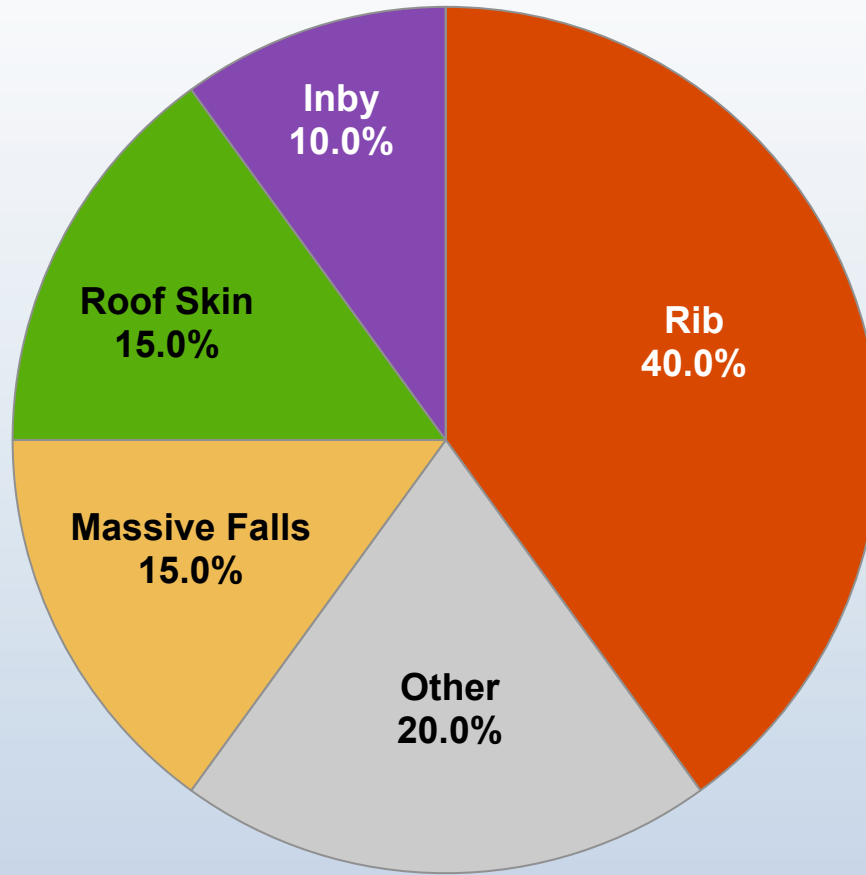
*Includes contractors and anthracite





GROUND FALL FATALITIES 2008-2012

(MSHA, NIOSH N=20)



*Includes contractors and anthracite



The program is intended to be solution driven.

- Focused on problems.
- Provide an impact that meets a strategic goal.
- Blend of practical solutions and advancing the science that can lead to next major breakthroughs.



Maintain global stability with pillar design



Maintain local stability with roof control



Control skin failure with roof screen or other roof coverings

Provide best practices to ground control engineering





Strategic Goal: Eliminate ground failure fatalities and injuries in the mining industry.

- Develop mine and pillar design strategies to prevent catastrophic roof collapses, pillar failures, and excessive stress-related damage that degrades **global stability**.
- Develop ground support strategies to prevent **local instabilities** that lead to roof and rib falls.
- Develop **surface control** of roof and rib structures to prevent injuries from rock falls between supports.
- Reduce injuries associated with the **application of ground control technologies** through improved ground control practices and support design.

Ground Control Approach



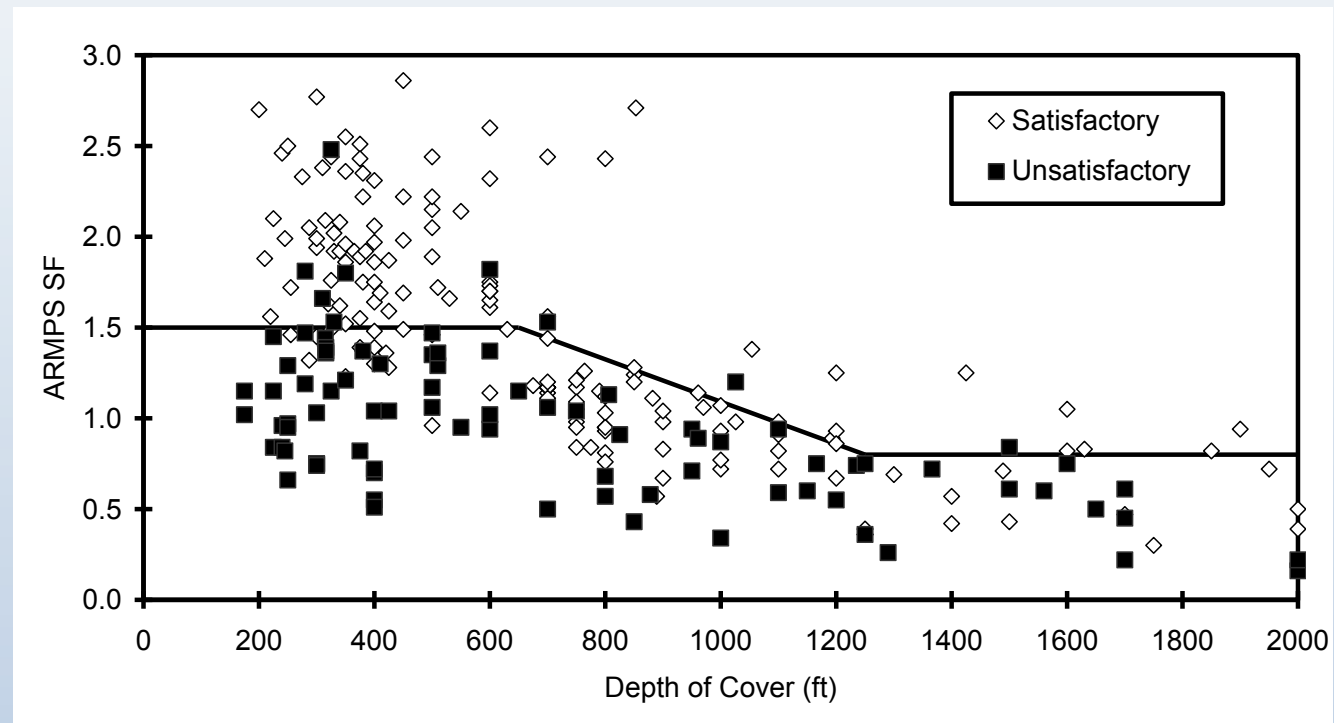
The Past

- Designs based on trial and error
- Geology, stresses, and geometry – significant variables
- Codified into standard practice
- Bolt spacing example

Ground Control Approach

The Present

- Software suite of engineering design programs
- Largely empirical based built from case history analysis
- Puts experience into a practical design approach





NIOSH suite of ground control design software

ALPS
Analysis of Longwall Pillar Stability

ARMPS
Analysis of Retreat Mining Pillar Stability

ARMPS-HWM
Analysis of Retreat Mining Pillar Stability – Highwall Mining

CMRR
Coal Mine Roof Rating

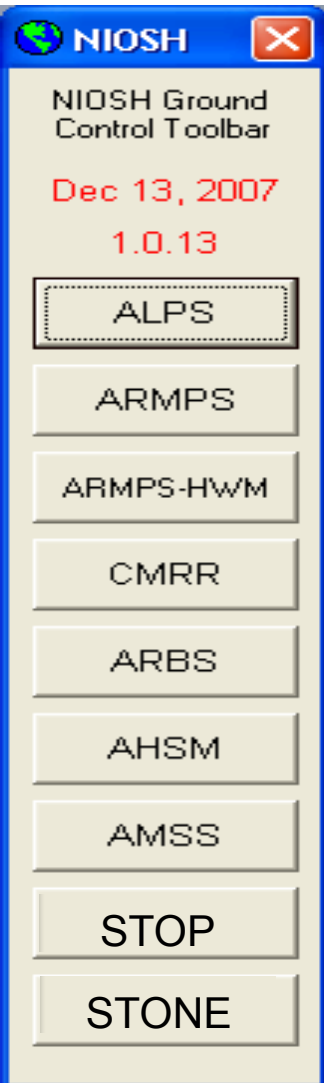
ARBS
Analysis of Roof Bolting Systems

AHSM
Analysis of Horizontal Stress in Mining

AMSS
Analysis of Multiple Seam Stability

STOP
Support Technology Optimization Program

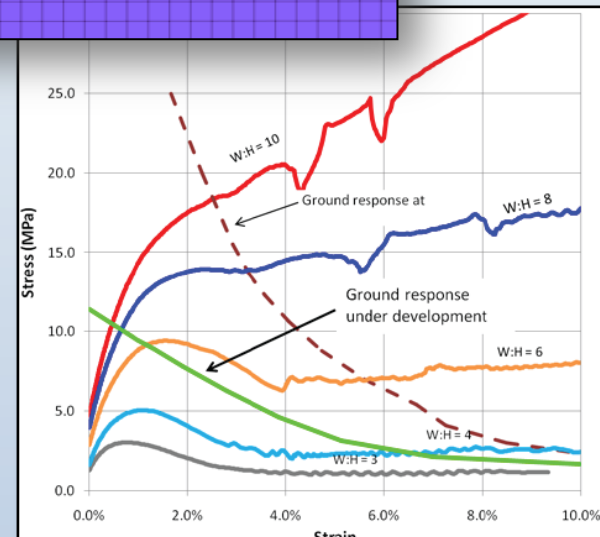
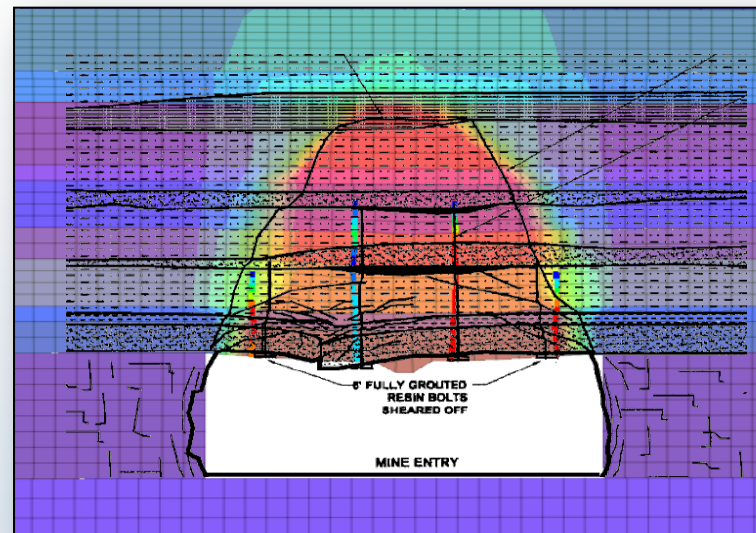
STONE
Stone Pillar Design Program



Ground Control Approach

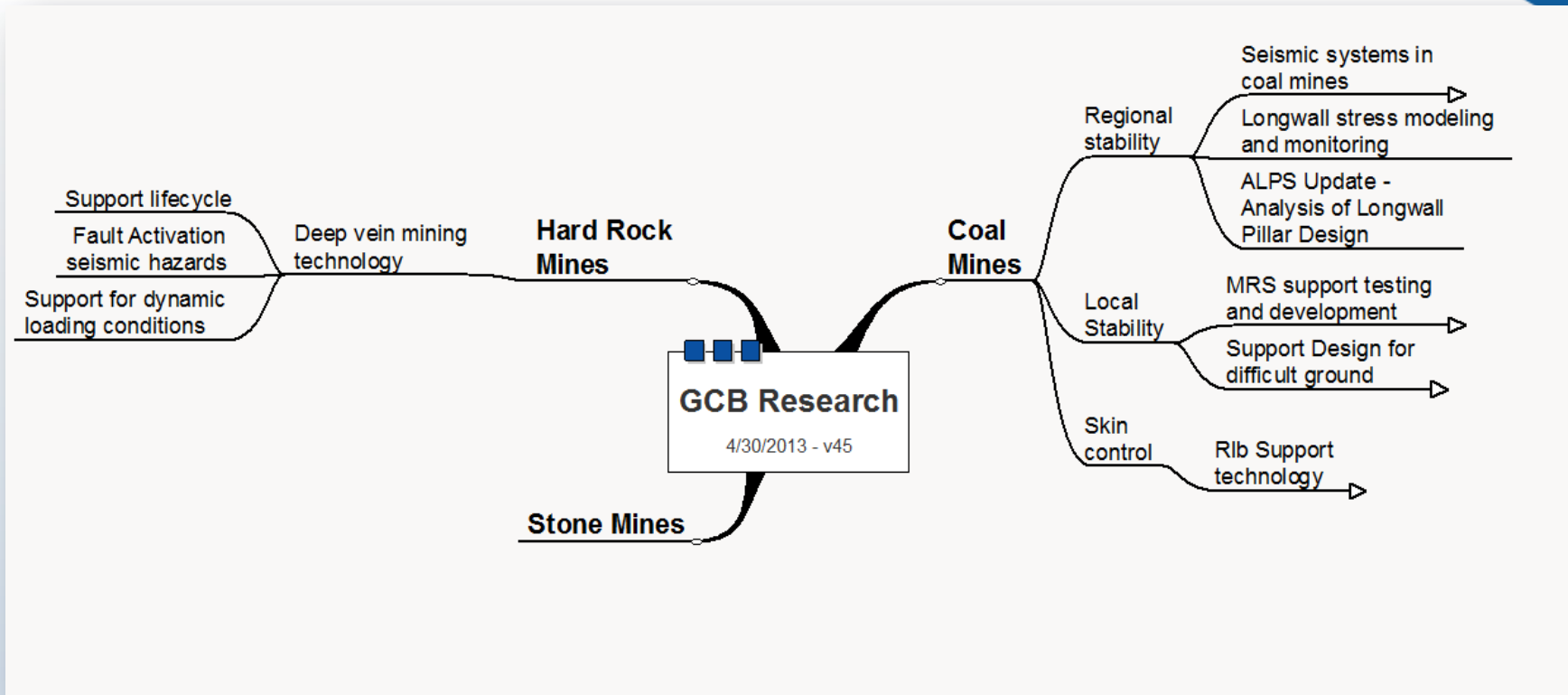
The Future

- Numerical modeling to develop design tools
- Geological assessment methods
- Field validation studies
- Laboratory testing
- Seismic monitoring
- Updating current empirical methods





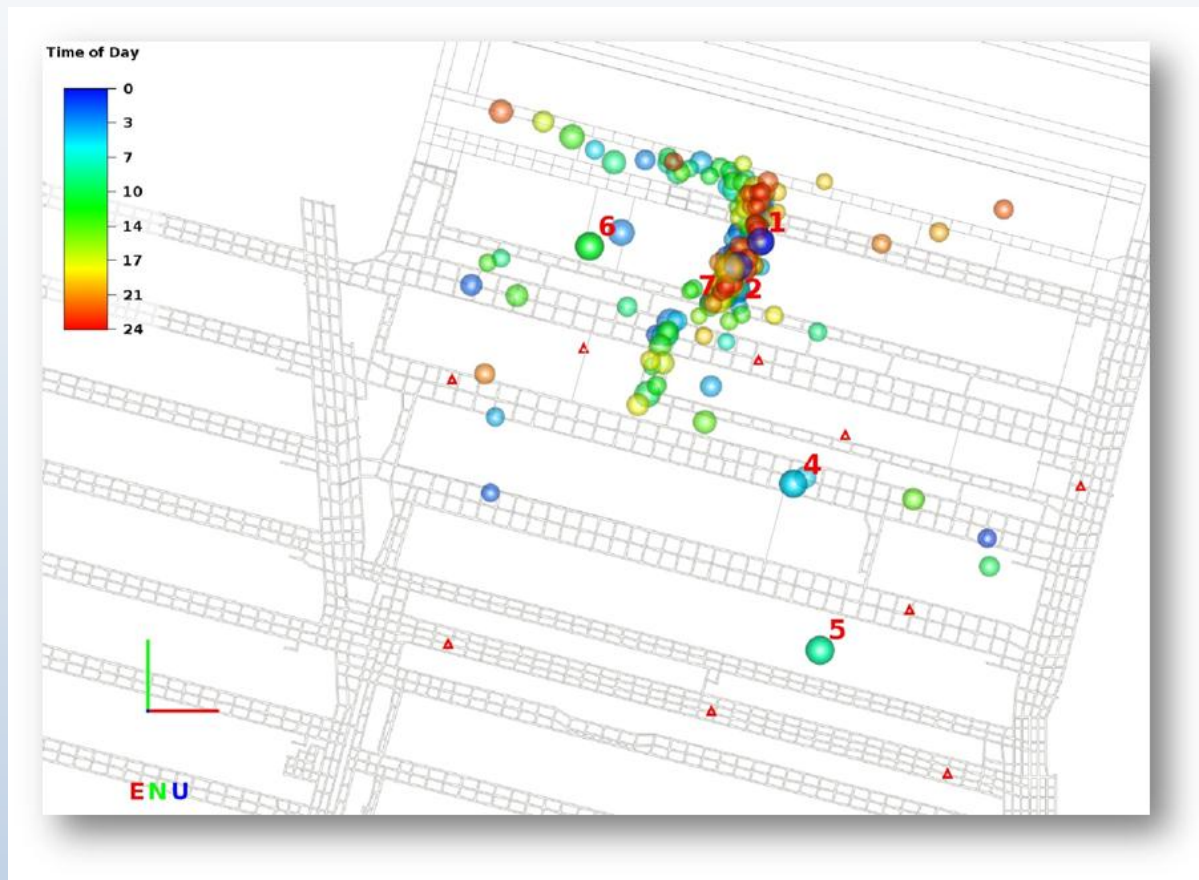
Our current research portfolio



Regional Stability

Coal Mine Safety Application of Seismic Monitoring

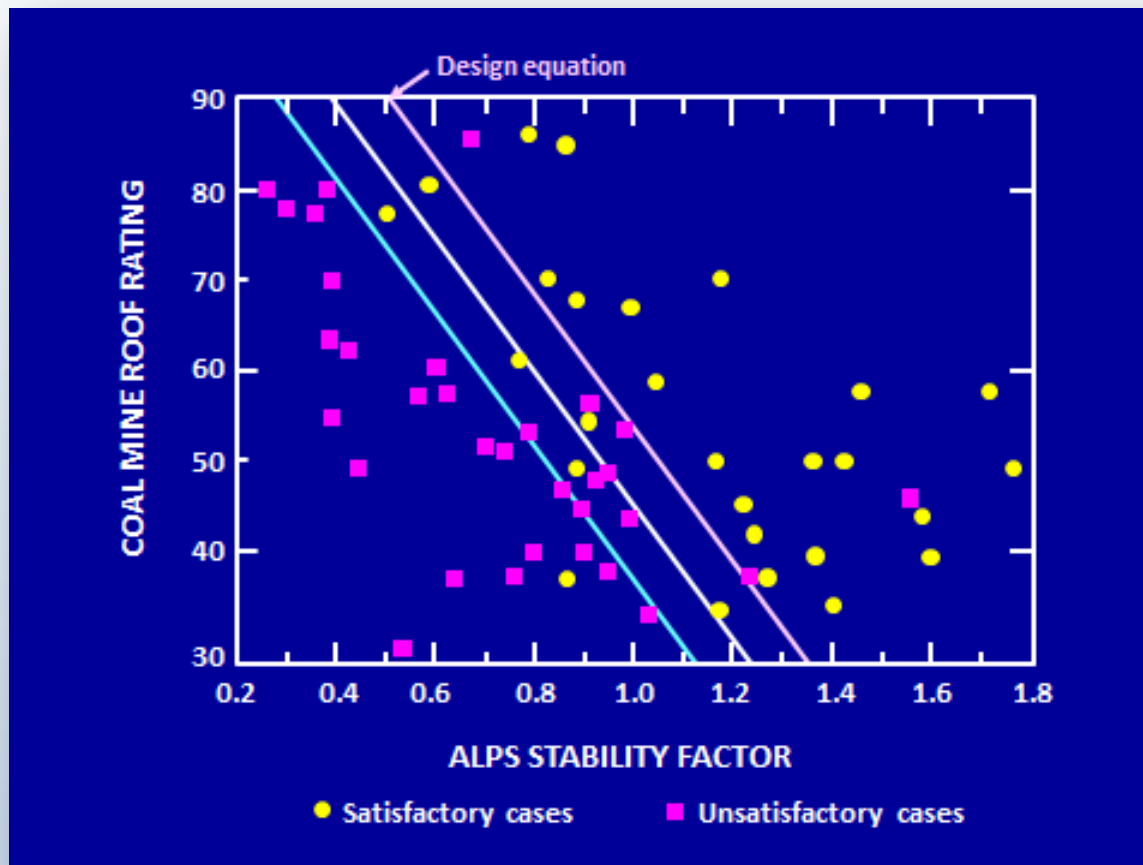
Benefits of close-in seismic monitoring



Regional Stability

Empirical Guidelines for Longwall Ground Control Design

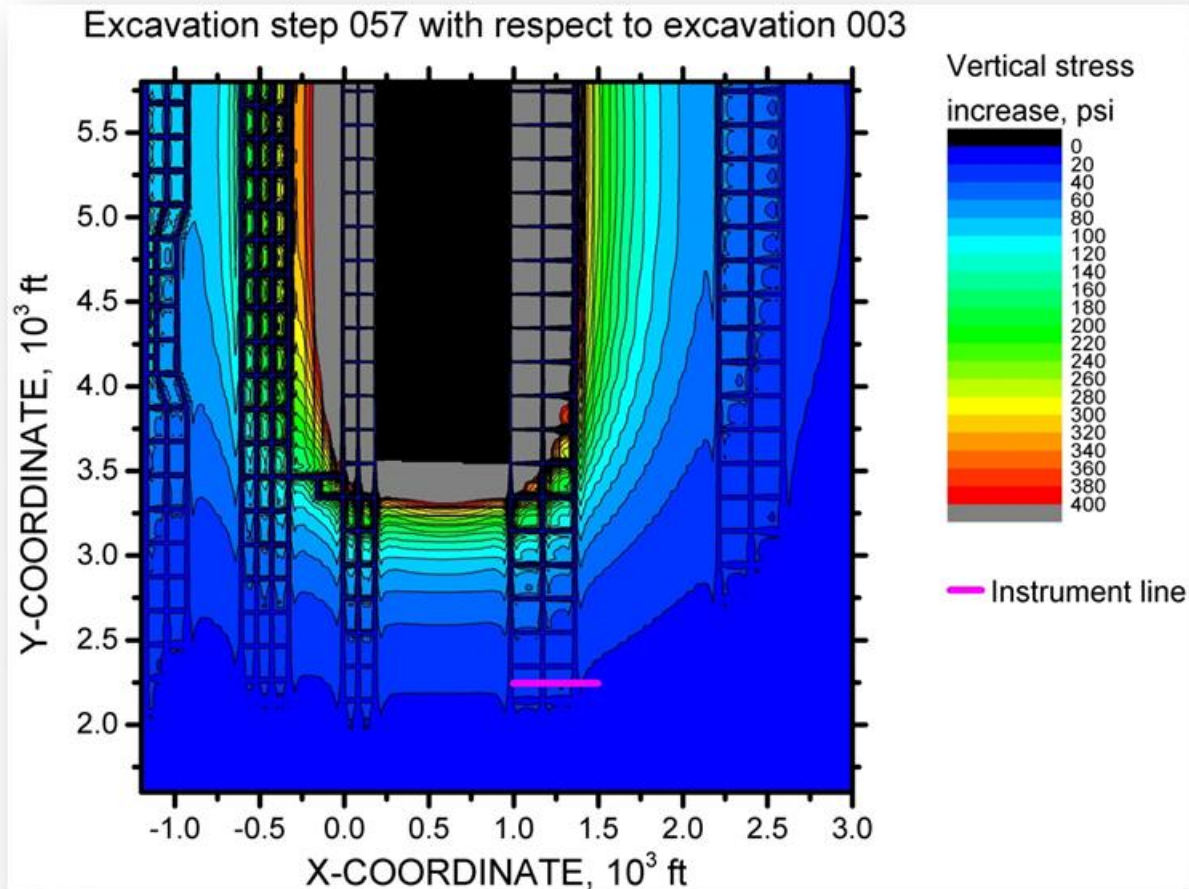
Update and refinement of empirical longwall design using ALPS



Regional Stability

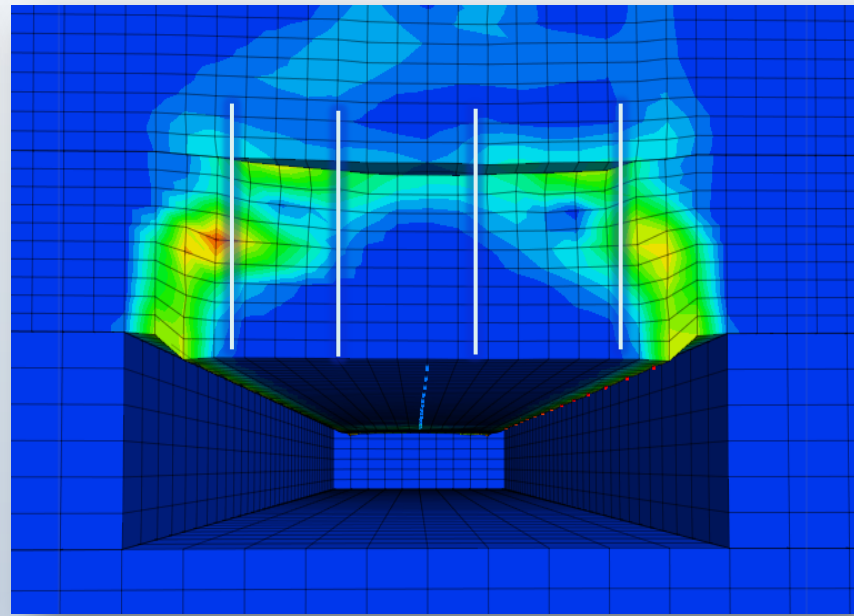
Calibration and verification of longwall stress models

Improved longwall design using calibrated numerical models



Local Stability

Support design procedures for difficult ground conditions



Local Stability

Mine Roof Simulator Support Testing and Development



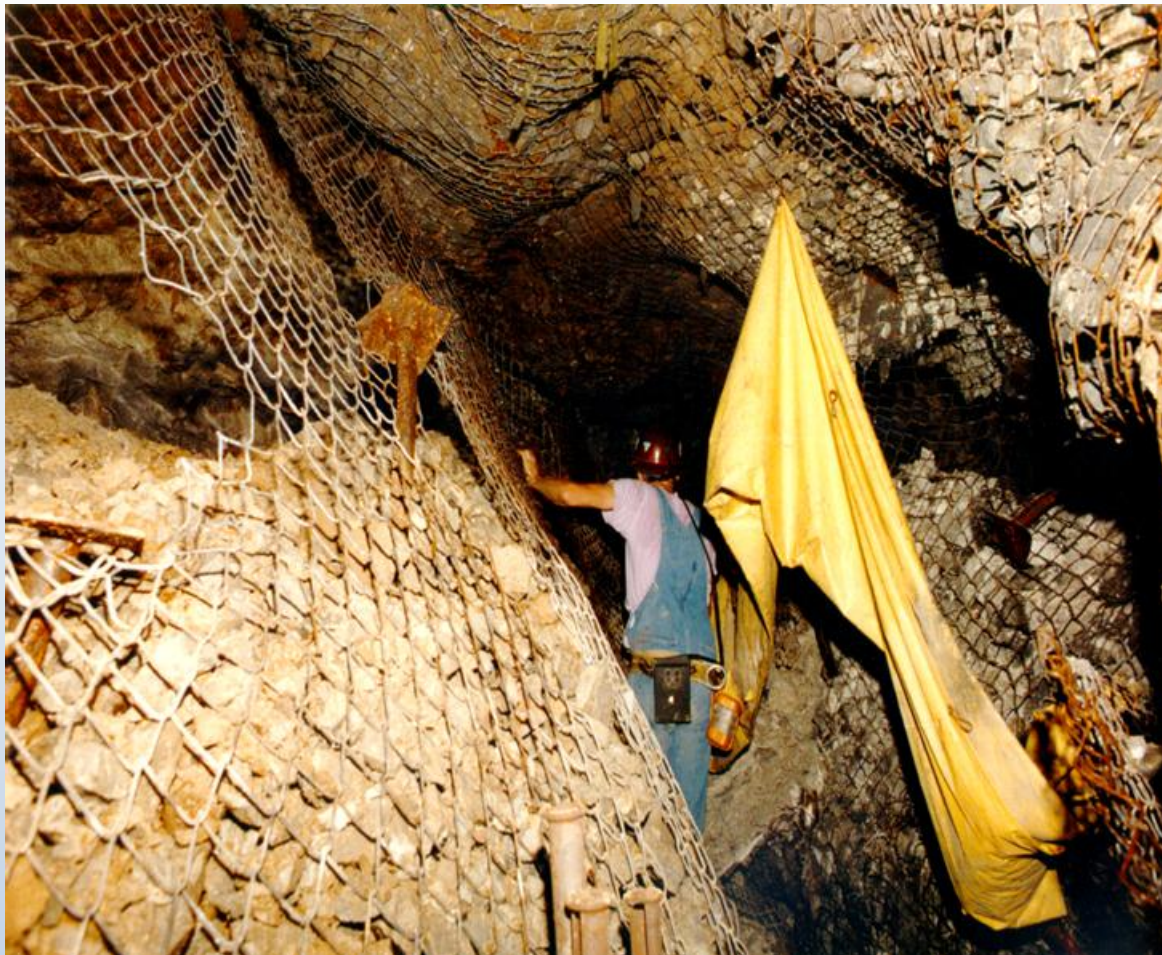
Skin Control

Design of Support Systems to Manage Coal Mine Rib Hazards



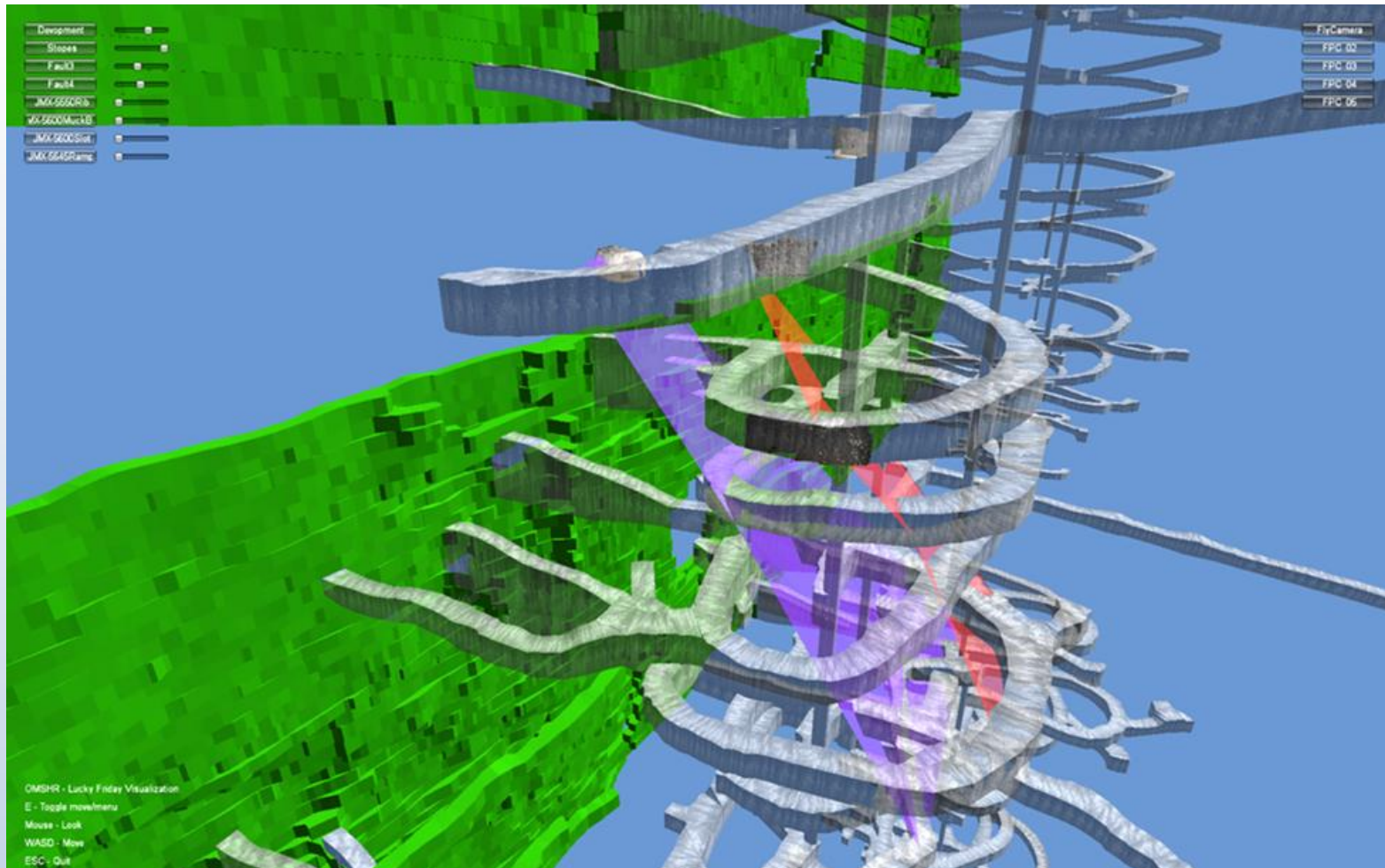
Deep Vein Mines

Ground Control Safety for Deep Vein Mines
Support for Dynamic Loading



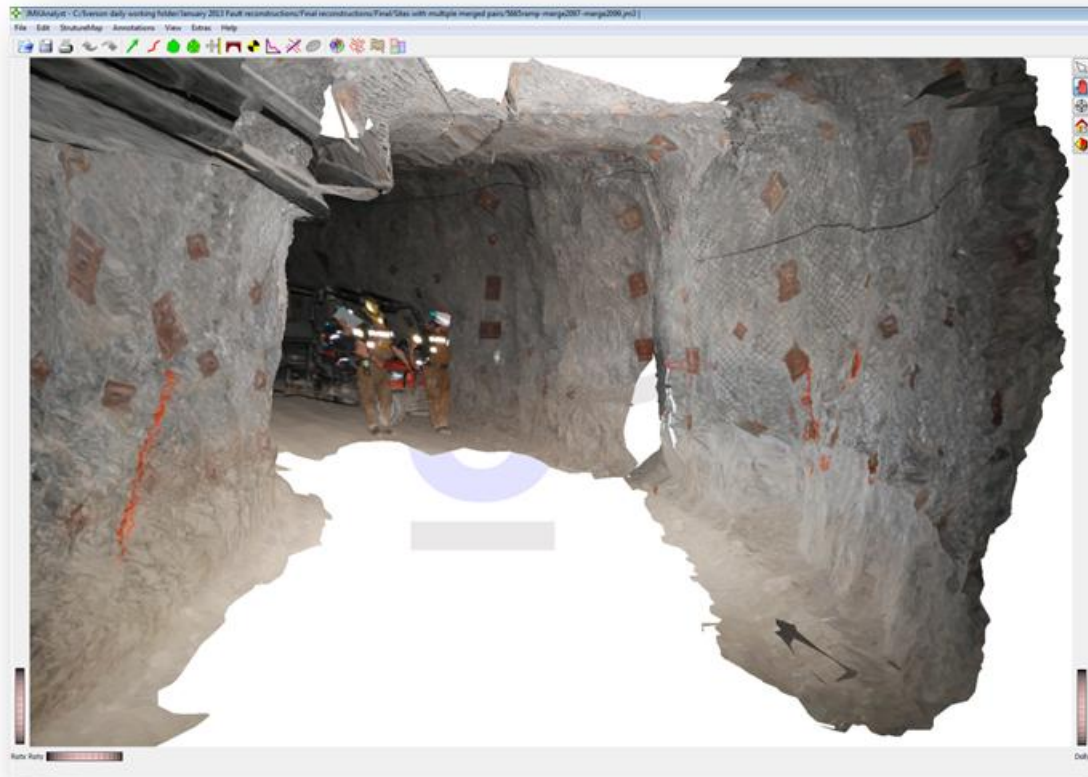
Deep Vein Mines

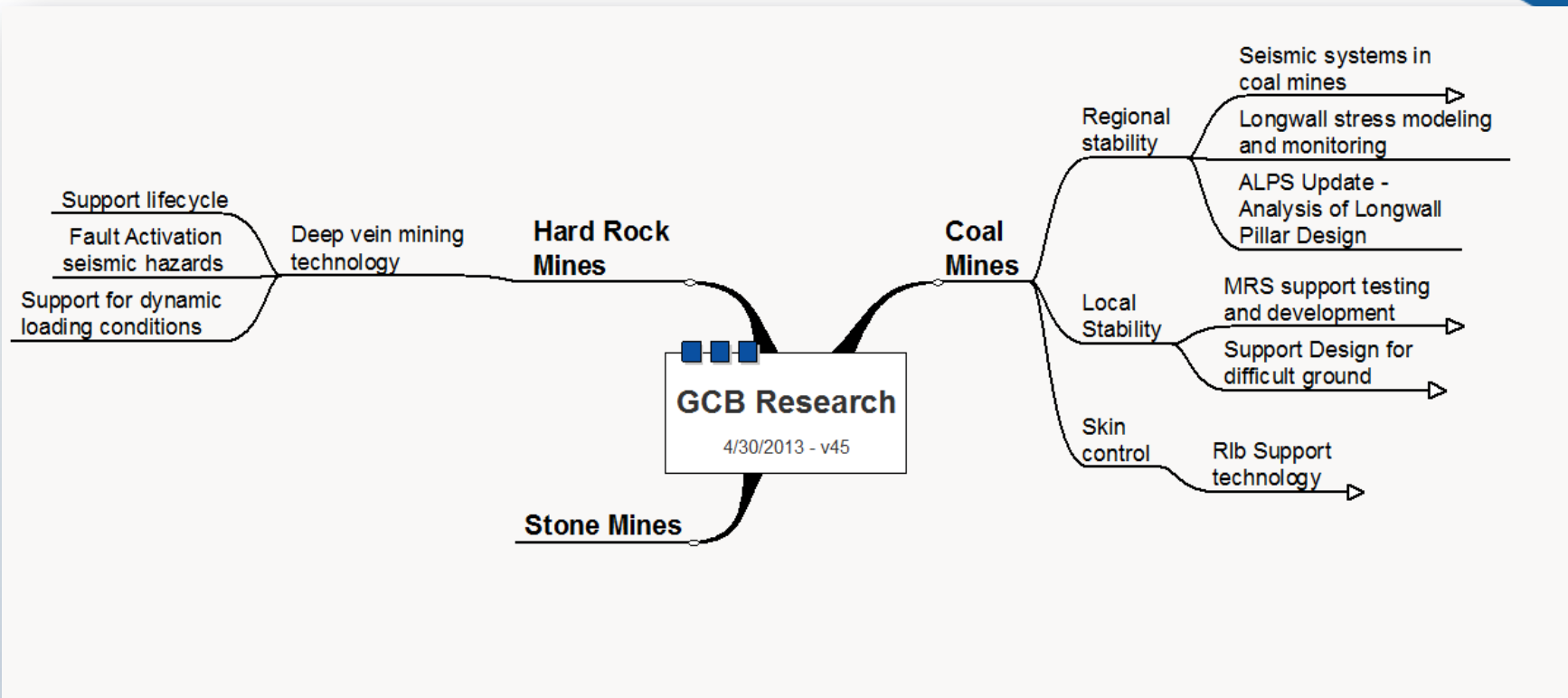
Ground Control Safety for Deep Vein Mines Fault Activation



Deep Vein Mines

Ground Control Safety for Deep Vein Mines
Support Lifecycle Safety



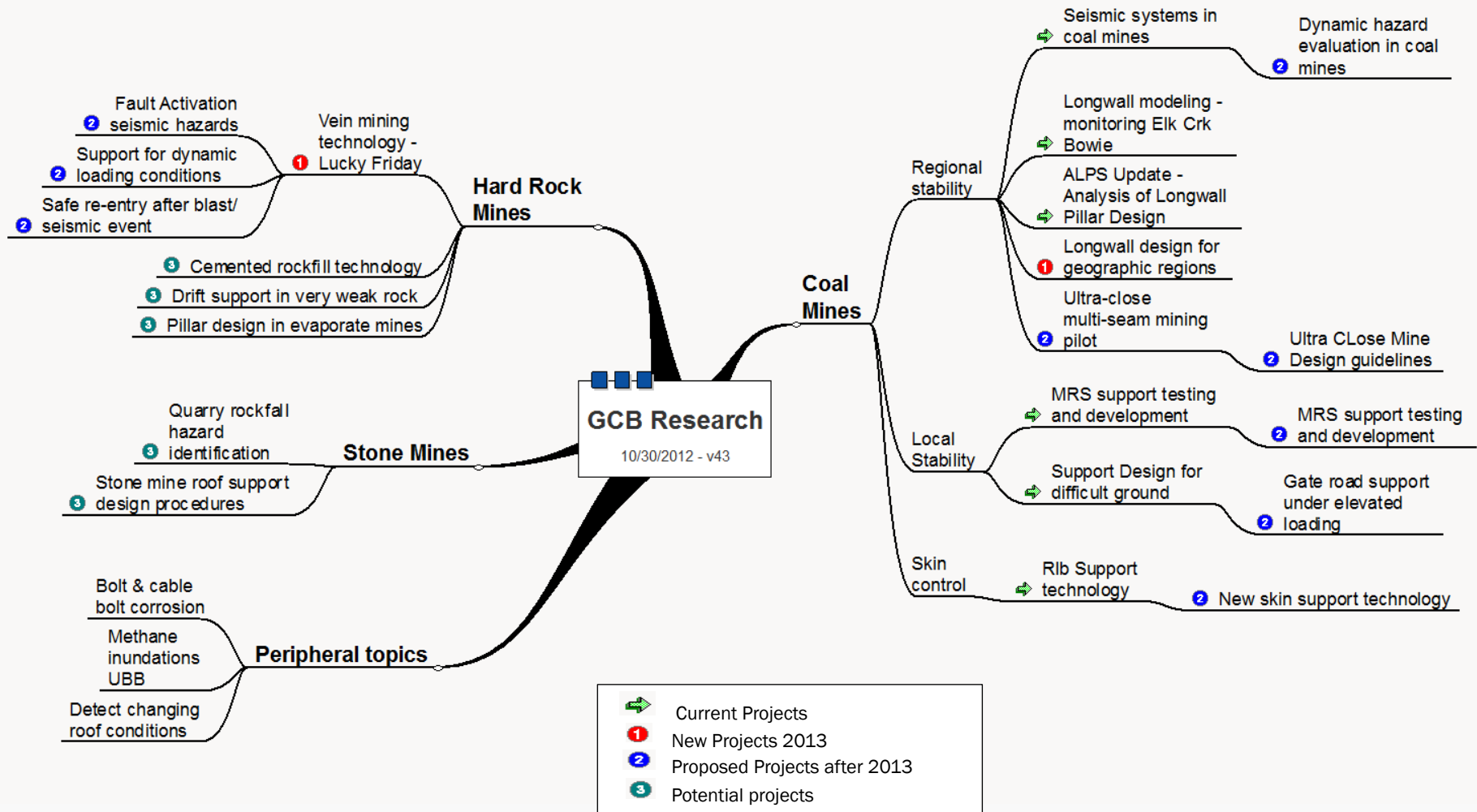


The findings and conclusions in this presentation have not been formally disseminated by NIOSH or Pennsylvania Services Corporation and should not be construed to represent any agency or company determination or policy.

Presented by the National Institute for Occupational Safety and Health



Ground Control Strategic Plan





NIOSH Supported External Research

- West Virginia University – Generation of Geomechanical and Time Dependent Properties of Coal and Coal Measure Rocks
- University of Arizona – Development of a Strength Criterion for Coal and Non-Sedimentary Rock Masses and Investigation of Underground and Open Pit Mine Stability in Such Rock Masses
- University of Nevada Reno – Weak Rock Mass in Nevada Gold Mines: Behavior, Support Design and Performance
- University of Kentucky – Identification of Potential Roof Problems Using LED Lighting & Numerical Modeling of Highwall Stability Using FLAC



NIOSH Supported External Research

- Penn State University – Instrumentation of Roof Bolter for Ground Characterization, Mapping and Support Design
- University of Utah – Analysis of Mine Seismicity and Geotechnical Modeling for Improved Safety in Underground Coal Mines
- Virginia Tech – New Technologies for Identifying and Understanding Ground Stability Hazards
- West Virginia University – Building Capacity and Enhancing Ground Control Safety Through Improvement and Extension of the LaModel Program

Discussion

