

Highlights of the Alpha Foundation Research Program

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Technical Director



Alpha Foundation for the Improvement of Mine Safety and Health, Inc.



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The Alpha Foundation Team

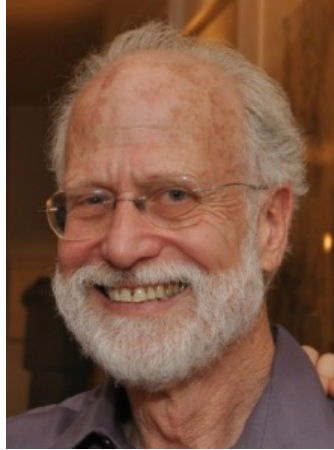
The Directors



Michael Karmis



Keith Heasley



David Wegman

Exec. Director



Warren Hunt

Technical Staff



Tom Barczak



Michael Silverstein



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Foundation Genesis

- Outcome of the Upper Big Branch settlement.
- **December 2011:** Non-Prosecution Agreement with Alpha Natural Resources, Inc.
 - Established a **\$48 million dollar** trust to fund projects designed to improve mine health and safety.



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Mission and Vision



Mission: To improve mine health and safety through funding research and development projects by qualified academic institutions and other not-for-profit organizations.



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Scope of Research

EXPLORE OUR TOPICS

Health and Safety
Interventions



Mine Escape, Rescue
and Training

Safety and Health
Management and
Training



Injury and Disease
Exposure and Risk
Factors

- **Broad research agenda**
 - Both safety and health
 - Both underground and surface mining
 - All mining sectors
- **Four major topical areas**
 - Health and Safety Interventions
 - Mine Escape, Rescue, and Training
 - Safety and Health Management and Training
 - Injury and Disease Exposure and Risk Factors



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HEALTH & SAFETY INTERVENTIONS



GRANT ACTIVITIES AND OUTPUTS

The Foundation has funded 24 grants to 13 different organizations as of July 2017.

[View Grant Portfolio](#)

Some projects have been completed with Final Technical Reports submitted.

[View Project Outputs](#)

PRIORITY AREA FUNDING SUMMARY

- Dust and Toxic Substances – 3 awards
- Ground Control – 4 awards
- Fire and Explosion Prevention – 6 awards
- Monitoring Systems and Integrated Control Technologies – 5 awards
- Machine Design and Ergonomics – 3 awards
- Personal Protective Equipment – 3 awards

Prevention Through Design

OVERVIEW

These studies encompass efforts devoted to prevention by design whereby engineering controls, mine design, machine design, or use of personal protective equipment or safety and health technologies are used to prevent conditions, circumstances, or events that cause illness, disease, injury or death to mine workers. A number of specific aims are targeted for intervention and intervention effectiveness studies that address specific aspects of mining.

PRIORITIES

Dust and Toxic Substance Control: *Prevention of health risks due to generation of dust or other toxic substances.*

Ground Control: *Prevention of unstable ground conditions that result in collapses, ventilation disruption, and miner entrapment; roof and rib falls; and injuries due to insufficient support coverage.*

Fire and Explosion Prevention: *Prevention of conditions that cause or contribute to mine explosions and fires and effective intervention measures to extinguish their propagation.*

Monitoring Systems and Integrated Control Technologies: *Recognition and intervention of the escalation of conditions that lead to health and safety risks before they reach hazardous levels.*

Machine Design and Ergonomics: *Prevention of machines inadvertently striking or pinning miners and injuries related to operation and repair of mining equipment.*

Personal Protective Equipment: *Prevention of injury and disease by application of PPE or environmentally-controlled spaces.*

Website is a good source of reference

<https://www.alpha-foundation.org>

- Organized around topical areas.
- Each topical area shows:
 - Priority descriptions
 - Grant portfolio (funded projects)
 - Project outputs (Final Reports)
 - Priority area funding summary



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Progress Update

- Released 8 solicitations requesting proposals.
- Received 376 concept papers and 227 full proposals.
- Funded 72 grants to 33 different organizations.
- Completed 24 grants.



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Highlights of the Alpha Foundation Research Program

Key outcomes and discoveries



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HEALTH & SAFETY INTERVENTIONS



PRIORITIES

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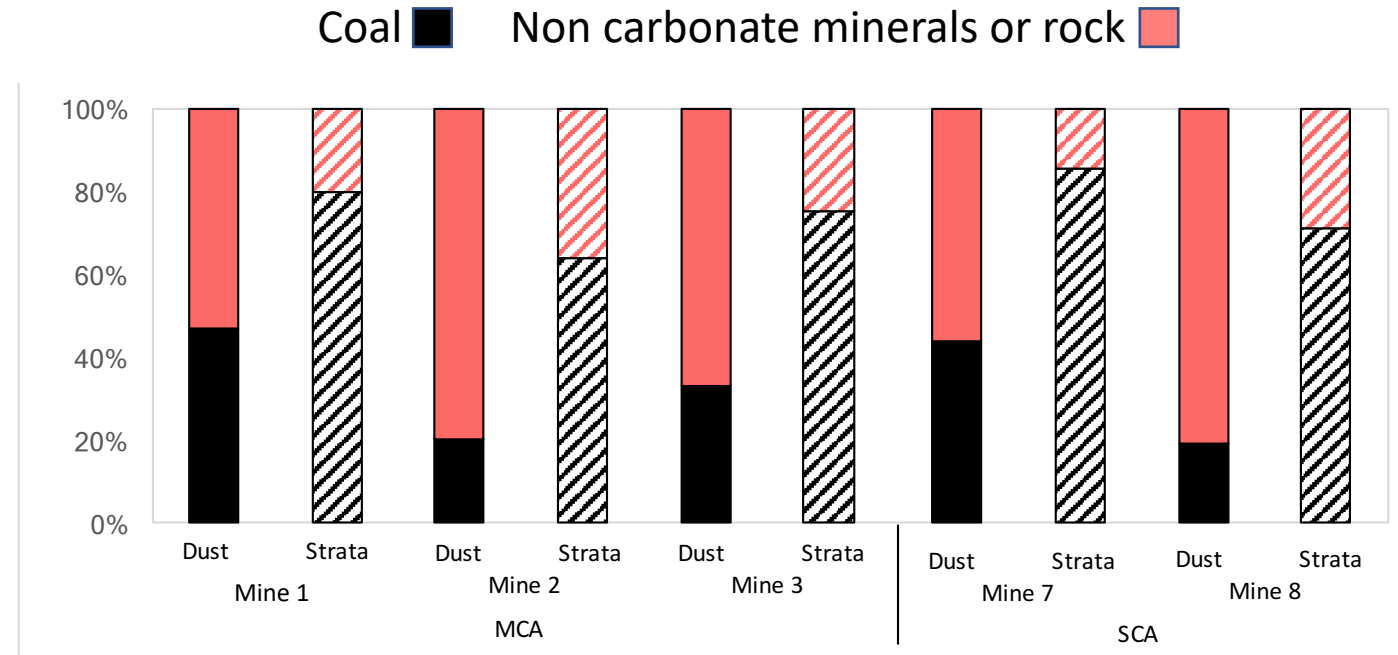
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Virginia Tech researchers find high fractions of non-coal particles in respirable dust samples

- Respirable dust samples taken in coal mine are generally assumed to contain mostly coal.
- This study proved otherwise.
- Carbonate and noncarbonate minerals tended to dominate many samples.
- Example of mines from Mid and Southern Appalachia shown in chart.



**Measurement of respirable dust mass alone
may be
inadequate to assess health risks.**

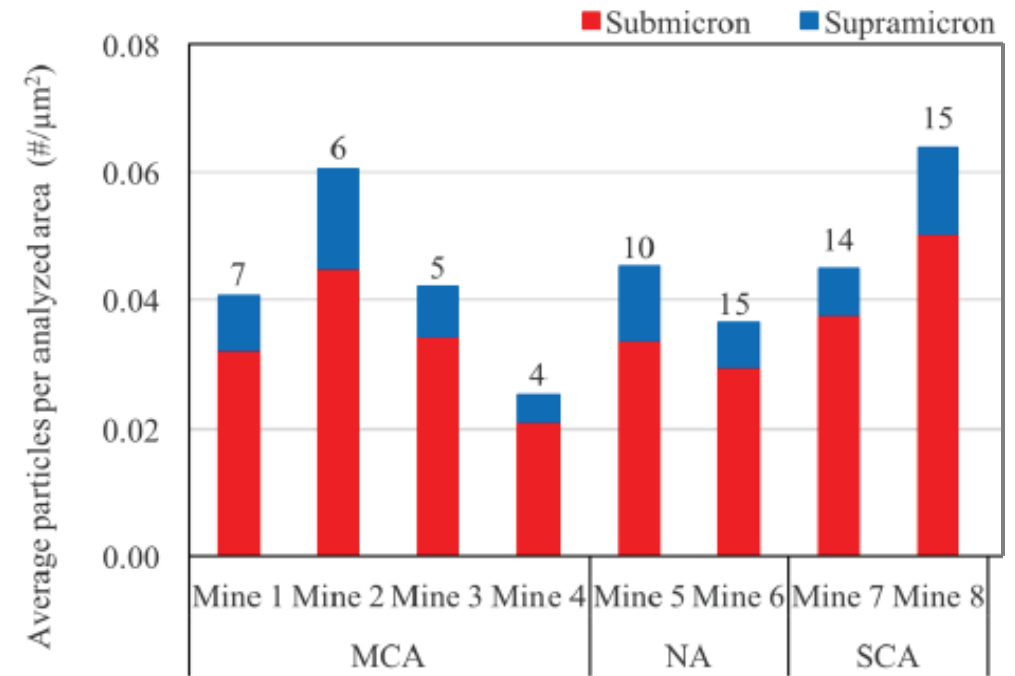
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Virginia Tech finds that submicron particles frequently occurred in very high numbers in respirable coal mine dust samples

- Concerns over lung disease have risen due to spike in Appalachian miners.
- Much is still not known about characteristics of respirable particulates in underground mines.
- One of the goals of this project was to examine particle size.
- Most dust is assumed to be in supramicron range i.e. > 1 micrometer



Submicron particles generally account for >75% of total dust particles, and ultra fines (100-400 nano meters) generally account for >50%.

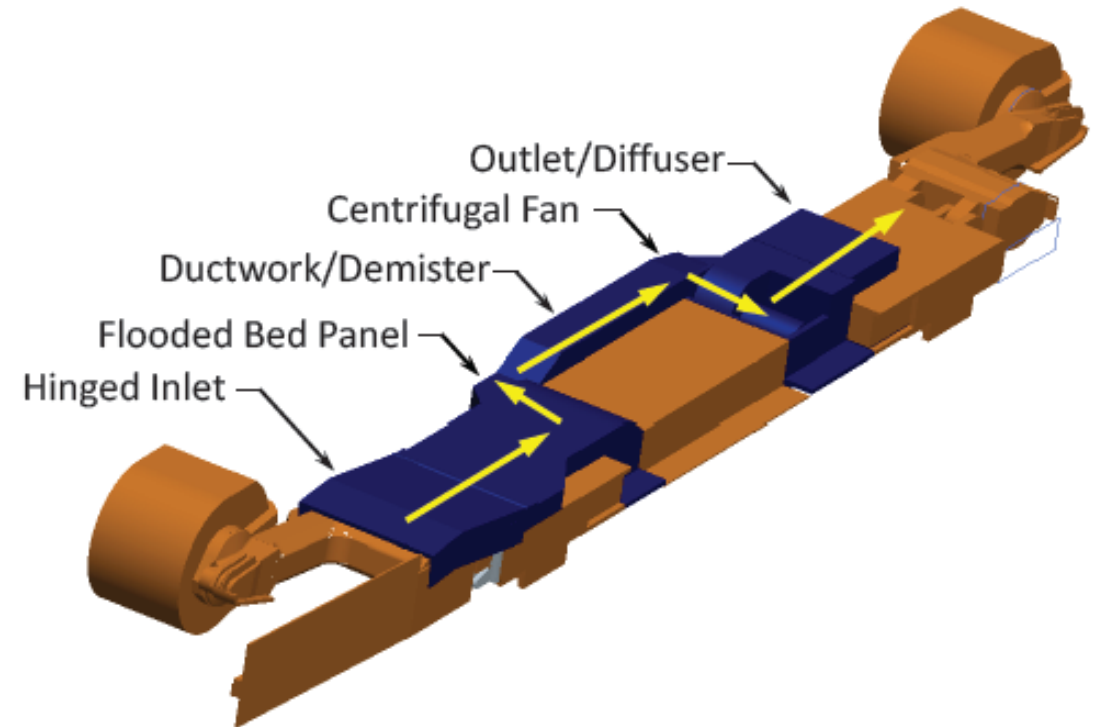
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University of Kentucky developed scrubber for longwall shearer

- Scrubber technology has proven to be an effective dust control intervention.
- But has not been implemented on longwall shearers.
- This project developed a flooded-bed scrubber and proof-tested it on a full-scale shearer mock-up at the NIOSH dust gallery.

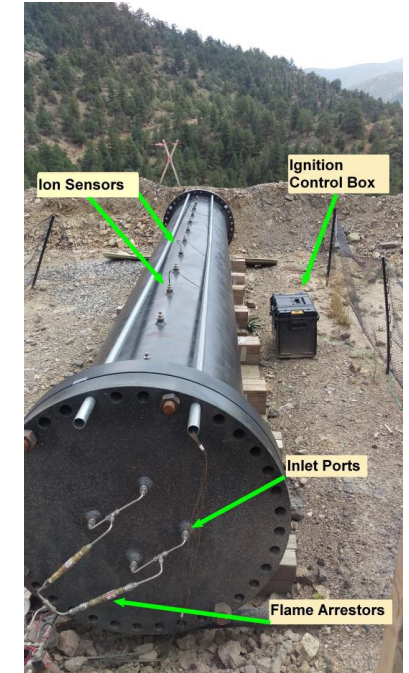
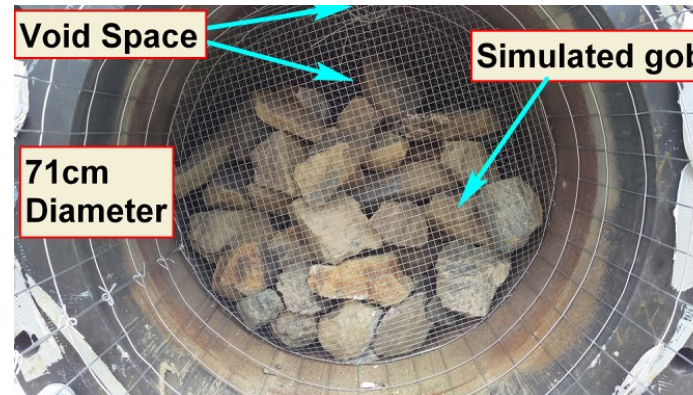


Longwall shearer scrubber reduces dust concentrations in face walkway by 74 pct and with 56 pct less dust leaving the longwall face.



Colorado School of Mines studies flame propagation through rock rubble to investigate explosive behavior in longwall gobs

- Constructed a facility which allows investigation of methane explosions through rock rubble.
- Two large-scale (31 cm and 71 cm) combustion reactors were built.
- After the flame passes through and over rock rubble, a portion of unburned gas mixes with hot products and interacts with the hot rock to cause a re-ignition event.



Rubble increases turbulence which enhances the explosion and shortens and run-up length to detonation transition.

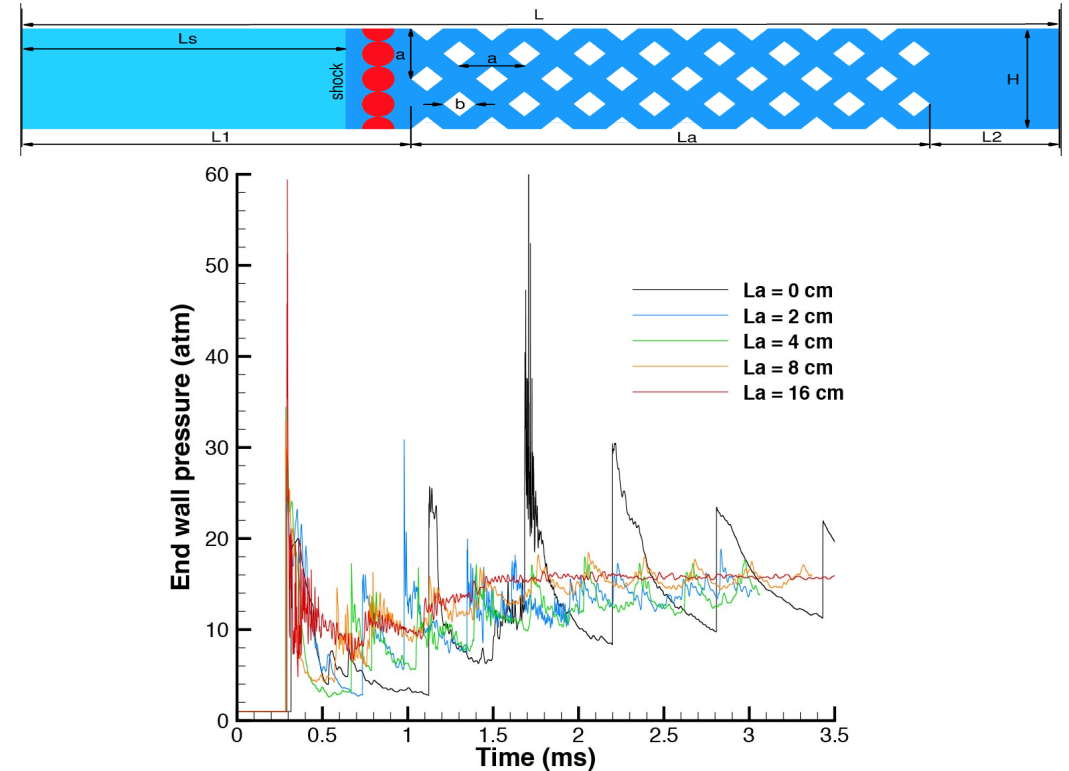
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University of Maryland computational explosion modeling finds that rock debris in coal mines can be conducive to detonation explosions

- Numerical computations studying explosion propagation with arrays of obstacles to simulate rock debris.
- Loose pile of rocks can eliminate inert pressure pulses if the length of the pile is comparable to the pulse length.
- This is not, however, the case for reactive waves, such as flames and detonations.



Seal pressure remains below 120 psi for open pathways < 20 m, but can reach 800 psi for short (microsecond) durations for run up lengths > than 35 m.



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Colorado School of Mines develops new instrument for measuring rock dust

- Rock dusting is essential to inerting float coal dust and preventing explosions.
- Current approach is to use a brush to remove a “surface” layer of dust.
- This project developed a pneumatic mine dust sampling device.
- Designed to scour to depth of 1/8-inch to be compatible with MSHA requirements.



Sampling using a brush and dust pan does not mimic the dust entrainment process that happens in an explosion. A pneumatic system is more realistic.



Colorado School of Mines demonstrates that squat coal pillars can fail violently resulting in coal bumps

- Historically, coal bumps have been the most catastrophic form of ground control failure.
- This project investigates quasi-brittle coal failure along pillar/roof interface.
- Shear failure along the pillar and roof interface leads to rapid de-confinement and excessive energy releases that can cause sudden dynamic failure.

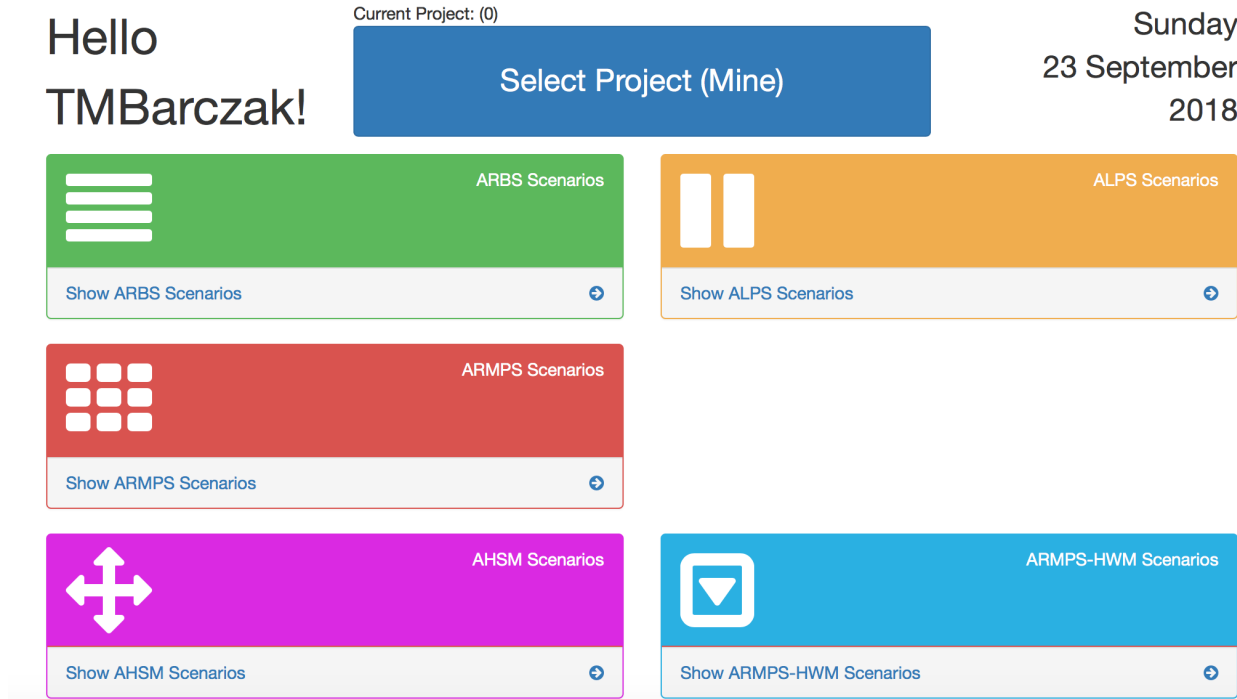


Squat pillars with high width-to-height ratio, which typically will maintain highly confined inner cores, can fail in a highly unstable and dynamic manner.



University of Kentucky transforms NIOSH Ground Control Tool Bar to web based platform

- The NIOSH Ground Control Toolbar has been an industry standard for coal mine ground control design.
- Up to now, these programs have been available as stand-alone PC-based software packages.
- This project has transformed them into a web-based platform.



webGroundControl provides a web-platform allowing users to share design information and previous analyses.

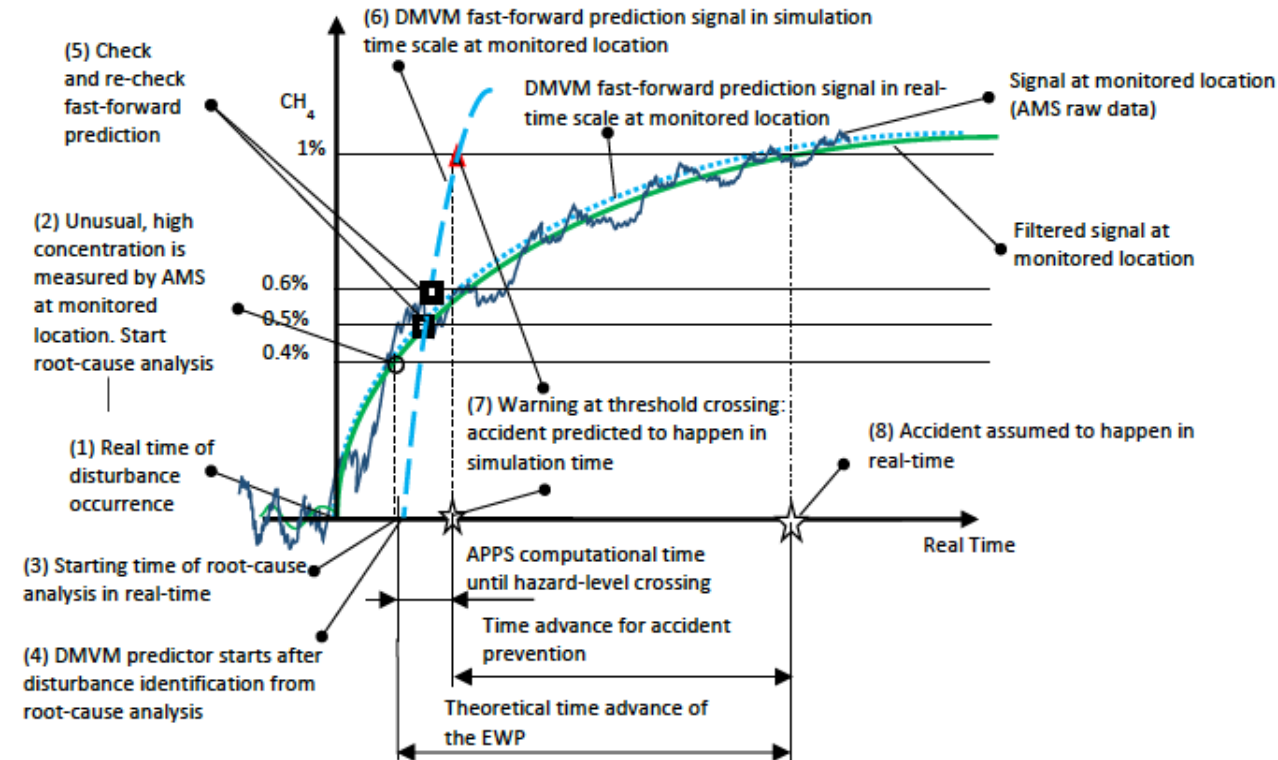
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University of Nevada, Reno develops system to recognize hazardous atmospheric conditions before their evolution toward an accident

- One of the outcomes of the MINER ACT was to require mines to install atmospheric monitoring systems.
- While these systems monitor the atmosphere, they do not analyze the information.
- This project has integrated an assessment and forecasting capability to anticipate hazardous developments and provide intervention warnings.



Plans are underway to test this system in both an underground gold mine (Nevada) and an underground coal mine (Australia).



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West Virginia University incorporates brain-sensing headband into integrated system to eliminate equipment-related injuries

- A persistent area of concern in mine safety continues to be related to mining equipment.
- 643 fatal injuries between 1995 and 2011 in U.S. coal, metal, and non-metal mining.
- Driver fatigue is a serious concern for surface mine operations.
- This project experimented with headbands that monitor brain activity.

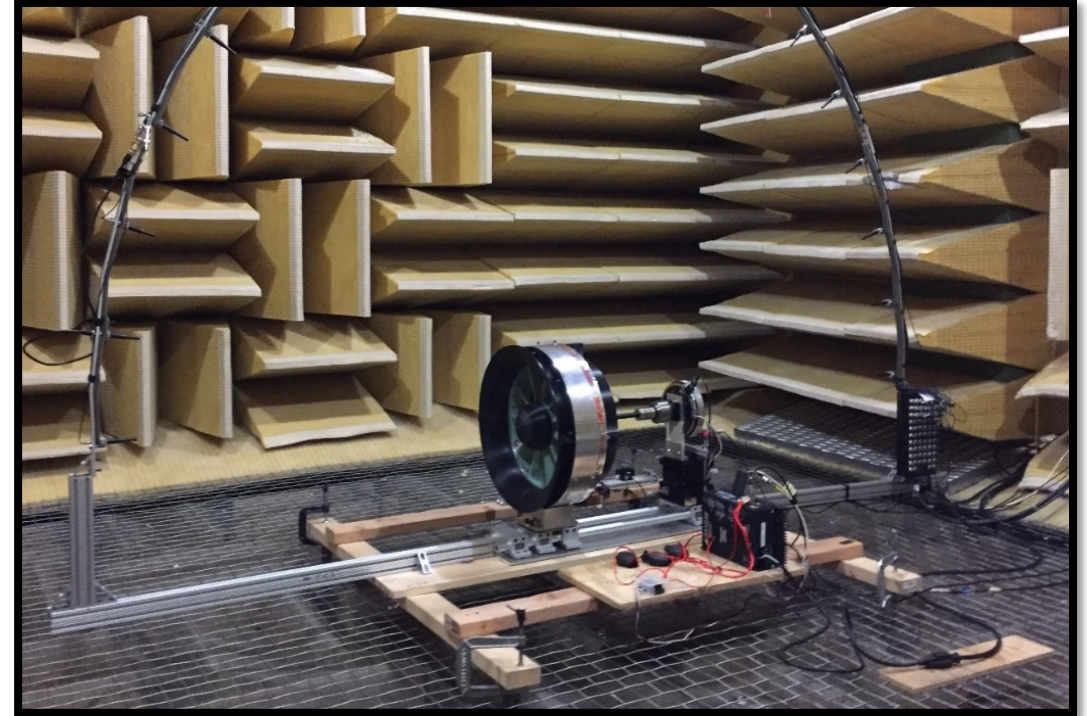


EEG headbands are more robust than camera-based approaches for blink analysis, and EEG spectral analysis can detect onset of drowsiness.



Virginia Tech develops quieter auxiliary mine fan

- Auxiliary ventilation fans are noisy and have received little attention in noise reduction efforts.
- A low tip speed with an optimum blade design is the best approach to reduce fan noise.
- Compact design shown to deliver equivalent flow rate compared to larger commercial fans.



Possible to reduce noise levels by 15-20 dB relative to typical commercial fans.

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MINE ESCAPE, RESCUE & TRAINING



PRIORITIES

Communications and Tracking: *Providing the capability to know where every miner is at all times and to be able to communicate with them during any emergency situation.*

Training and Decision Making: *Making sure that miners are properly trained to recognize the onset of emergency situations and manage decision making to facilitate effective escape.*

Sheltering and Escape Strategies: *Developing escape strategies and technologies to aid in escape including systems that provide for sheltering when escape is not immediately attainable.*

Rescue Strategies and Technologies: *Developing procedures and technologies to assist in managing incident command and rescue operations during and following a mine emergency.*



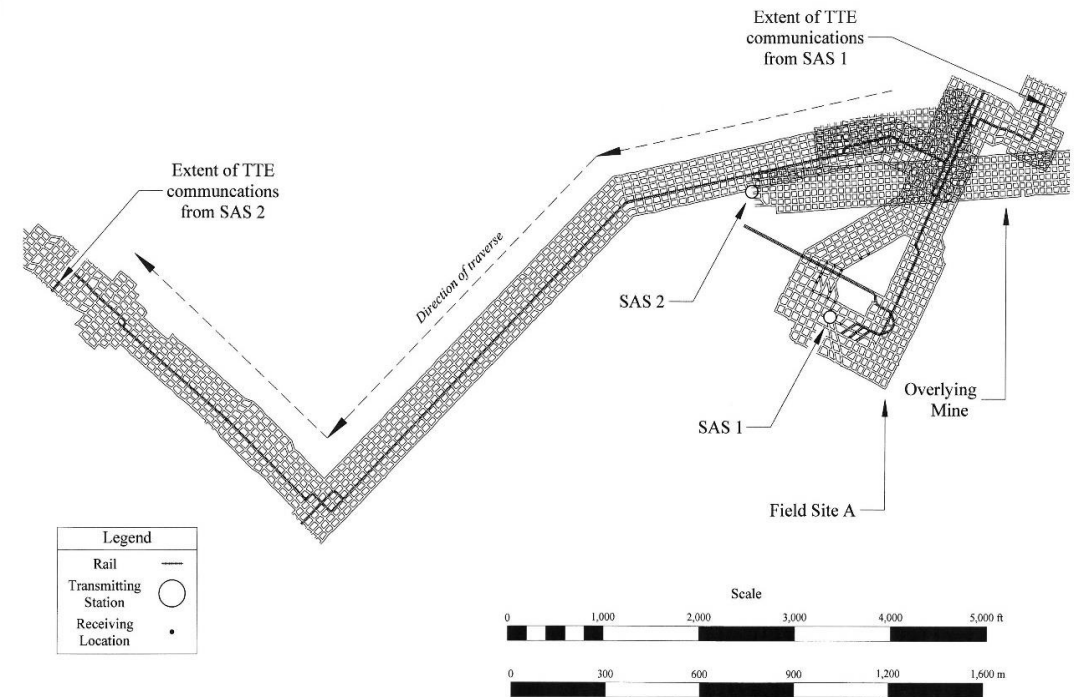
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Virginia Tech researchers find that rail and roof mesh can significantly extend transmission range of Magnetic Communication Systems

- It is commonly known that TTE communication is enhanced with “consolidated” geology.
- There is less understanding of anthropogenic influences.
- This project studied the influence of rail and wire roof mesh.



MCS achieved a maximum underground-to-underground communication distance of 10,000 ft with rail and 15,000 ft with mesh.



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SAFETY & HEALTH MANAGEMENT & TRAINING



PRIORITIES

Safety and Health Management: *Provide a health and safety culture that enables transparent risk identification and communication at the most fundamental level and proactive intervention measures before and beyond mandatory regulatory compliance.*

Training: *Provide miners with the necessary skills to properly assess the onset of hazardous conditions at the personal level and increase awareness relative to behavioral influences that lead to unnecessary risk taking.*



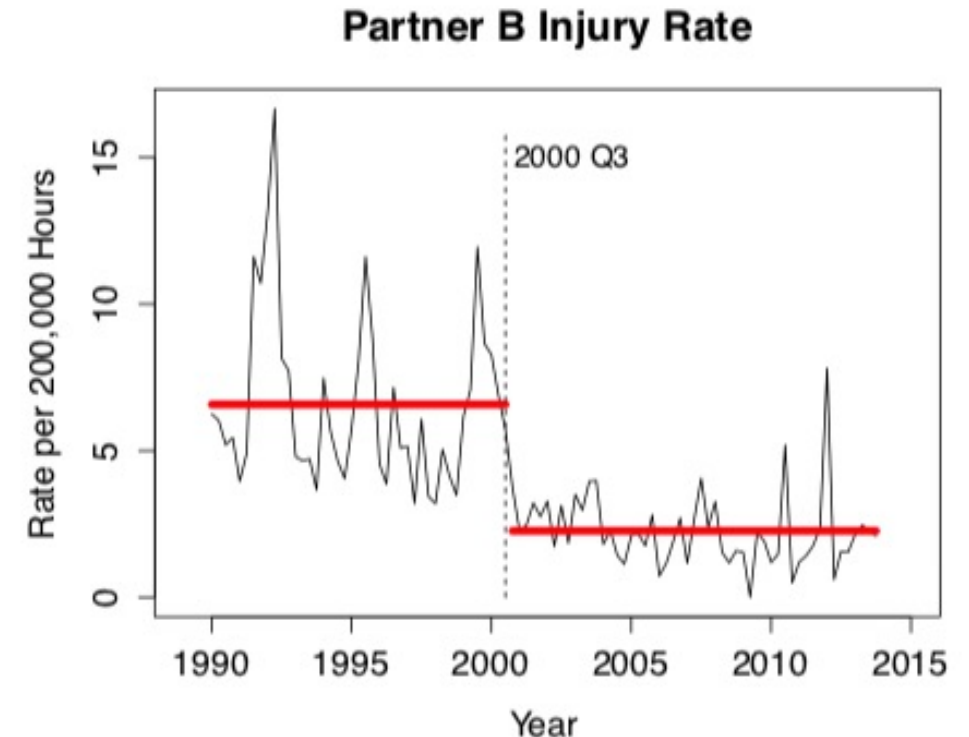
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University of Arizona studies risk management practices at four mines and finds significant safety and economic impact

- Compared their study mines to 25-year injury rates for mines of similar employee size and coal production.
- Estimated S&HM implementation costs ranged from a low of \$17,000 for updating of SOPs and SLAM program to a high of \$2.4M for Surveyors of Safety and Five Point Card programs.



A total of seven best-practice interventions were identified, with ROIs ranging from 183% to 104,061%.

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INJURY & DISEASE EXPOSURE & RISK FACTORS



PRIORITIES

Musculoskeletal Disorders: *Characterization of risk factors and implementation and evaluation of engineering changes or other modifications in job design or work practices to reduce these risks.*

Cardiovascular disease: *Study exposures to particulates, chemicals, and work-related stress that are unique to mining and contribute to cardiovascular disease and develop prevention measures to mitigate them.*

Respiratory Disease: *Understand the reasons for elevated occurrence of CWP and other chronic obstructive pulmonary disease, including asthma, and silicosis in miners and develop prevention measures to mitigate them.*

Hearing Loss: *Implementation and evaluation of the effectiveness of engineering controls that reduce chronic noise exposure and work to prevent hearing loss.*

Surveillance and Epidemiology Methods: *Develop systems to improve gathering, preserving, and analyzing essential mining information that provides leading indicators of hazards or biomarkers for health and safety effects.*



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University of California Berkeley finds that healthy worker survivor bias can lead to highly misleading conclusions of health impact

- Health-related exposure-response relationships can be challenging due to confounding variables and biases.
- The healthy worker effect indicates observed employee populations tend to have lower mortality experience than general population.
- Examined impact of REC and RPM exposure to developing heart disease.



Failure to consider the healthy worker effect attenuates the real risk of developing heart disease.



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University of California, San Francisco finds significantly elevated risk of arthritis in coal miners

- Project studied 973 miners in areas of a high burden of coal workers' pneumoconiosis (CWP).
- Rheumatoid arthritis is an autoimmune disease and it was hypothesized to be elevated in miners due to dust inhalation.
- 60% of West Virginia miners over age of 65 have arthritis.

Table 5. Multivariate analysis: Risk of arthritis and rheumatoid arthritis associated with coal and silica exposure adjusted for smoking, ergonomic factors, and age

	All arthritis Model n=973	Rheumatoid Arthritis Model n=566*	Non-RA Arthritis Model n=861**
Risk Factor	OR (95% CI)	OR (95% CI)	OR (95% CI)
Coal and Silica exposure			
Coal mining work	2.2 (1.6, 3.1)	3.5 (2.0, 6.0)	2.0 (1.3, 2.8)
Silica, no coal exposure	1.7 (1.2, 2.4)	1.9 (1.01, 3.6)	1.6 (1.1, 2.4)
Smoking			
Current	1.2 (0.8, 1.9)	2.0 (1.0, 3.8)	1.1 (0.7, 1.7)
Former	1.1 (0.8, 1.4)	1.2 (0.7, 1.9)	1.1 (0.7, .5)
Ergonomic exposure			
11-13 factors	1.5 (1.1, 2.0)	1.8 (1.1, 3.0)	1.4 (0.99, 2.0)
Age (per year)	1.03 (1.01, 1.04)	1.04 (1.01, 1.05)	1.03 (1.01, 1.04)

For coal and silica, referent category=neither exposure; for smoking, referent=never smoker; for ergonomic exposure, referent category= 0 to 10 factors.

*Excludes 407 reporting arthritis or selected autoimmune diseases without concomitant RA.

**Excludes 112 participants reporting RA and glucocorticoid treatment



Study finds that coal mining work more than doubles odds of having osteoarthritis and more than triple for rheumatoid arthritis.



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Northeastern University researchers find that heavy surface mine equipment operators are likely to exceed ISO daily vibration limits

- Exposure to musculoskeletal injuries is a concern for operators of large-scale mining vehicles.
- Impulsive loading exposures are worse than time-weighted average exposures.
- Load in the horizontal and lateral axis are just as damaging as those in the vertical axis.



Study shows that operation would be restricted to less than 4 hours per day for time weighted exposures and less than 2 hours for impulsive focused exposures.



On the horizon

A peak at on-going projects



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On the horizon

Drone Technologies

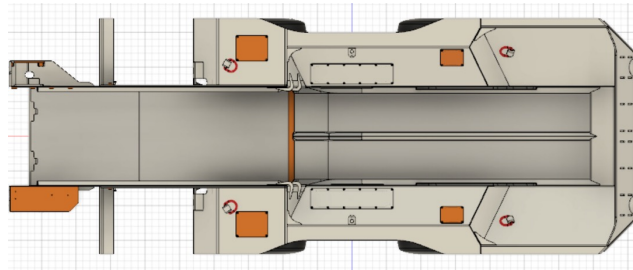
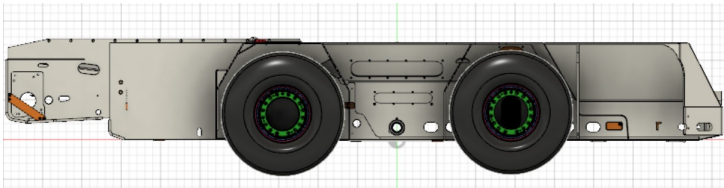


- Can we move this technology underground to conduct geological mapping?
- Can we make a permissible drone for mine rescue?

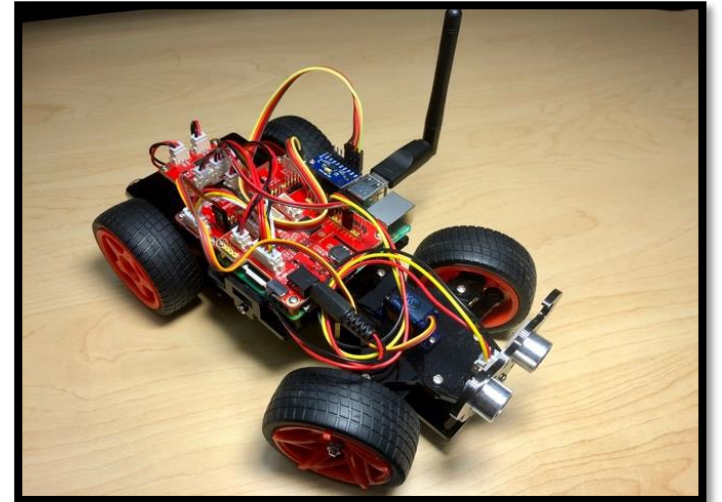


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On the horizon



Autonomous Mine Vehicles



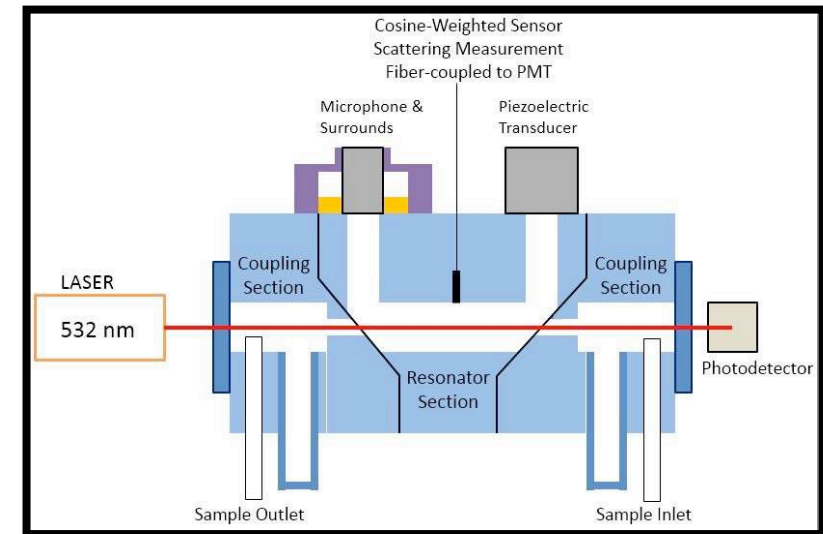
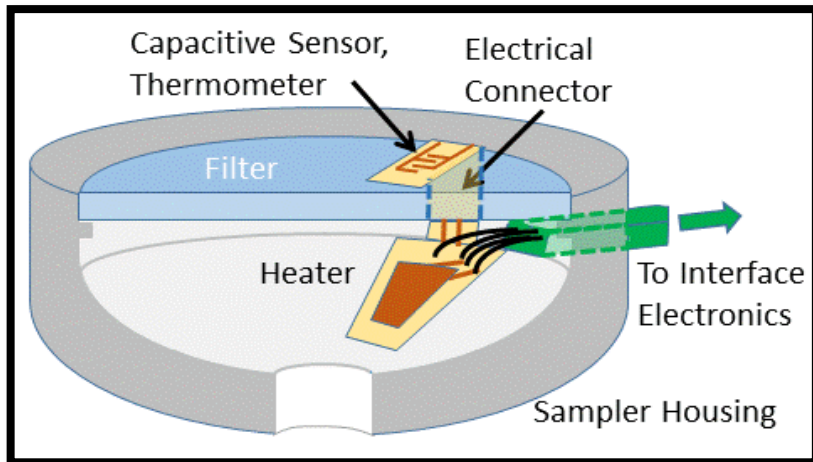
- Can we develop an accurate and reliable real time positioning/navigation system?
- Can we make an autonomous shuttle car?



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On the horizon

Respirable Dust Monitors

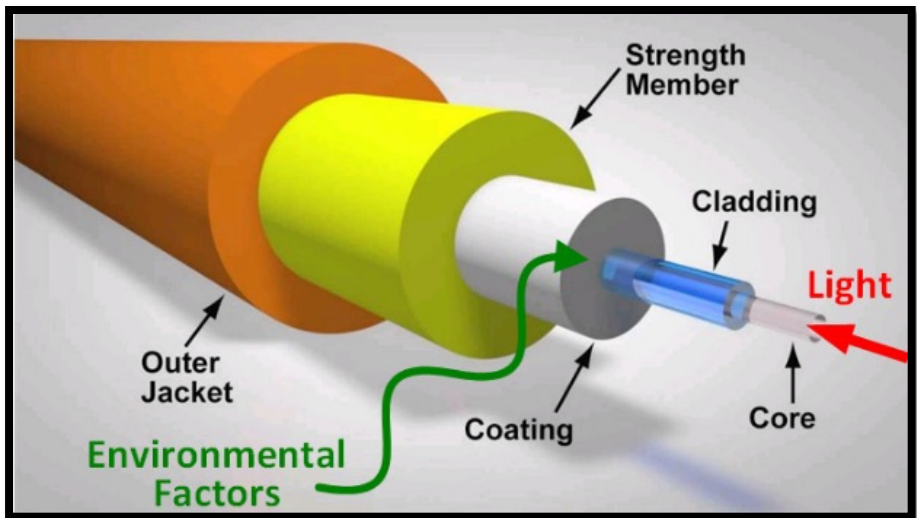


- Can we develop a monitor to measure dust constituents instead of just mass?
- Can we measure nano-sized particles?

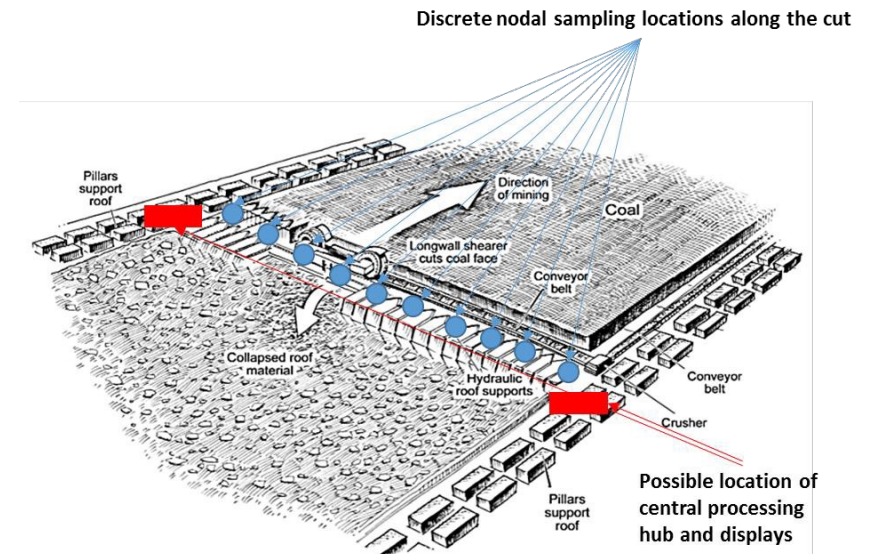


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On the horizon



Sensory Technologies



- Can we develop a distributed sensory capability as opposed to single point?
- Can we develop sensors to monitor methane development behind shield line?



On the horizon



Mine Escape and Rescue Communications



- Can we harden our communications systems to increase survivability?
- Can we use the refuge chamber as an “in-mine” fresh air communication base?

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Next Solicitation Coming Soon



Dates to Remember

The next Alpha Foundation solicitation,
AFC820, will be announced in the Fall.

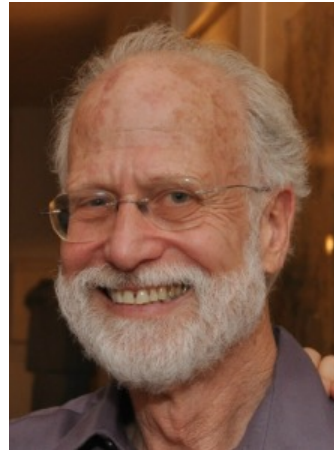


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**The Alpha Foundation thanks you for
inviting us to participate**



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