Overview of extramural automation projects

BAA & IAA Contracts

JPL 2024

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Office of the Director – Mining Program

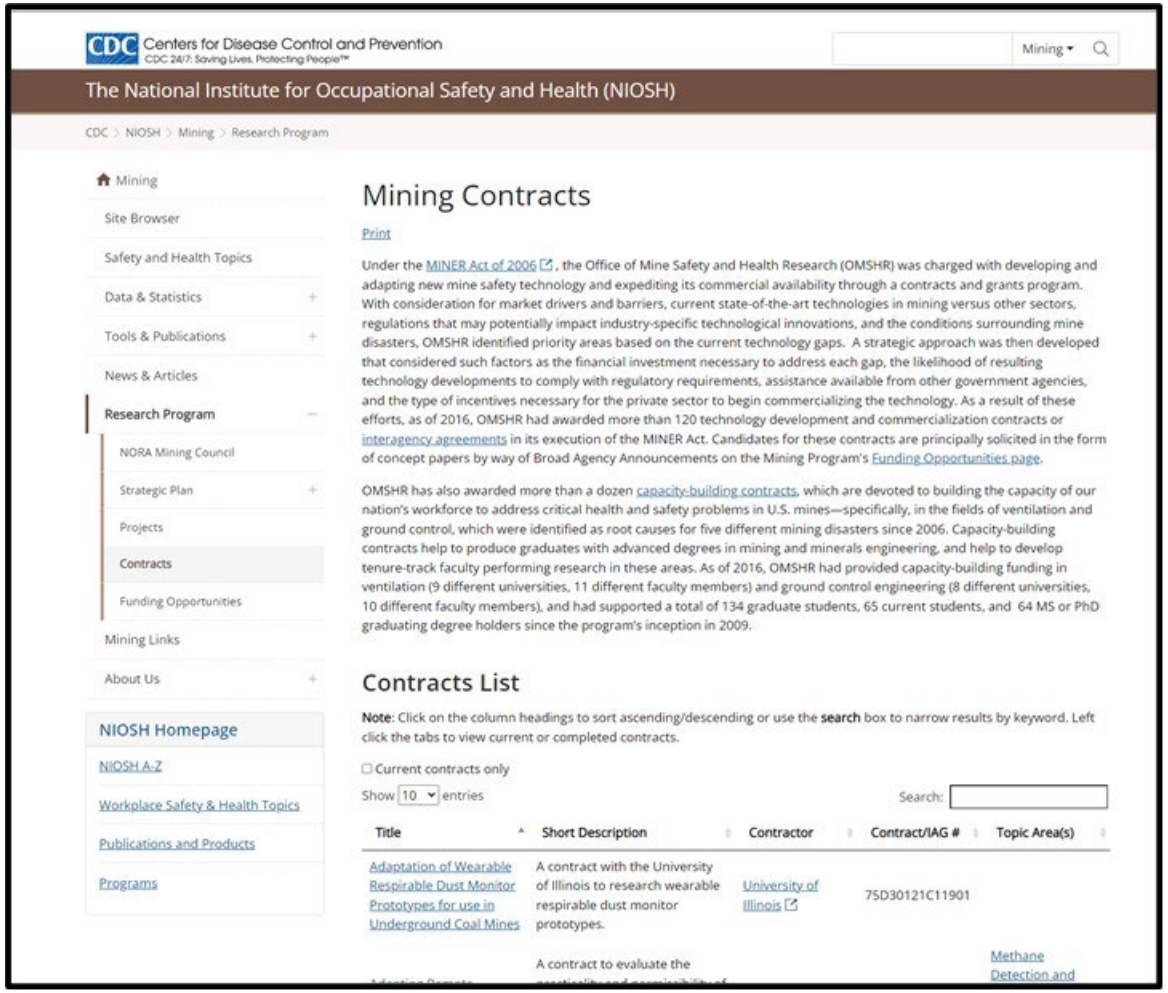
Extramural Programs

- **Grants (OEP)**
  - Western Mining Safety and Health Training
  - Underground Mine Evacuation Technologies and Human Factors Research
  - Robotic and Intelligent Mining Technology and Workplace Safety Research
- **Contracts (Mining Program)**
  - Broad Agency Announcement: Development and Demonstration of Mine Safety and Health Technology
  - University (Capacity Build) BAA cycle
- Interagency Agreements (IAA)
  - NASA JPL/Caltech
    - Advance Sensors and Robotic Deployment Platform for Increased Safety and Rapid Response
  - NASA KSC and NSWC-PCD (managed by NPPTL)
    - Liquid Oxygen Storage Module (LOXSM)

Extramural Programs

- Current program established in 2007
- 161 **Technology BAA Contracts** - over 17 years
  - Contracts awarded for many different subtopics in mining H&S
- 41 Capacity Build BAA Contracts
- Also, RFP, SAP contracts

- 12 contracts awarded related to developing automation
  - 4 awards planned for FY2025



NIOSH – Broad Agency Announcement (BAA)

- 2021 BAA Automation Focus Area
  - Roof bolter automation and operator dust exposure reduction
    - 2 contracts awarded
- 2022 BAA Automation Focus Area
  - Regulatory Review for Automation
  - Simulation and Modeling for Automation System Design and Implementation for Health and Safety
    - 13 concepts submitted
    - 2 contracts awarded

NIOSH – Broad Agency Announcement (BAA)

NIOSH strongly encourages responders to propose solutions to other health and safety issues that are responsive to our guidelines

- These proposals are evaluated under the same criteria as submittals under the focus area
  - Receive equal consideration for funding
  - 26% of contracts funded under this program have come from this category of submittals
  - In some fiscal years, have made up 50 – 70% percent of funded proposals

NIOSH strongly encourages proposals that include collaboration with mining industry partners who understand the reality of the mining environment and can provide insight into mine design requirements and potential commercialization of the technology.

Automation Contracts

CONTRACT	CONTRACTOR	TITLE	COR
200-2017-94151	ROHMAC, Inc.	Modification and Approval of Mine Rescue Support Machine	Completed
75D30118C02634	RESPEC	A Fully Autonomous Unmanned Aerial Vehicle Solution for Underground Mines	Completed
75D30120C08908	UNIV KENTUCKY	Autonomous Docking of Face Haulage Mining Machinery in GPS-Denied Environments	Completed
75D30120C09628	UNIV PITTSBURGH	Automation Experience with a Global Perspective – An Assessment of the Automation Impact on Worker Safety and Health	Completed
75D30121C12010	FLETCHER	Remote Blast Hole Location Detection for Powder Loader Automation	Completed
75D30122C14875	U ARIZONA_GEO TECH	Development of Automated Rockfall Detection via Thermal Video Cameras in open pit mines, extension to NIOSH Contract 75D30120C09871	Heather Lawson/ Mark Larson
75D31021C11971	KOMATSU/JOY	Improved Longwall Automation by Utilizing Sensors to Detect the Rock Coal	Randy Reed
75D30121C12206	COLORADO SCHOOL OF MINES	Machine Learning Enhanced Perception for Automated or Remote Roof Bolting Operations in Underground Mining	Jim (Chenming) Zhou
75D30122C14149	SME	Eliminating Barriers for the Implementation of Automation in the Mining Industry	Randy Reed
75D30122C14757	UNIV NEVADA_RENO	AutonoDES: A discrete Event Simulation Platform for Safety Scrutiny of Autonomous Mining Systems	Tim Orr
75D30123C17307	UNIV KENTUCKY	In-Mine Underground Collision Avoidance Information System	Randy Reed
75D30123C17411	J.H. FLETCHER	Design and Manufacture of an Outby, Single Module, Electric, Automated, Roof Bolter	Randy Reed

A Global Perspective on Automation in Mining – An Assessment of the Impact on Worker Safety and Health, 75D30120C09628, University of Pittsburgh - Completed

- Understand the current state of autonomation in mining to inform researchers and manufacturers of safe future deployment of automated technology
- Visits to many of the automation-implementing companies in various countries (Australia, Canada, Chile, and Sweden).
  - Conducted interviews with key people involved in the automation transition
- Obtained fatality and accident data from three countries, Australia, Canada, and the U.S.
  - Analysis showed that there were no fatalities due to automated equipment.
  - Loss of situational awareness appears to be a main cause of incidents.

Eliminating Barriers for the Implementation of Automation in the Mining Industry; 75D30122C14149, Society of Mining Engineers

- Review and identification of U.S. regulation that may limit or discourage adoption of automation in both underground and surface operating environments for a variety of commodities.
  - Emphasis on mine safety and health
  - Comprehensive review of Title 30 Code of Federal Regulations (30 CFR)
  - Other statutes, regulations, and corporate policies
- Identify appropriate stakeholders to organize technical workshops (8) in conjunction with existing national and regional meetings organized by the Society.

A Fully Autonomous Unmanned Aerial Vehicle Solution for Underground Mines, 200-2018-02634, RESPEC Inc - Completed

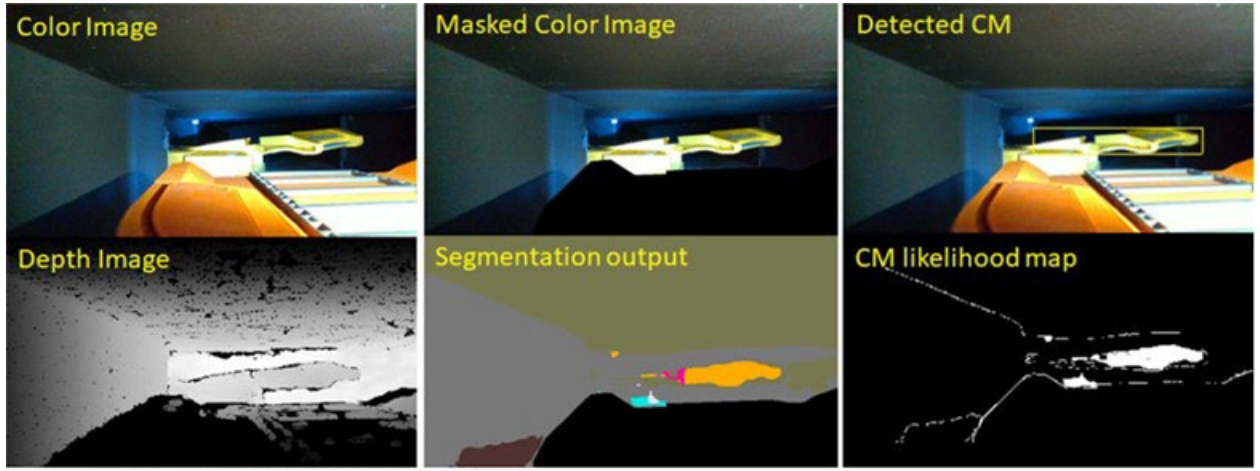
- Develop autonomously operated prototype drones for use in field testing at a mine site.
- Test completed at the Sanford Underground Research Facility (SURF) in South Dakota (the former Homestake Mine).
  - Test conducted in a ramp system at SURF.
  - The drone was successfully flown in underground entries at SURF

Modification and Approval of Mine Rescue Support Machine, 200-2017-94151, ROHMAC, Inc. - Completed

- Development of a diesel powered mine rescue support vehicle that can be operated via a remote control by mine rescue personnel.
- The machine includes a scoop on the front end for clearing debris to gain access into a blocked entry
- Updated wireless remote, and the ability to include sensors to transmit information back to the operator.
- The machine is currently undergoing MSHA approval for intrinsic safety certification.

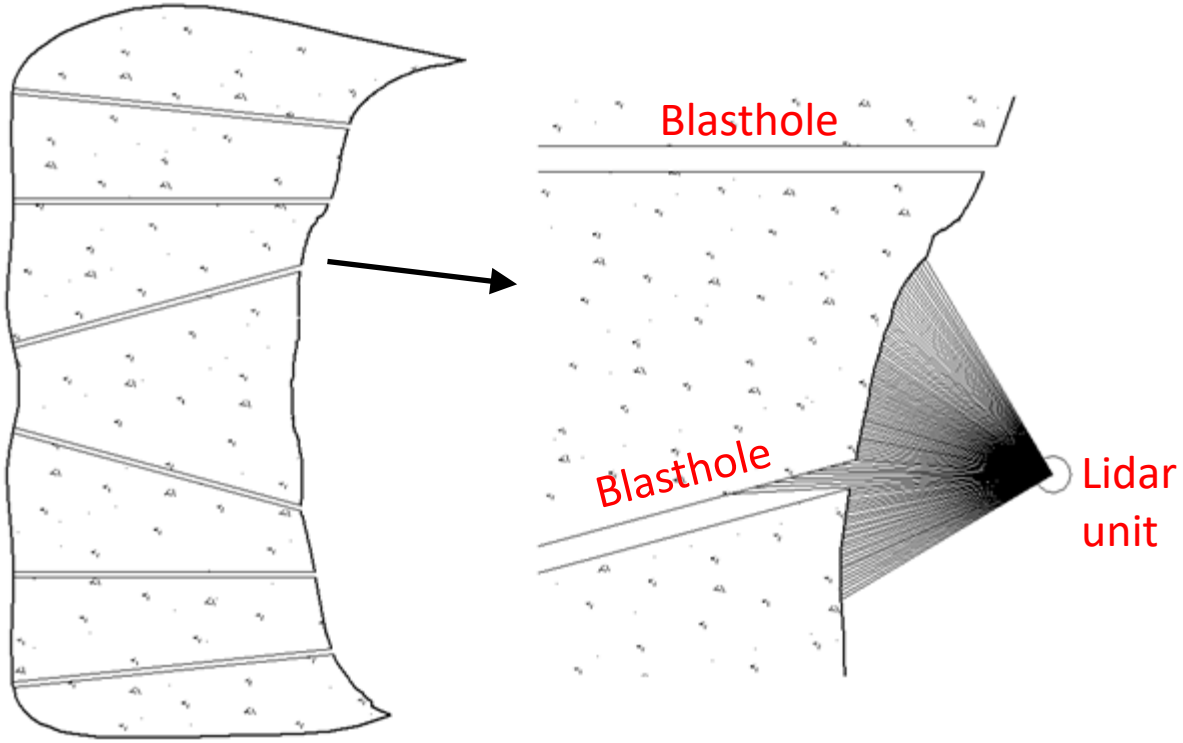
Autonomous Docking of Face Haulage Mining Machinery in GPS-Denied Environments; 75D30120C08908 – University of Kentucky - Completed

- Develop and demonstrate autonomous navigation and positioning of a shuttle car to the continuous miner's discharge conveyor
  - Simulated underground mine environment.
  - Various positions simulating cutting and loading locations for straight entries, turning crosscuts, etc.
  - Shuttle car autonomously trams and positions under continuous miner coal discharge conveyor.
- Full-scale shuttle car instrumented
  - Low- cost cameras, light detection and ranging (LiDAR) sensors, and ultrasonic sensors
  - Demonstrated the ability to navigate the shuttle car into position under the continuous miner discharge conveyor.



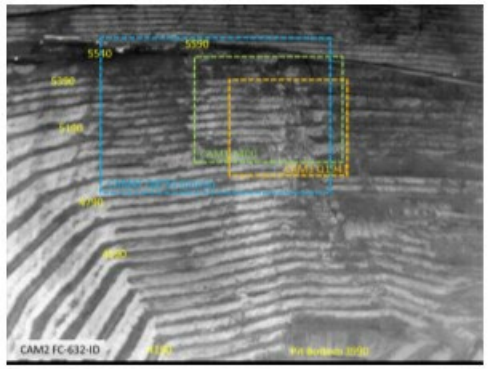
Remote Blast Hole Location Detection for Powder Loader Automation; 75D30121C12010, J.H. Fletcher, Inc. - Completed

- Automate the powder loading process.
- Designed a drillhole location system to be located at the end of a boom on the powder loader.
  - Remove the powder loader occupation from the area
    - Eliminate hazards of potential roof falls
    - Reduce exposure to diesel particulate matter.
  - Successfully moved the boom to drillhole locations.
  - Poor lighting conditions reduce accuracy and repeatability of orienting boom to borehole.



Development of Automated Rockfall Detection via Thermal Video Cameras in open pit mines, extension to NIOSH; 75D30122C14875, University of Arizona (followup to 75D30120D09871)

- Developed Automated Rockfall Detection Algorithm
- Developed Empirical Rockfall and Failure Forecasting



Machine Learning Enhanced Perception for Automated or Remote Roof Bolting Operations in Underground Mining; 75D30121C12206, Colorado School of Mines

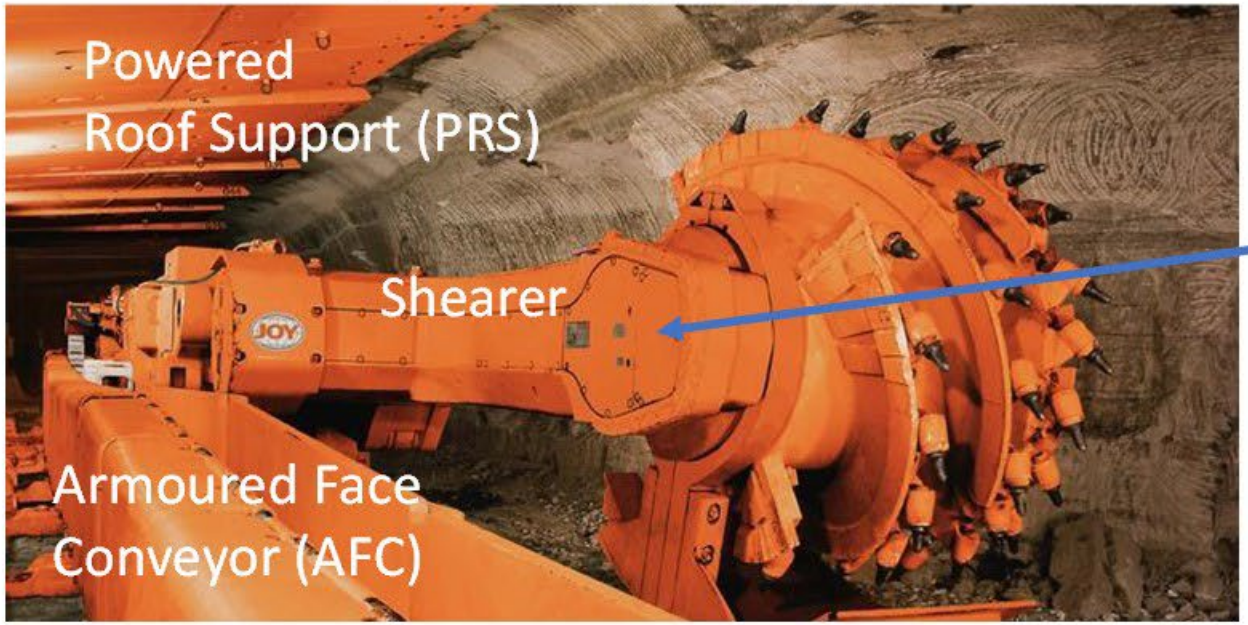
- Enable roof bolting automation using imaging and ranging technologies
- Identify native rock from support materials (wire mesh, steel straps, etc.) to determine drilling locations
  - Use machine learning techniques
- Automate planning of rig placement and drilling operations
- Develop design concepts for automated mechanisms to handle drilling rods, bolts, plates and nuts, and resin or grouting.

Fletcher roof bolter at EMI rock drilling lab CSM

Improved Longwall Automation by Utilizing Sensors to Detect the Rock Coal; 75D30121C11971, Joy/Komatsu

- Investigate technology to improve the ability to locate the Rock-Coal Interface on a longwall face for future use to control the shearer without requiring local human intervention.
- Investigate combinations of sensing technologies
  - Determine when shearer drum of longwall mining system moves beyond the coal seam into the roof or floor rock.
  - Hyperspectral camera (Hyspex by NEO) along with other hardware required for testing.
  - Vibration and audiology instruments
- Development of the roof/floor sensing system
  - Analysis of vibration data can differentiate between coal/rock.
  - Audio data collection obstacles due to XP/IS approvals
  - Hyperspectral camera – none available that can fit on a longwall shearer

Longwall mining equipment

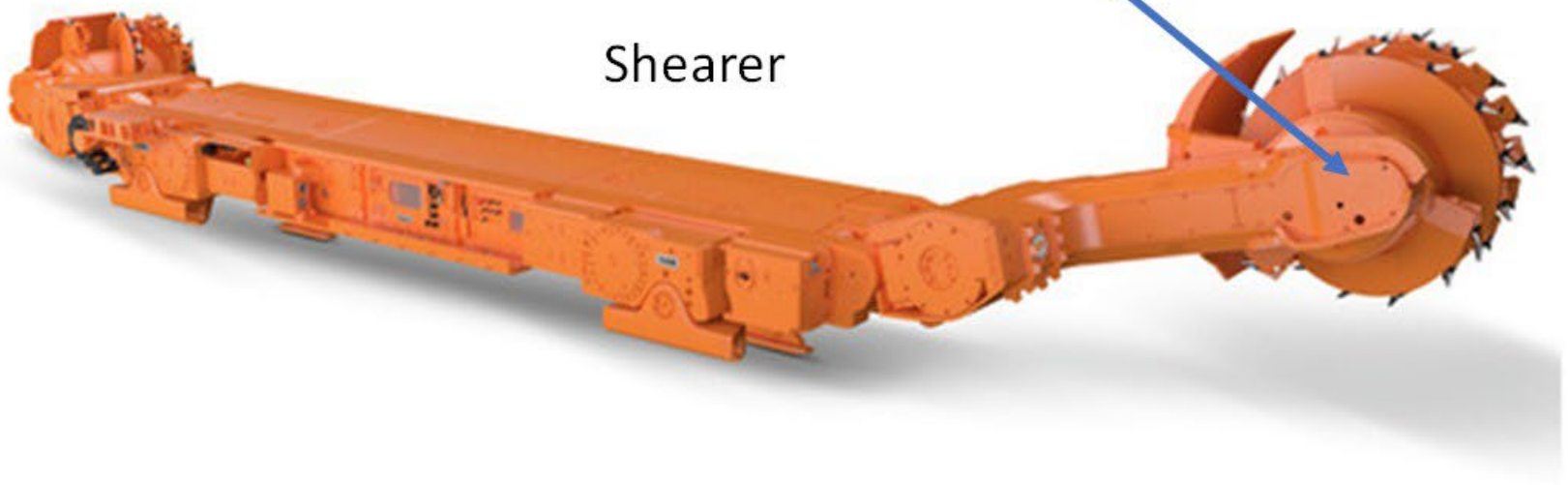


Vibration sensors

Magnets for vibration
Sensor mounting

Located on ranging arm
of longwall Shearer

Vibration Data Collector
Cabled to vibration sensors



AutonoDES: A discrete Event Simulation Platform for Safety Scrutiny of Autonomous Mining Systems; 75D30122C14757, University of Nevada-Reno

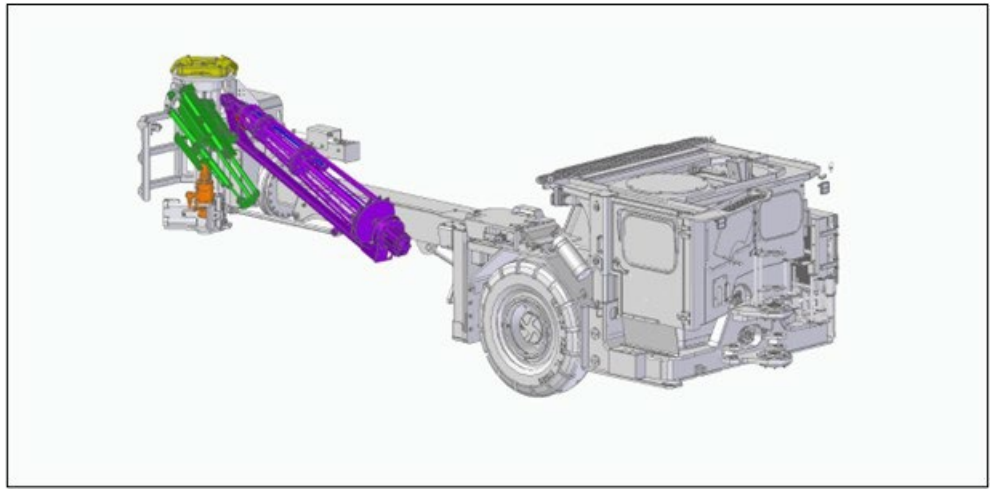
- Create a user-friendly software platform that helps mining companies in safely transitioning to autonomous systems and checking the effectiveness of their safety policies
- Collected data for the fleet specification, mine layout, dispatch history and accident reports
- Running the DES models over safety scenarios and determine risk levels
- Validation ongoing at field sites

In-Mine Underground Collision Avoidance Information System; 75D30123C17307, Univ. of Kentucky

- Provide useful collision-avoidance information to a machine operator using a vision-based system for underground equipment by training and modification of an existing system.
  - Collecting training data (video images)
  - Using an SRI International vision-based recognition engine in underground stone operations.

Design and Manufacture of an Outby, Single Module, Electric, Automated, Roof Bolter; 75D30123C17411, J.H. Fletcher

- Develop and construct a working automated roof bolter machine for outby use in underground coal
- Plan to prove prevailing technology will work in a coal mine
- The machine will demonstrate
  - The ability to measure reductions in operator dust exposure
  - The versatility of the drill control algorithm in coal mine roof conditions
  - The reduction in physical effort required to complete the task
  - The reduction of operator hazards
  - The potential productivity, and the limitations of current technology to direct further research
- Machine design almost complete
- Procurement of components underway

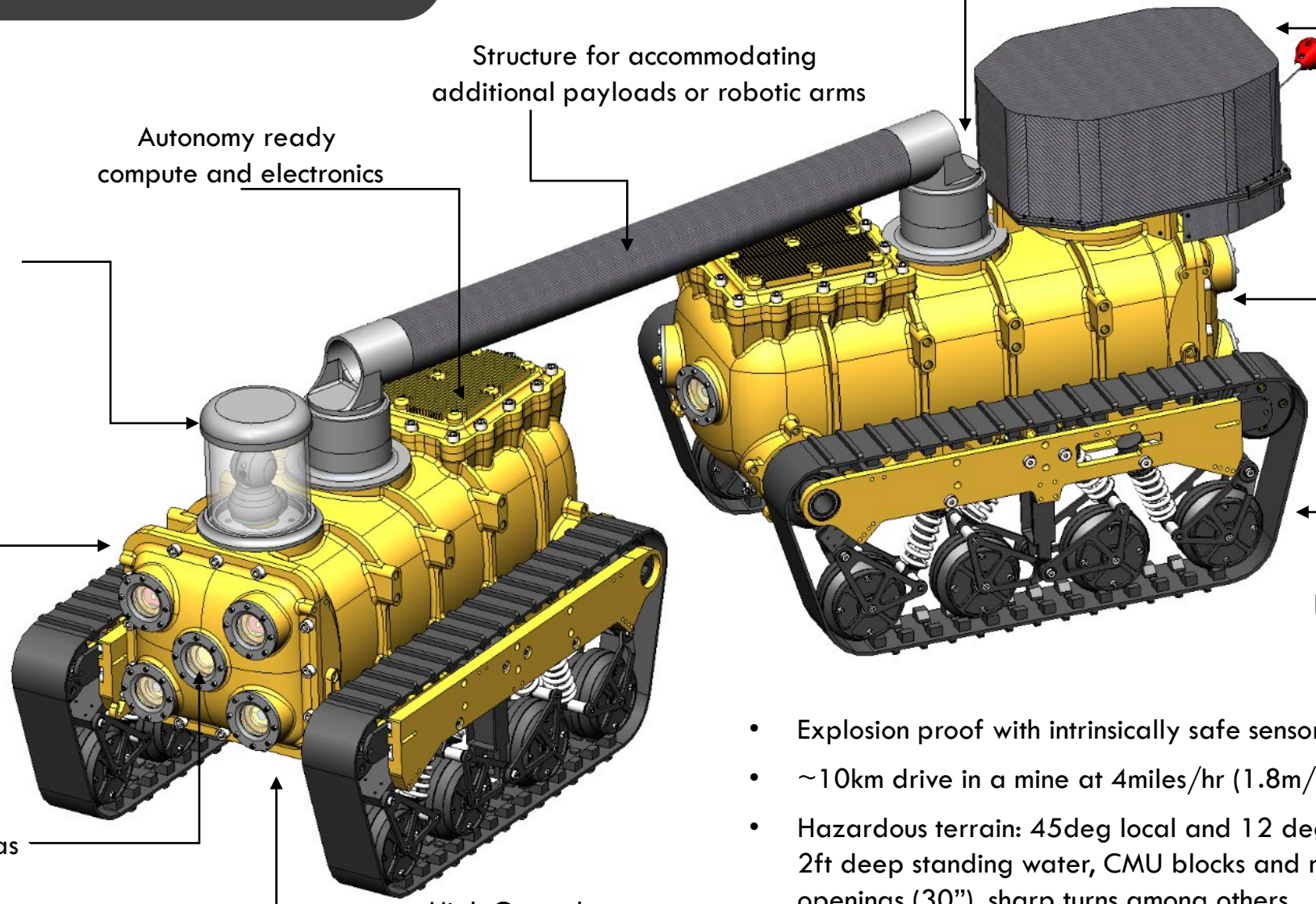


IAA - Advanced Sensors and Robotic Deployment Platform for Increased Safety and Rapid Response within Coal Mines

20FED2000351OHR – National Aeronautics and Space Administration – Jet Propulsion Laboratory (NASA-JPL)

- Develop a robotic deployment platform for improving mine safety and disaster response within coal and other gassy mines.
  - Mobility Subsystem – Track/wheeled system
  - Tether Subsystem - 5 km capacity on the spool.
  - Explosion Proofing – New Tech being evaluated - foams and honeycomb structures
  - Sensors - Develop a fast methane sensor and evaluating existing commercial sensors for use on the robot
  - Avionics and Software – Development underway

Extreme Environment Explosion Proof Robot
Sponsor: NIOSH-CDC



- Explosion proof with intrinsically safe sensors for Zone 0
- ~10km drive in a mine at 4miles/hr (1.8m/s) top speed
- Hazardous terrain: 45deg local and 12 deg global slopes, 6in mud, 2ft deep standing water, CMU blocks and roof falls, stairs, narrow openings (30”), sharp turns among others
- Dark and smokey ambience, -30 to 60C, network denied
- Onboard gas sensors

New Contracts FY2025

- University of Kentucky Research Foundation (with Francis Enterprises) - In-Mine Autonomous Shuttle Car Demonstration
- Innovative Wireless Technologies, Inc. - Wireless Ventilation Monitors for Improved Mine Safety and Efficiency
- Desert Research Institute - A Lithium-Ion Battery Fire Detection and Suppression System for Mining Applications
- Virginia Tech - Evaluating and Modifying a Back Exoskeleton for Use in Underground Mines

NIOSH Mining program awards contracts to advance health & safety in mine automation

Respec 2022

University of Kentucky 2023

JPL 2024

Rohmac 2022

NIOSH Mining Program

OMSHR • PMRD • SMRD

www.cdc.gov/NIOSH/mining

References below pictures refer to images obtained from reports

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