OMSHR

Office of Mine Safety and Health Research

Safety of Automated and Mechanized Equipment

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Cognitive Engineering

- *Cognitive Engineering* refers to the research and development committed to **IMPROVING THE INTERFACE** between people and their jobs, equipment and tools…

  (a.k.a. Human Systems Integration, Human Machine Interface)

- H&S Concern: Current and New Technologies Design
  - Developing quickly
  - Developing as individual components
  - Lacking consideration to integration with other technologies and their environment

- H&S Concern: Physical and Information Overload
  - Too many wearable technologies and not enough space
  - Too much information - overloaded and distracted
  - Not the right information at the right time

IMPROVING SITUATIONAL AWARENESS to IMPROVE HUMAN PERFORMANCE

NIOSH's CE Team

Team members include cognitive psychologists, mechanical and biomedical engineers, electrical engineers and industrial engineers

Research Outcomes

- Help mining companies and government agencies understand what to look for in the design and application and adoption of technologies
- Help manufacturers design more usable products that impart only the necessary and appropriate information at the right time
- Provide design guidelines (MinerFirst) for new technologies and processes

Cognitive Engineering Research

- Assessing Manufacturer Designs and Providing Recommendations
  - Refuge chambers location, deployment, and usability design
  - BIP shelter functional needs analyses
  - Area, warning and feedback lighting for various equipment
  - Testing and designing mining vests and SCSR alternatives
  - Control design principles for mining equipment
  - Fatigue management systems investigation for haul trucks

- Conducting Laboratory Testing
  - Cognitive workload measurement and analyses
  - Assessing information needs to improve situational awareness
  - Comparing cognitive aspects of real world and virtual environment situations for testing and training applications

Research Opportunities

Cognitive Engineering

- Monitoring of multiple remotely controlled loaders and automated surface haulage vehicles
- Hands-off operation of roof bolting machines and non-line-of-sight/tele-operation of continuous mining machines
- Standardization of controls across similar function equipment
- Fatigue Monitoring: Measurement standard needed to ensure/compare all validity of monitoring technologies
- Understanding the balance: skill sets of miners (judgment, flexibility, decision making), complexities of the system, risk levels, disconnection of work and thinking = good fit to ensure skills and ability to “think”

Proximity Detection

- Laboratory and field evaluations of magnetic proximity detection systems for underground coal mining equipment

- Development and testing of the Intelligent Proximity Detection System for continuous mining machines and other mobile underground equipment

Research Opportunities

Proximity Detection

- Survey of proximity detection and collision avoidance system installations throughout the industry
  - Surface, Underground
  - Coal, Metal/Nonmetal, Stone, Sand and Gravel
  - United States, International
- Interlocked proximity technologies for processes where more than one machine and operators connect
- Surface Collision Avoidance Technologies
  - Identification, testing and implementation

Mine Automation

- **Concerns**
  - becoming pervasive
  - taking on more functions impacting safety
  - automation is likely to escalate
  - functional safety issues
- **Functional safety issues with automation**
  - Unexpected machine movements
    - Longwall shield “ghosting”
  - Increased complexity impacts safety
    - Software: 4 branches, 2 loops, 8 states = 8000 paths
    - 2 “bugs” created for every ”bug” fixed
  - Mining has not formalized functional safety assessment & evaluation as done by other industries

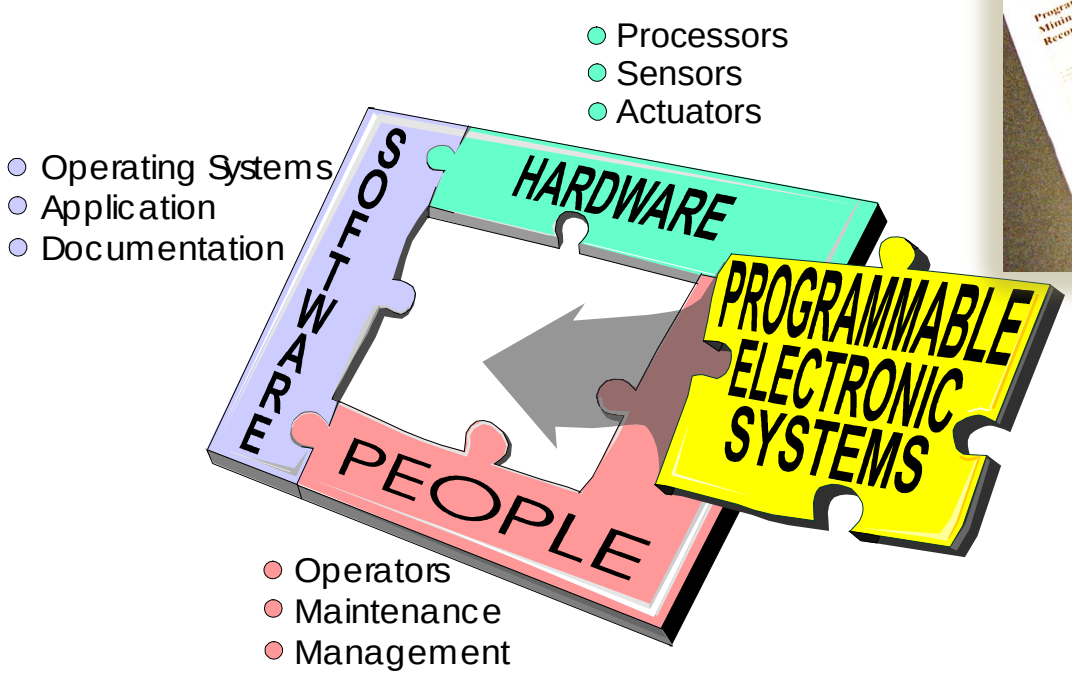
Functional Safety

Functional safety: equipment operating correctly in response to inputs and the safe management of likely operator errors, hardware and software failures and environmental changes.

Objective: freedom from unacceptable risk of injury to people either directly or indirectly

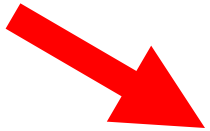
NIOSH nine-part best practice recommendations functional safety of programmable electronic systems

- NIOSH research ended 2004
- System safety approach
- Quantify safety integrity



Health and Safety Executive Study of Industrial Automation Accidents

Requirements errors: most frequent contributing factor



Research Opportunities

Functional Safety Standards

- Formalize functional safety assessment & evaluation for mining as done by other industries
  - Railway Industry (EN 50128 for software/EN 50128 for signaling)
  - Process Industry (IEC 61511)
  - Automotive (MISRA, ISO 26262 and several others)
  - Nuclear Power Plants (IEC 61513)
- Develop a complexity assessment methodology and tool for assessing system requirements
  - NIOSH developed a approach for assessing system requirements complexity (Ph.D. Dissertation 2002)

Research Opportunities

Summary

- ❑ Monitoring fleets of remotely controlled or automated fleets
- ❑ Hands-free/tele-operated Roof Bolters/CMM
- ❑ Standardization of controls across similar function equipment
- ❑ Fatigue Monitoring systems standard
- ❑ Operator engagement/Decision making balance
- ❑ Surface mining proximity detection
- ❑ Functional safety assessment and evaluation
- ❑ Develop complexity assessment tool