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Heavy Equipment Autonomy

Automation and Emerging Technologies Team

NIOSH Mining Program

Definitions and Context

Assured Autonomy – The ability of autonomous equipment to operate safely in the presence of humans.

System Safety – The evaluation of system level risk exposures and mitigation strategies.

Mining Environment – Bounded, relatively static environment where all players are readily identified and understood.

Barriers to Implementation

- Unmaterialized productivity gains
- Sensitivity to liability
- Cost and complexity
- Lack of comprehensive guidance
- Fear of change (management and personnel)

Drivers to Implementation

- Ultimate Productivity
- Liability reduction
- Availability of Personnel
- More hazardous activity
- Reduced safety and health exposure

Classic Approach

- Non-integrated systems / equipment

  Equipment and systems from multiple vendors with proprietary technologies not shared across platforms.

- “Control” based safety

  One primary controller with an attempt to integrate safety intervention with little redundance.

- Functional safety evaluation

  Subjective evaluation of components and sub-systems with subjective judgement.

- Reliance on Machine Learning / Artificial Intelligence

  Limited use test and anomalous, indeterminant decision making.

ISO 17757

Earth-moving machinery and mining — Autonomous and semi-autonomous machine system safety -

- Transition from manual to semi-autonomous (remote operation, etc.) requires situational awareness to transfer from human operators to machines.
- Command structure is clear; safety structure is not.
- Implication and logical conclusion is that safety control should be a parallel system with primary function of intervention.
- Ultimately, there will be an ISO extension that lays out a framework and validation scheme.

Precursor Work

Conveyor Safety Project

Recognition that there was only so much that humans could do to improve safety around potentially hazardous equipment. The equipment itself would need to play a more active role (in contrast to passive) in preventing hazardous conditions.

AASIST Project (Assured Autonomy Safety Intervention System Technology)

Development of an approach to autonomy that was validatable, predictable, repeatable, flexible, and applicable to virtually all autonomous and highly automated equipment (stationary, mobile, and hybrid).

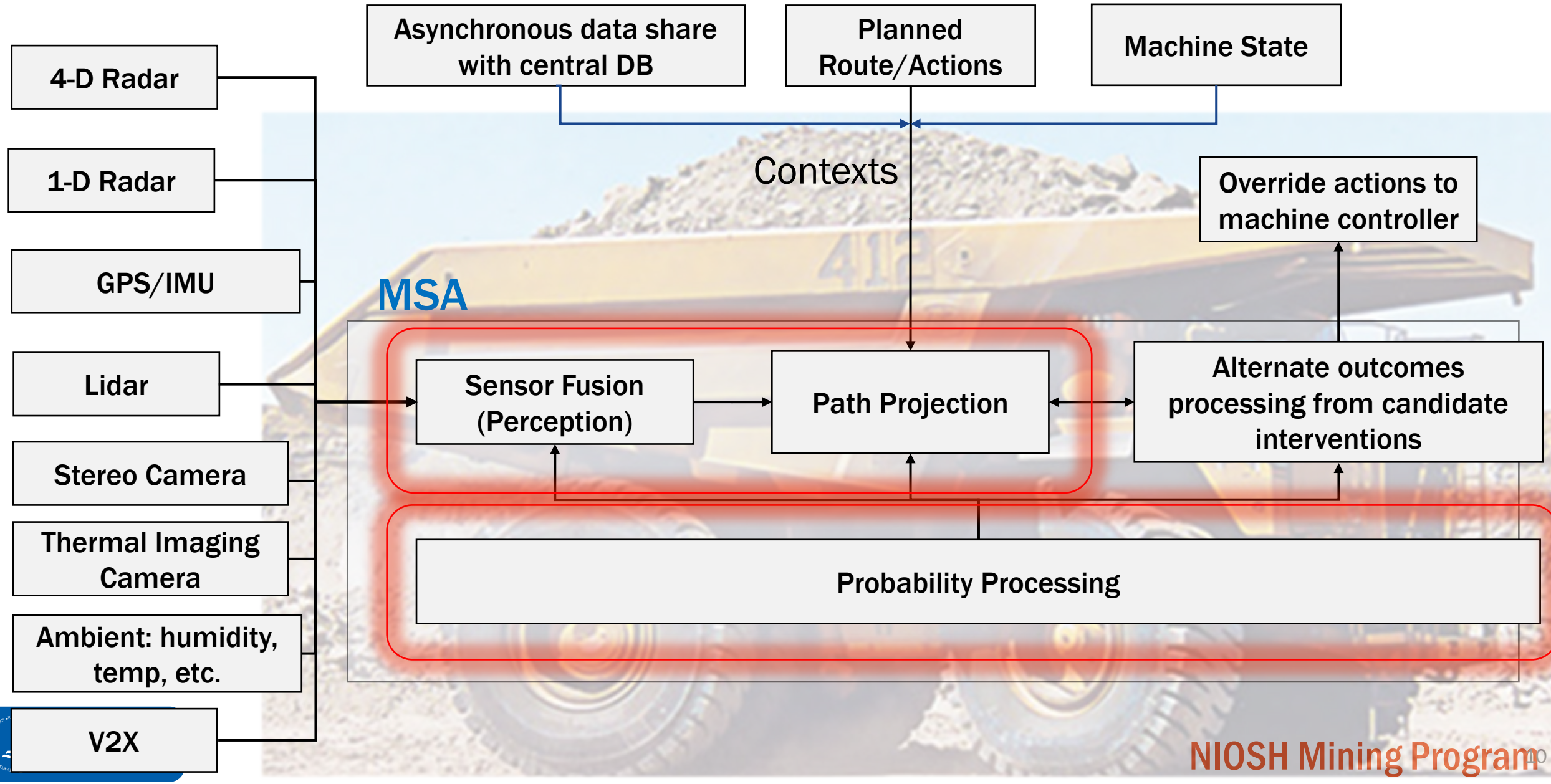
Machine Situational Awareness (MSA)

The ability of a machine to understand it's environment, identify existing and developing hazards, and recommend actions that minimize the risk/cost associated with that hazard.

NIOSH SMRD Mine Safety Approach

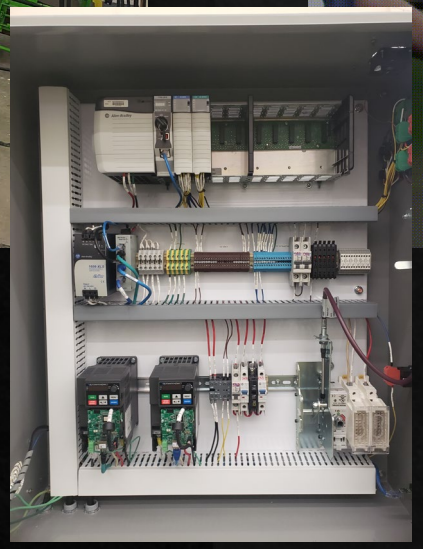
- Develop a framework that is validatable, determinant, accountable, flexible and universal.
- Use parallel system that is specific to safety intervention.
- Conduct test implementation in mining
- Release guidance for standards and regulatory agencies

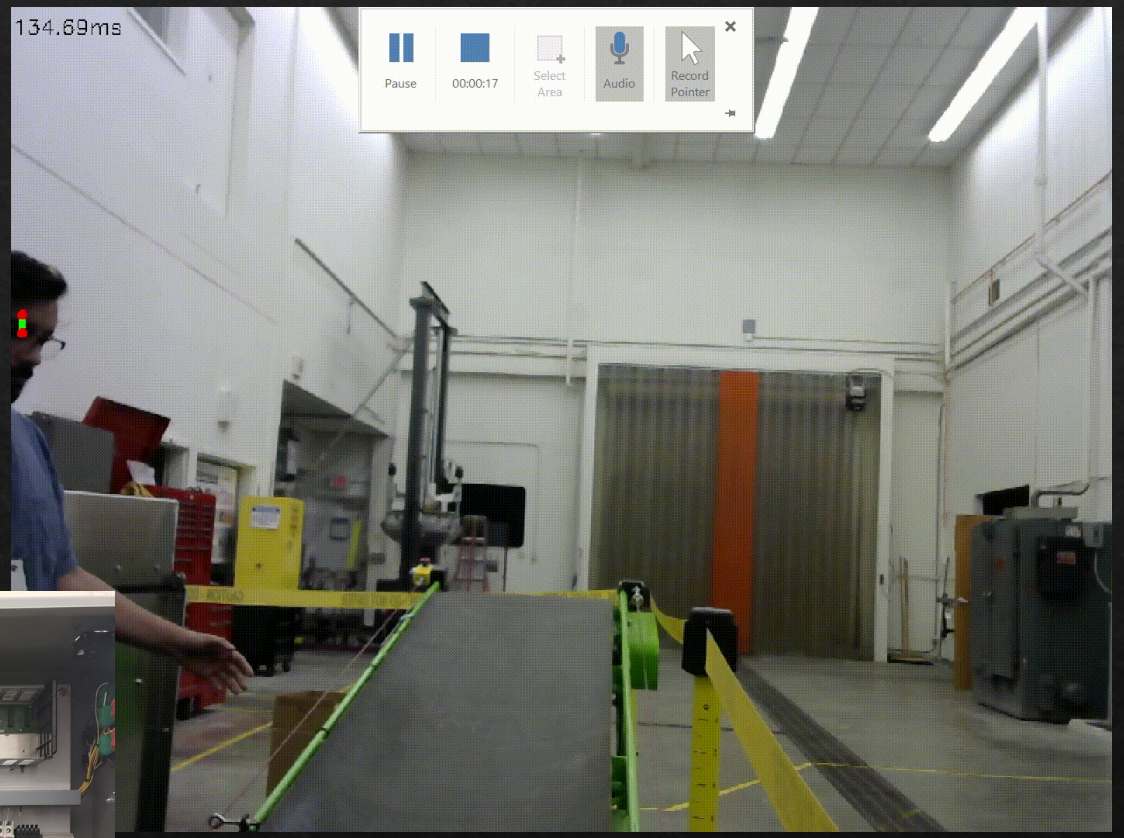
Assured Autonomy Safety Intervention System (AASIS)



Preliminary Test Facilities

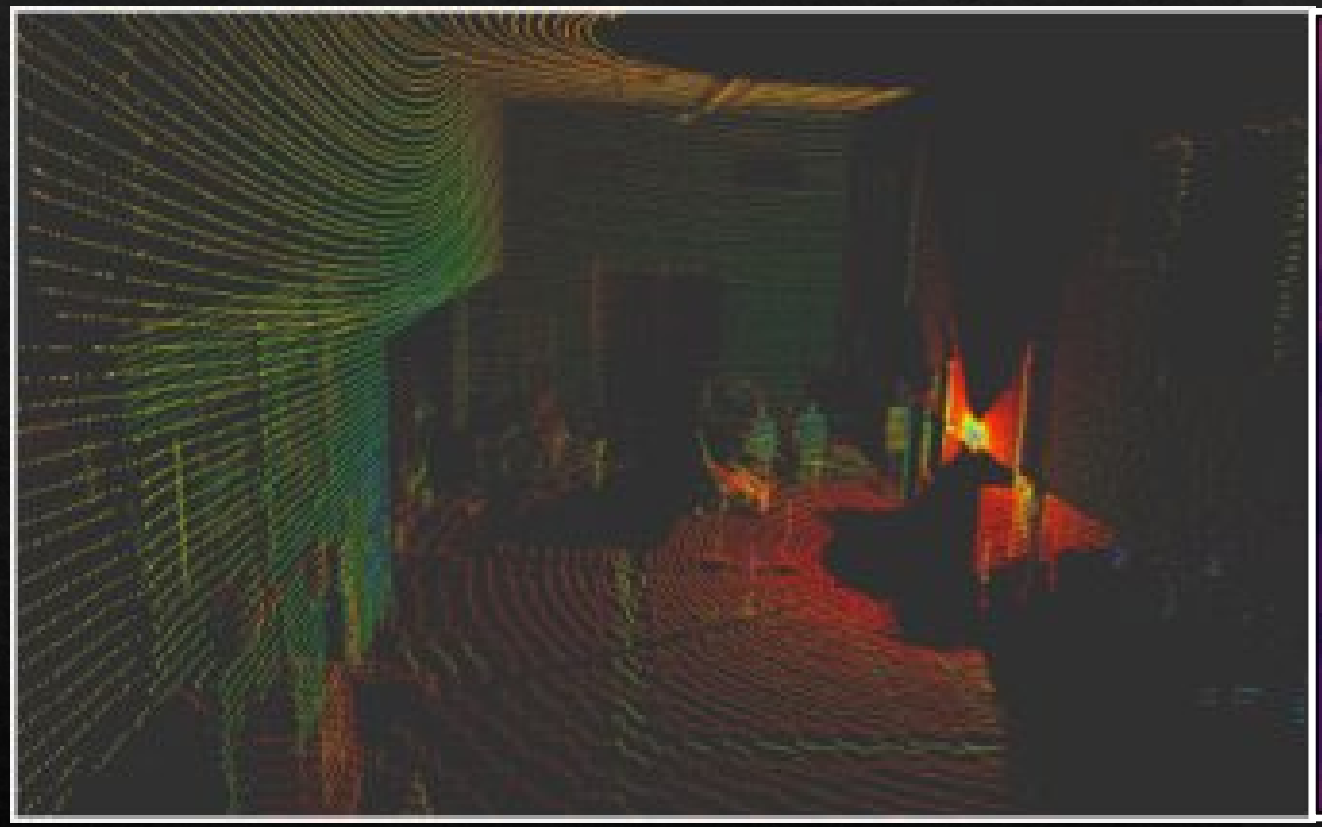
Machine Safety Lab





Skeletal Tracking System

Preliminary Testing



LIDAR

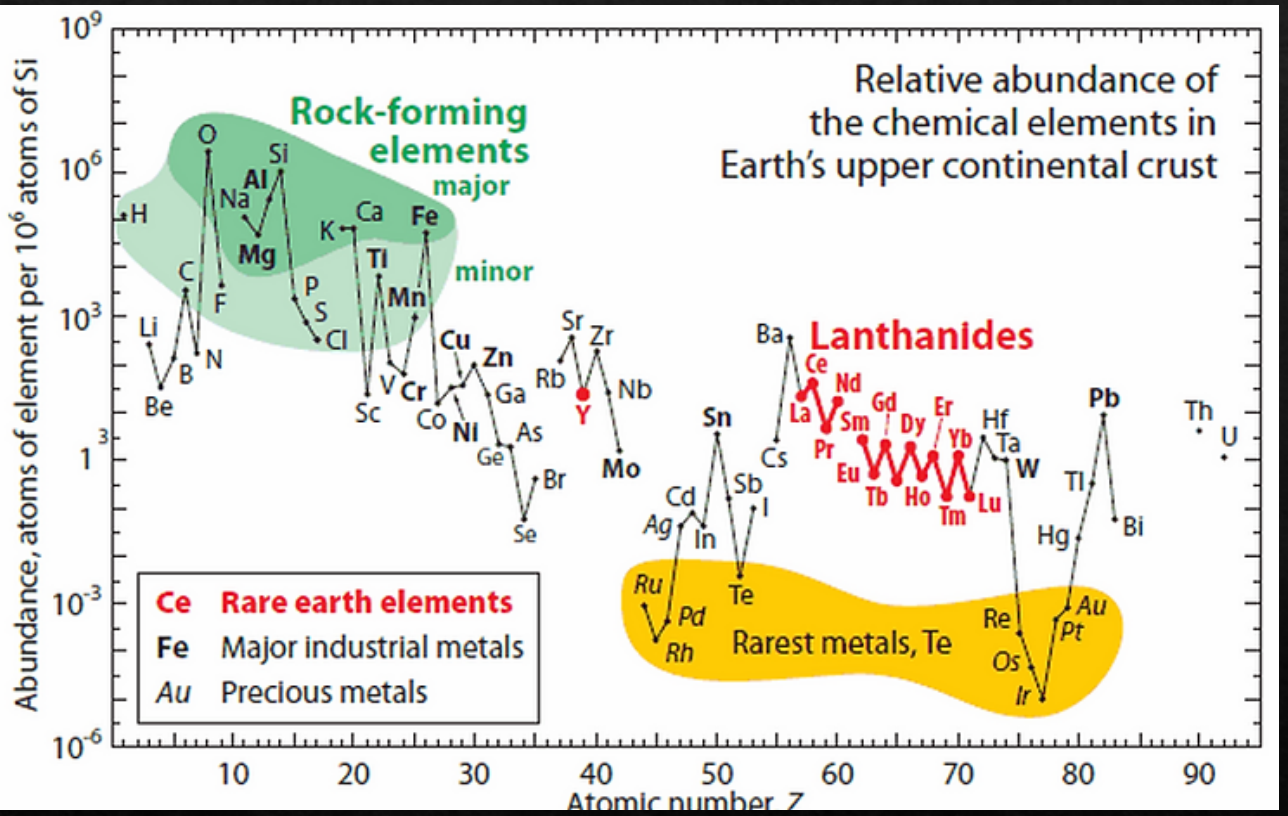
Thermal Camera

State of the Industry

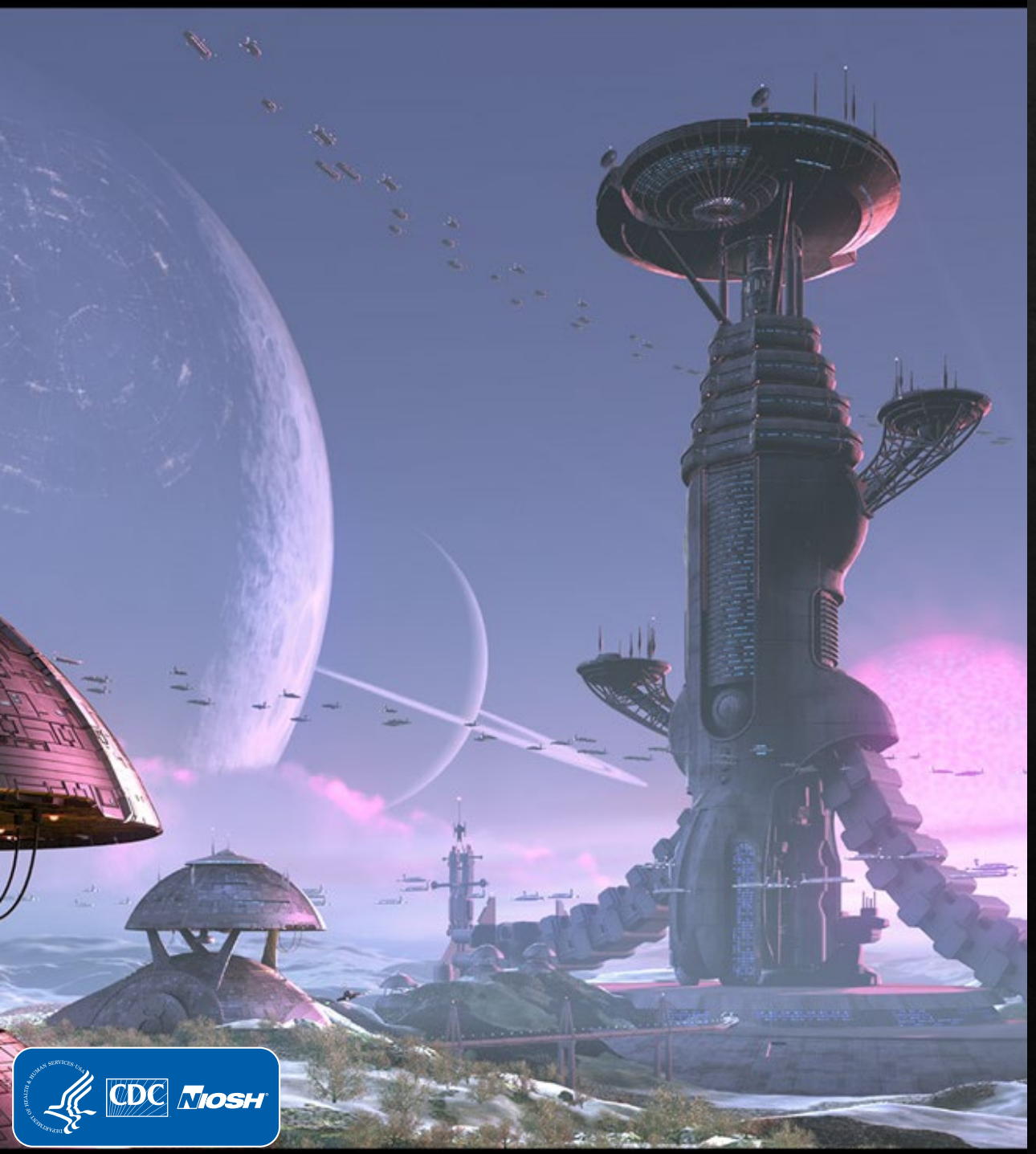
Our timing is right

1) Attempts at full autonomy have been fraught with setbacks (not just mining). Most use classic predetermined risk analysis.
2) Our approach is novel and deterministic. There is an instinctual aversion to Artificial Intelligence and Machine Learning where critical systems and liability are concerned.
3) Every factor is pointing to the need to get Assured Autonomy implemented successfully.
    a) Geo-politics
    b) Push for de-carbonization
    c) Population collapse (specifically working aged people)
    d) Ever increasing sensitivity to safety
4) Industry players (Operators, OEMs, etc.) are looking for a solution.

Simple Facts:



- Mining in US will become critical to environmental and economic preservation.
- Geopolitics are becoming complicated, and not improving soon.
- We will have to go deeper and extract from technically difficult deposits to maintain supply.
- We can't wait for BNI (Burden, Need and Impact) to address challenges and opportunities.



Resulting Future Realities:

- Fiscal reality will force the mining industry to take full advantage of automaton and autonomy.
- New mining environments would be exceptionally dangerous for traditional mining and miners.
- For the foreseeable future, autonomous equipment will need to be repaired and maintained by humans.

Questions?

Presented by – Bob Bissonette
Automation and Emerging Technology Team Lead

Contact us @ qnq8@cdc.gov if you have questions, concerns or critique.

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