Utilizing a human centered design approach for mine automation

Planned pilot project

https://www.cortexia.com.au/the-pitfalls-of-automation/

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Automation Partnership Meeting
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NIOSH Mining Program

Defining Human Centered (centred) Design

"Human-centred design is an approach

to interactive systems development

that aims to make systems usable and useful

by focusing on the users, their needs and requirements, and

by applying human factors/ergonomics, and

usability knowledge and techniques."

ISO 9241-210:2019: Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems

Planned research objective

- To identify, understand, and document human factors considerations and expectations when designing, deploying, and implementing automation along its continuum as part of a human system integrated approach to improve mineworker's health and safety.

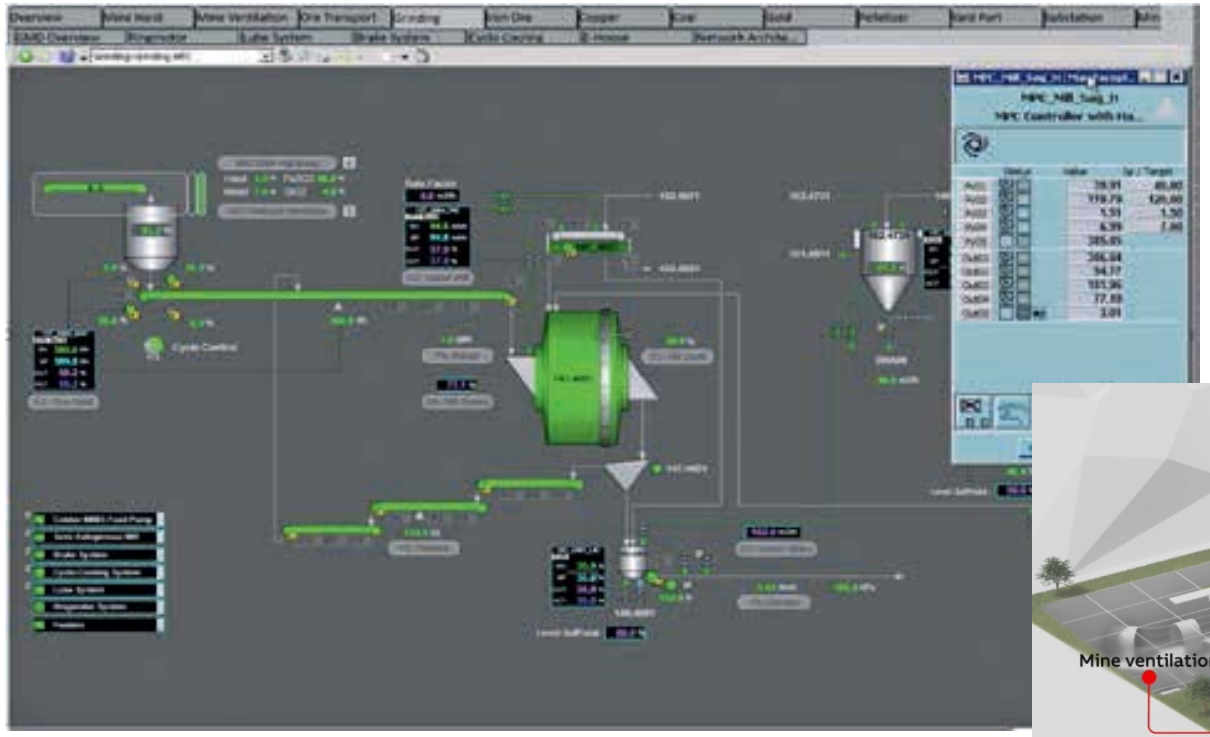
Automation at mines is increasing

Mobile haulage currently gets all the attention

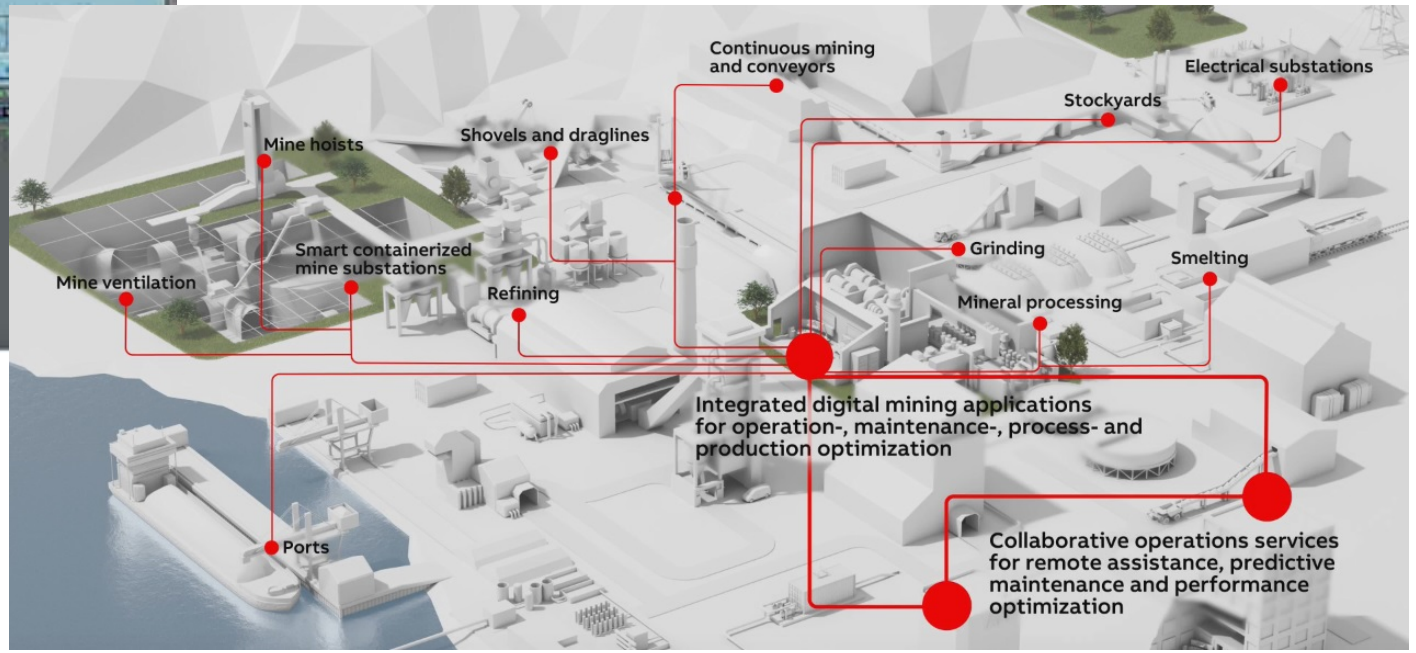
https://www.youtube.com/watch?v=F_Re68mLf9Q

https://www.heavyequipmentguide.ca/article/32255/first-volvo-ce-autonomous-hauler-to-be-piloted-by-harsco-environmental

Process automation is already imbedded in mining



https://new.abb.com/control-systems/industry-specific-solutions/mining/apc-grinding-flotation



https://new.abb.com/control-systems/industry-specific-solutions/mining

Do you see a problem thus far?

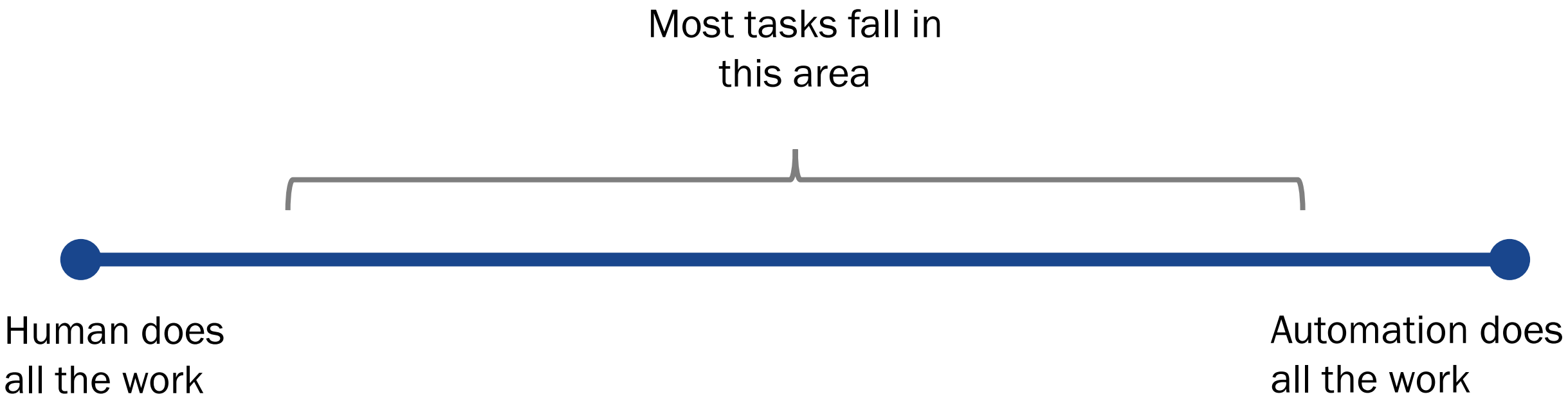
The focus is on the technology not the human

https://pixy.org/5777184/

Until we can design truly independent systems humans will be involved and need to interact with the system

https://www.cortexia.com.au/the-pitfalls-of-automation/

The continuum of automation

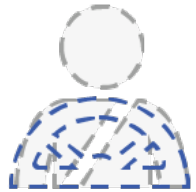


Humans interacting at different levels with the automated system

Example of levels of automation for self driving cars





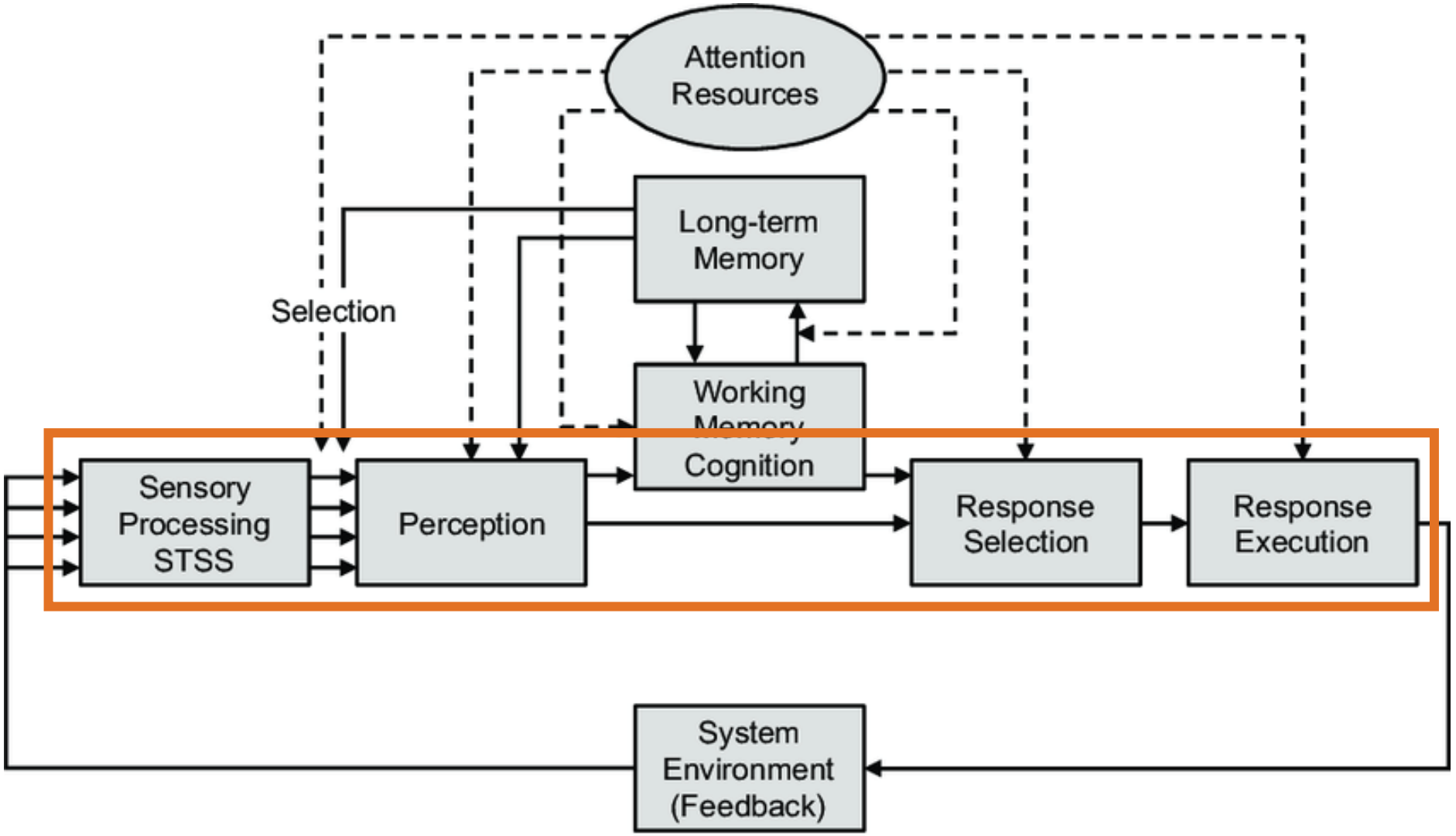



0	1	2	3	4	5
No Automation	**Driver Assistance**	**Partial Automation**	**Conditional Automation**	**High Automation**	**Full Automation**
Zero autonomy; the driver performs all driving tasks.	Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design.	Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times.	Driver is a necessity, but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice.	The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.	The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.

https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety

The focus is still on the technology

Human information processing model



Adapted from Wickens, C. D., & Flach, J. M. (1988). Information processing. *Human factors in aviation*, 111-155.

Simple human information processing model

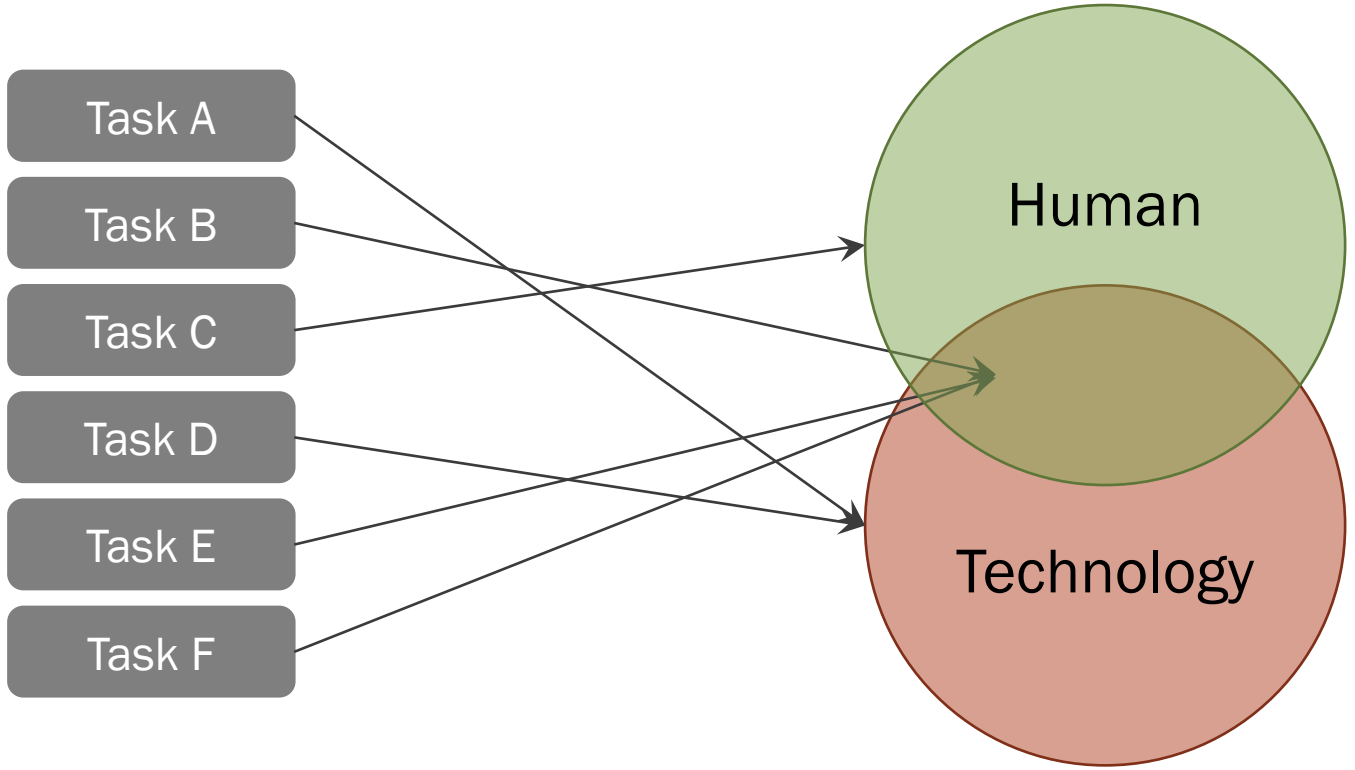
Levels of automation in the human context (based on decision making and response selection and execution)

1. Manual	The human performs all the required tasks.
2. Action Support	System assists the operator with performance of the selected action (eg tele-operation).
3. Batch Processing	Human generates and selects options to be performed, which are turned over to the system to be carried out automatically.
4. Shared Control	Both human and system generate possible decision options, human selects which option to implement, carrying out actions is shared.
5. Decision Support	The system automatically generates a list of decision options, human selects from list or generates own, then turned over to system to implement.
6. Blended Decision Making	The system automatically generates a list of decision options, which it selects from and carries out if human consents.
7. Rigid System	The system presents a limited set of actions to the human, human must select from list, the system will then implement the actions.
8. Automated Decision Making	The system selects the best option (from a system and human generated list) and implements it.
9. Supervisory Control	The system generates options, selects and implements the option, human monitors and intervenes if required, who can select a different option.
10. Full Automation	The system carries out all actions, human completely out of control loop and cannot intervene.

Kaber, D. B., & Endsley, M. R. (2004). The effects of level of automation and adaptive automation on human performance, situation awareness and workload in a dynamic control task. *Theoretical Issues in Ergonomics Science*, *5*(2), 113-153.

Function allocation or task allocation

- Deciding whether a particular function or task is accomplished by the human, the technology or some combination of the two.



What tasks are the humans responsible for?

- Installation and testing
- ~~Doing the work~~ → Overseeing the automation
- Maintenance & Repair
- Dealing with unusual circumstances
- Decommissioning / dismantling

Overseeing the automation

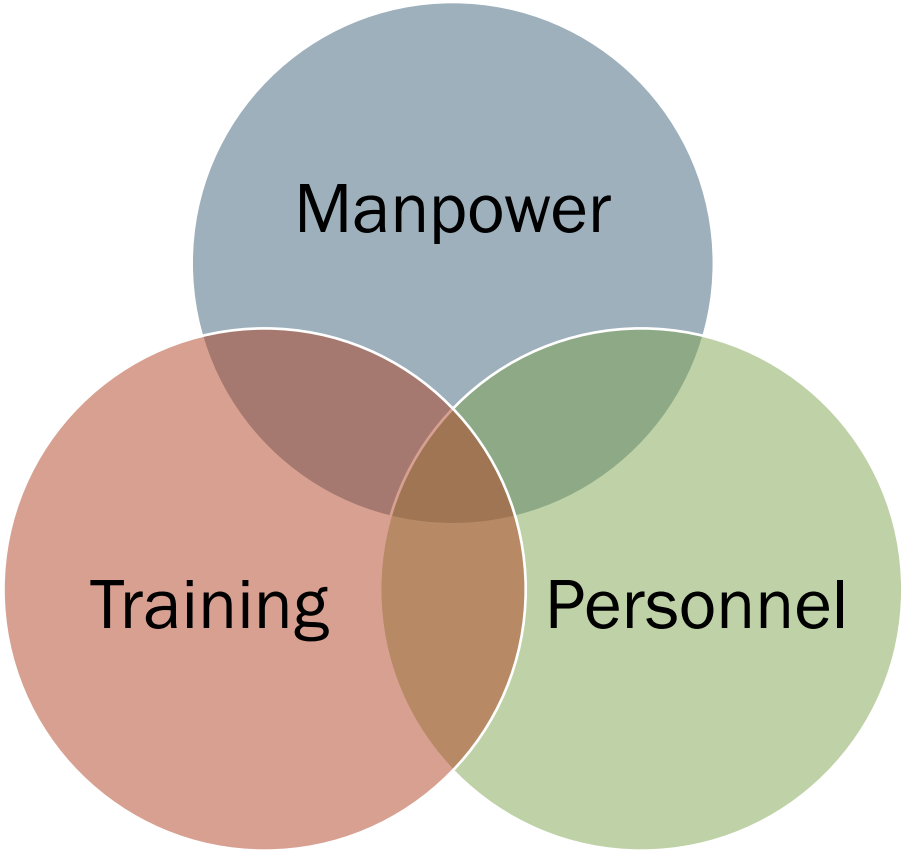
- Workload
- Situation awareness
- Trust and complacently
- Skill degradation

https://www.igfmining.org/technological-innovation-impacting-mining-sector/

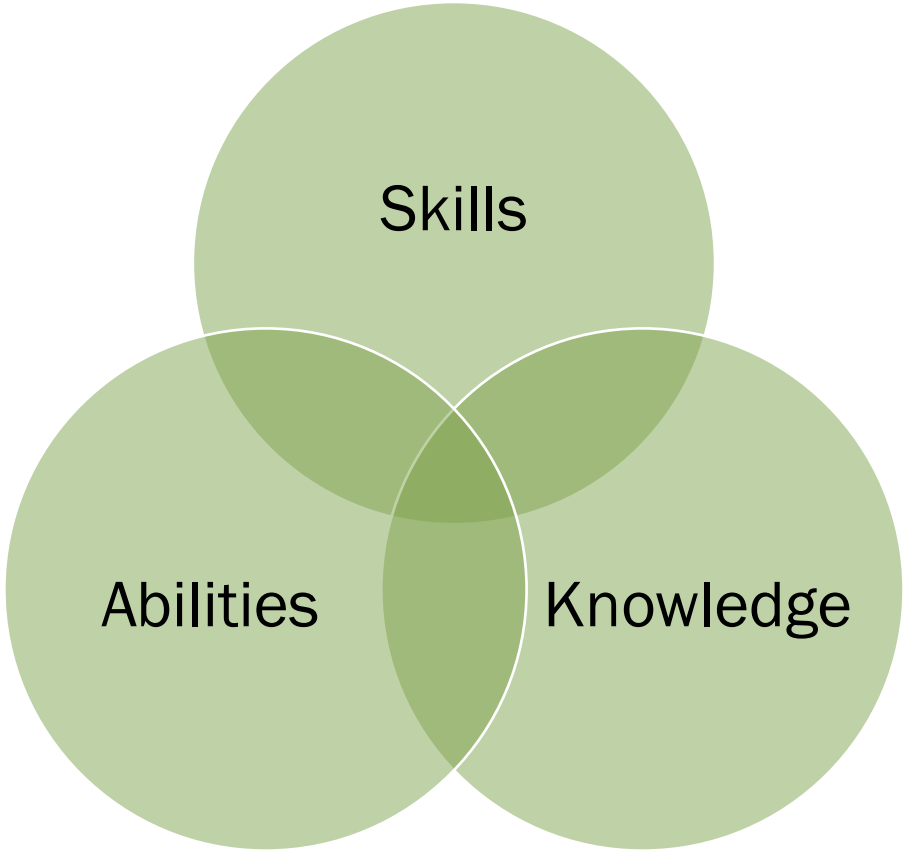
Parasuraman, R., Sheridan, T. B., & Wickens, C. D. (2000). A model for types and levels of human interaction with automation. *IEEE Transactions on systems, man, and cybernetics-Part A: Systems and Humans*, *30*(3), 286-297.

Changes to accommodate for the automation

At the mine



For the individual



The need for appropriate change management

Maintenance & repair

- Maintenance & repair work is hazardous
- Design systems with maintenance in mind

https://www.globalminingreview.com/mining/19062019/what-happens-leading-up-to-and-during-a-planned-shutdown/

Pollard, J., Heberger, J., & Dempsey, P. G. (2014). Maintenance and repair injuries in US mining. Journal of quality in maintenance engineering.

Reardon, L. M., Heberger, J. R., & Dempsey, P. G. (2014). Analysis of fatalities during maintenance and repair operations in the US mining sector. IIE transactions on occupational ergonomics and human factors, 2(1), 27-38.

Unanticipated events and unusual circumstances

- Significant safety concerns if humans are involved

https://www.martin-eng.com/content/industry/450/mining-industry

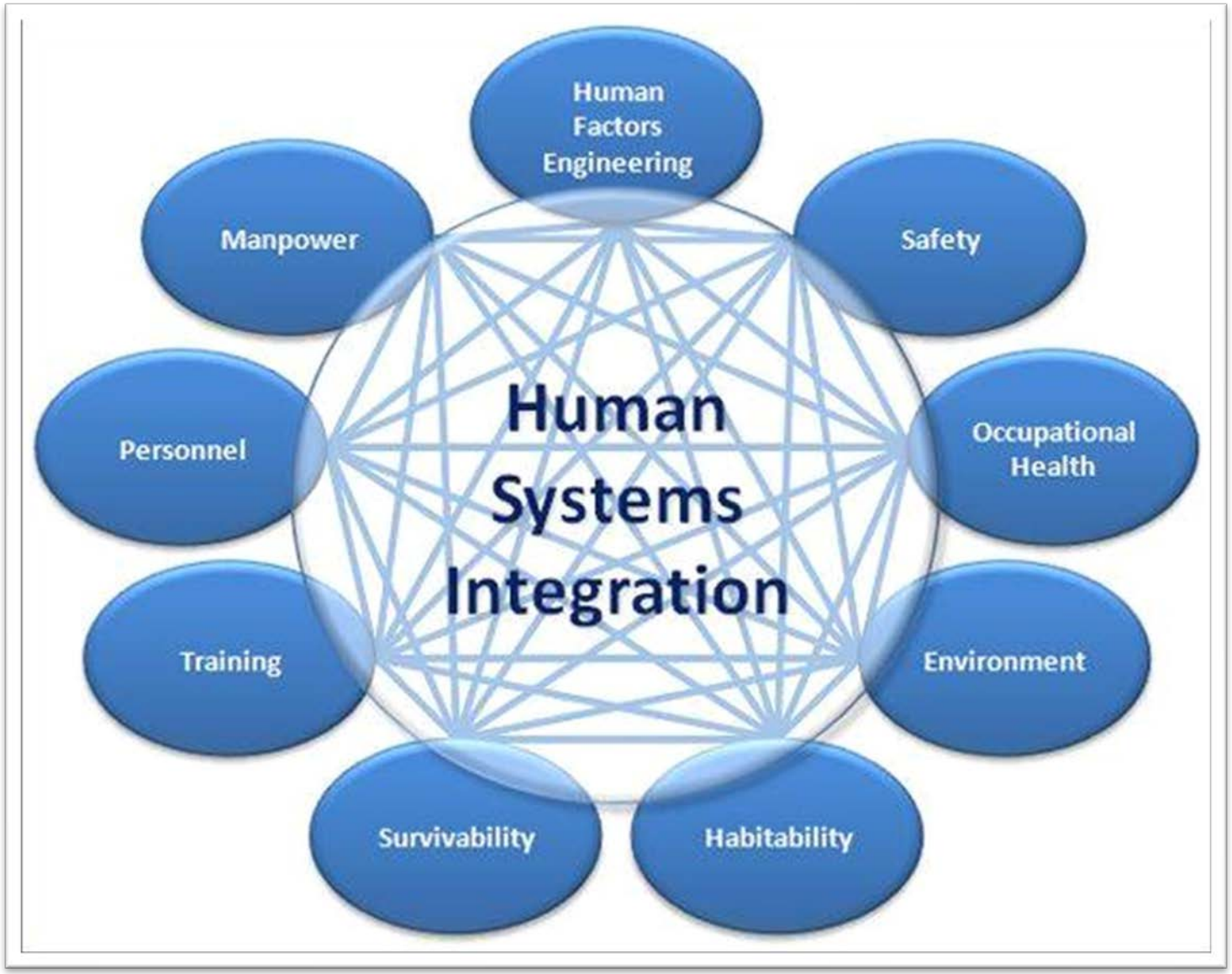
https://www.amsj.com.au/haul-truck-runs-over-light-vehicle/

The need for a systems approach

As systems grow, they get more complex

https://www.business.uzh.ch/en/research/professorships/networkscience/teaching/Guest-Lectures/phdcsmgmt.html

Human Systems Integration (HSI)



https://railroads.dot.gov/human-factors/elearning-attention/human-systems-integration

Planned research objective

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Specific Aims and Research Questions

- SA 1: Summarize literature and develop a taxonomy of challenges faced by humans when implementing automation with specific relevance/application to mining.
  - RQ 1: What human centered challenges should be considered when designing and implementing automation delineated along the continuum of automation?

- SA 2: Develop a framework for identifying known and potential health and safety issues at each level of automation with specific relevance/application to mining.
  - RQ 2: What health and safety issues and workforce considerations should be considered when designing a work system which includes automation?

Thank you!

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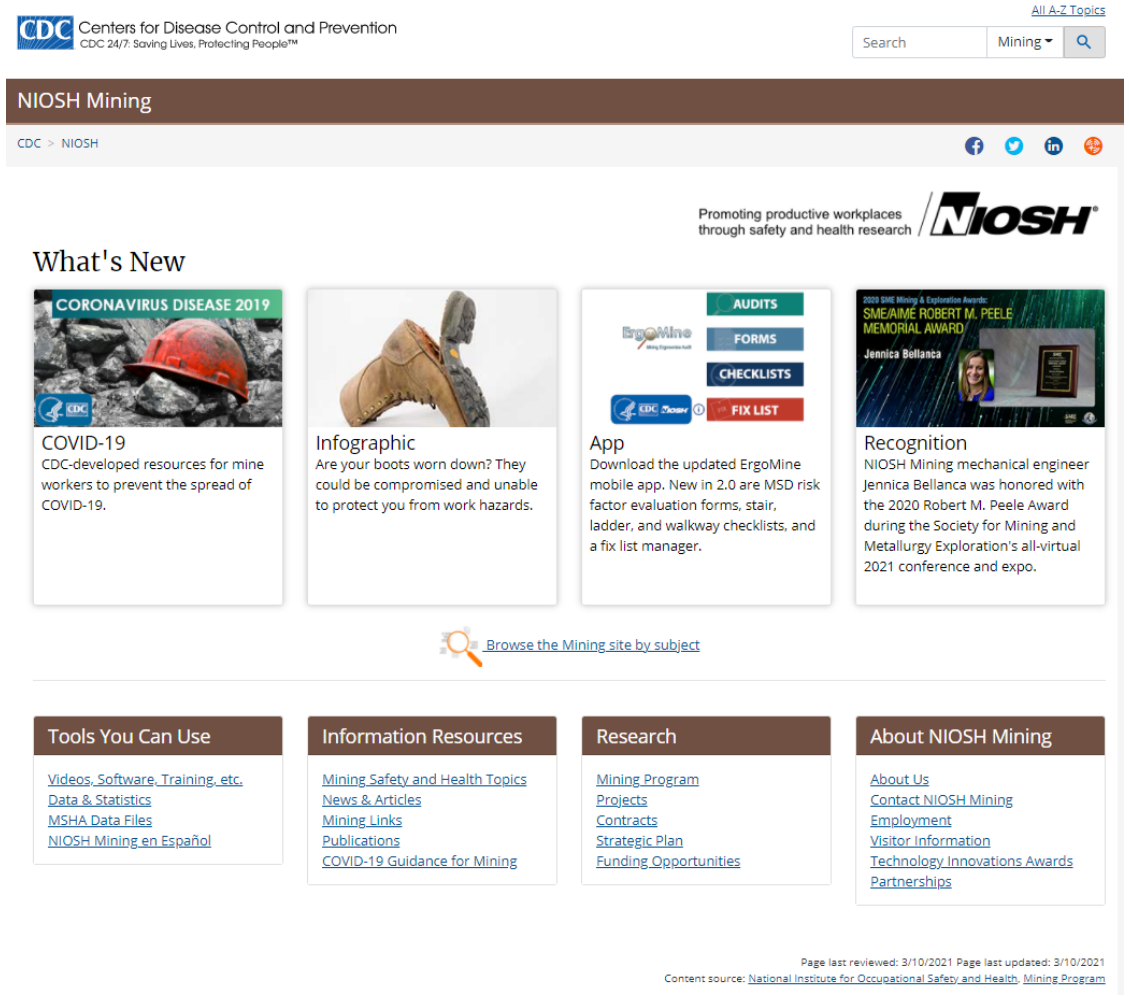

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www.cdc.gov/niosh/mining