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NIOSH Mine Automation and Emerging Technologies Health and Safety Partnership: International update

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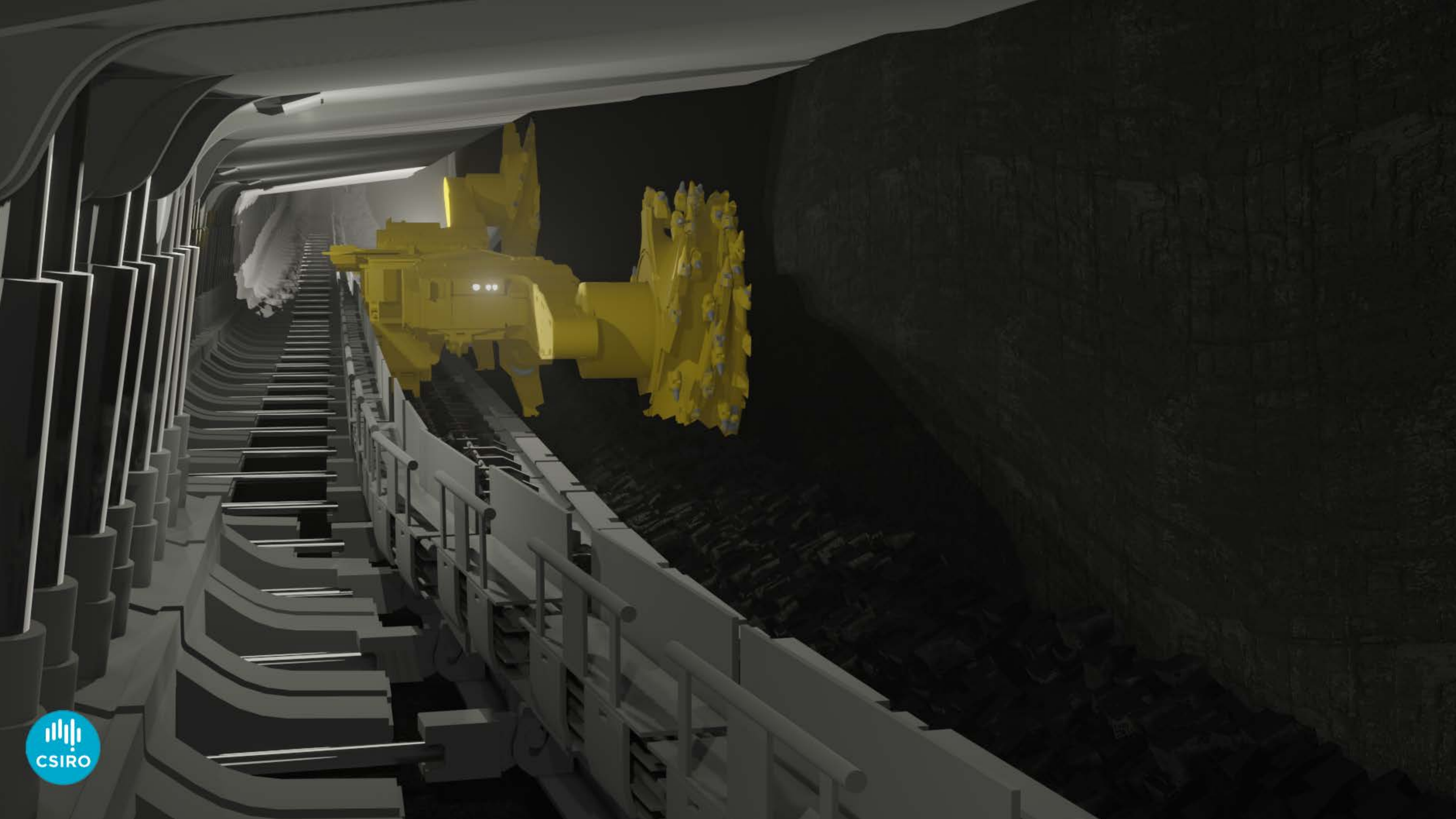

CSIRO

Where is it happening?

A review of public announcements to June 2020 yielded 173 examples of previous, current or planned installations of automated mining equipment fleets at mine sites.

Of these, 42% of the fleet installations are located in Australia, 19% in Canada, and 10% in the USA.
33% of the fleets are underground hard rock LHD, 30% are surface haul trucks, and 17% are drill rigs.

Surface haul trucks largest sector by number of vehicles (>500). 75% in Western Australia.
Installations in **Australia** include:

Rio Tinto (Brockman 4, Hope downs 4, Nammuldi, Robe river, West Angelas, Yandicoogina); *Fortescue* (Chichester, Cloudbreak, Solomon); *BHP* (Jimblebar, South flank); *Roy Hill*.
New installations underway at *BHP* (Eastern ridge, Newman East); *Rio Tinto* (Koodaideri, Mesa 4); *Roy Hill; Newmont* (Boddington); *BMA Coal* (Daunia, Goonyella Riverside); *Whitehaven Coal* (Maules Creek).

Others in **Brazil** (*Vale* Brucutu, Carajas); **Canada** (*Imperial oil* Albian sands; *Teck* Elkview, Highland valley; *Suncor* Fort hills, North Steepbank; *CNRL* Horizon, Muskeg river); **Chile** (*Codelco* Gabriela Mistral; *Teck* Quebrada Blanca Phase 2); **Russia** (*SUEK* Khakassia, Chernogorsky); **Ukraine** (FerrexpoYeristovo); **USA** (*Barrick* Arturo).

More automation is coming - and it is good for safety & health!

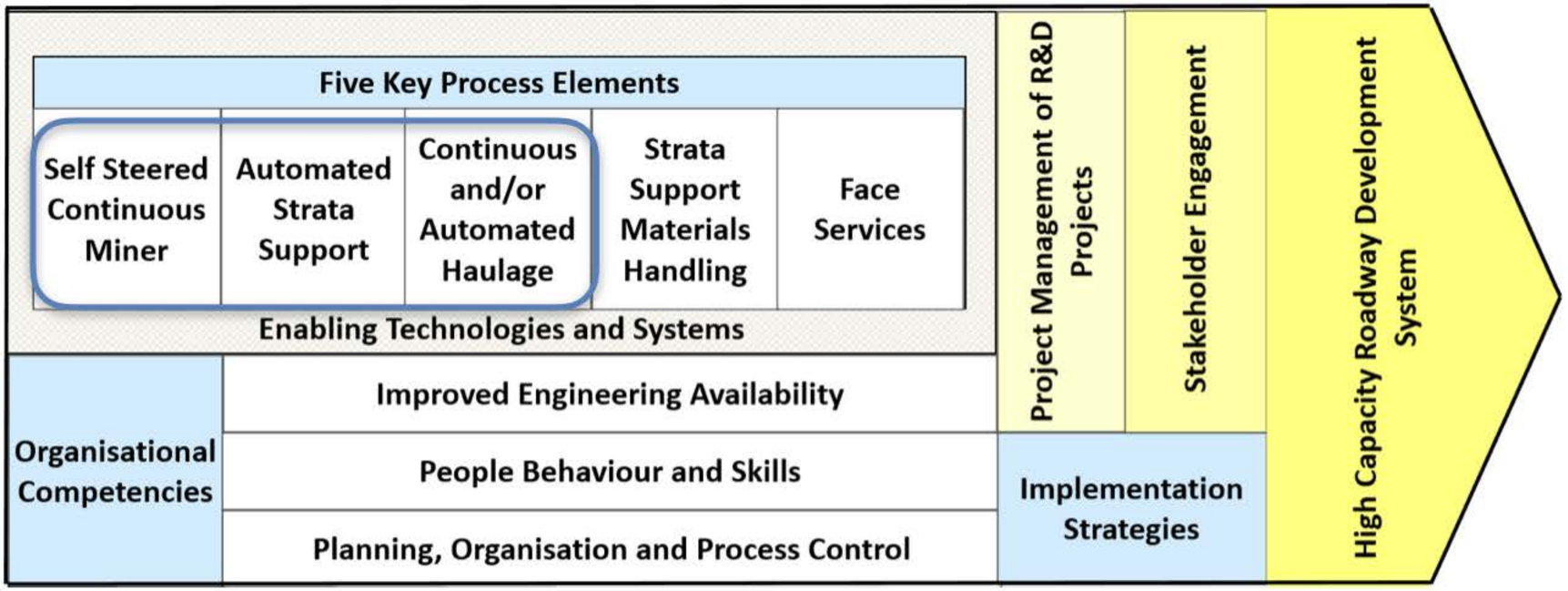
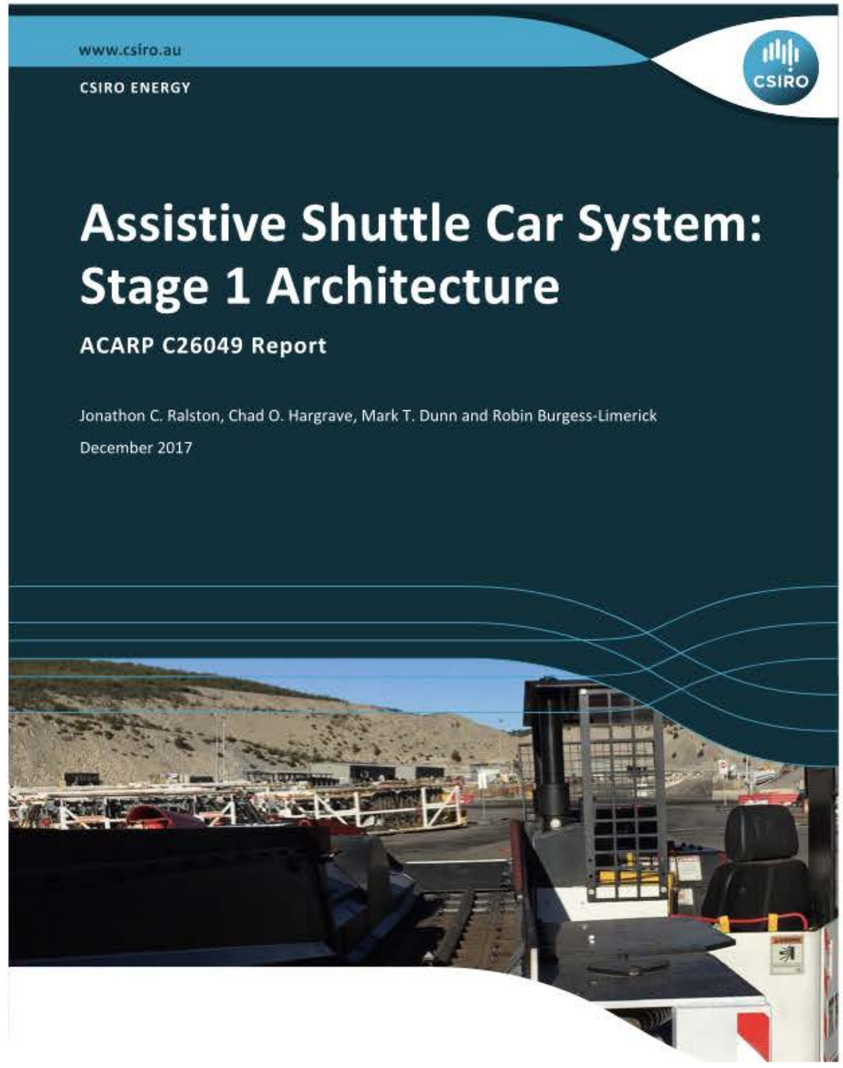
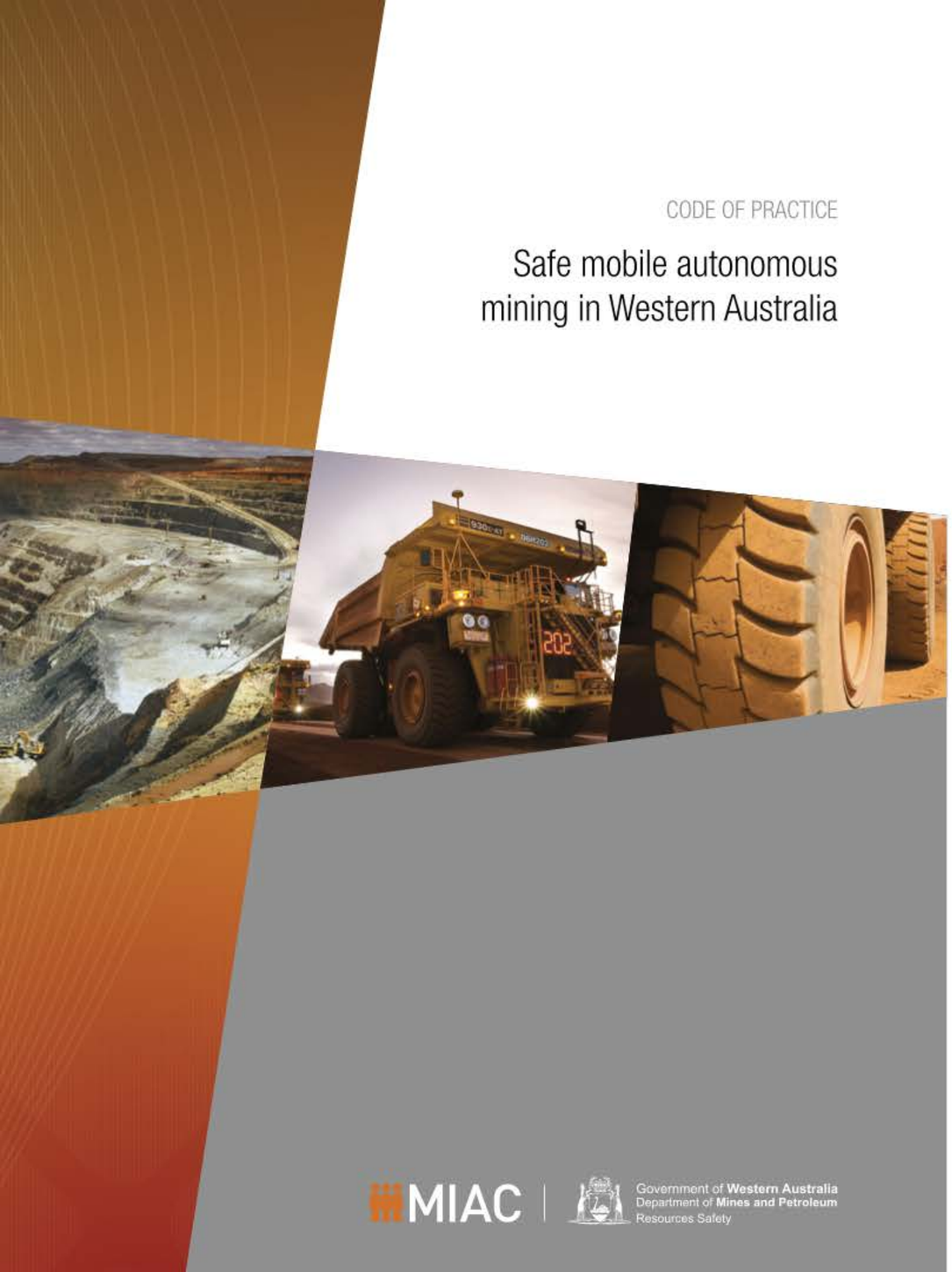


Figure 1: Current RDTG priorities for underground roadway development. Automated haulage (centre box) is one of the five key process elements identified as a priority (Reference Credit: G. Gibson [1])





Automation removes people from hazardous situations, however

"The addition of autonomous mobile equipment can introduce hazardous situations not normally encountered on a conventional manned mining operation. It is important that these safety challenges are addressed early in the planning cycle to maximise opportunities for solutions high in the hierarchy of control (i.e. elimination, substitution, engineering)."

Western Australian Code of Practice 2015

2.4 Risk identification

The use of autonomous technology in an operating mine environment will change established safety systems. It is important to identify these changes and the associated risks.

Hazard identification systems that can be implemented to ensure mobile autonomous mining risks are identified include:

- a hazard and operability study (HAZOP)
- layers of protection analysis (LOPA)
- functional safety analysis
- change management
- employee hazard identification and reporting procedures
- workplace inspections
- monitoring the working environment
- incident investigations (e.g. ICAM, Taproot)
- monitoring OEM and service company bulletins, recommendations and specifications
- regulator safety alerts.

2.5 Risk analysis

At the risk analysis stage, the nature of the risk is assessed and the risk level is determined. Factors to consider include:

- likelihood of an incident
- potential severity of any injury or damage.

It is important that those undertaking a risk assessment have the necessary information, training, knowledge and experience of the:

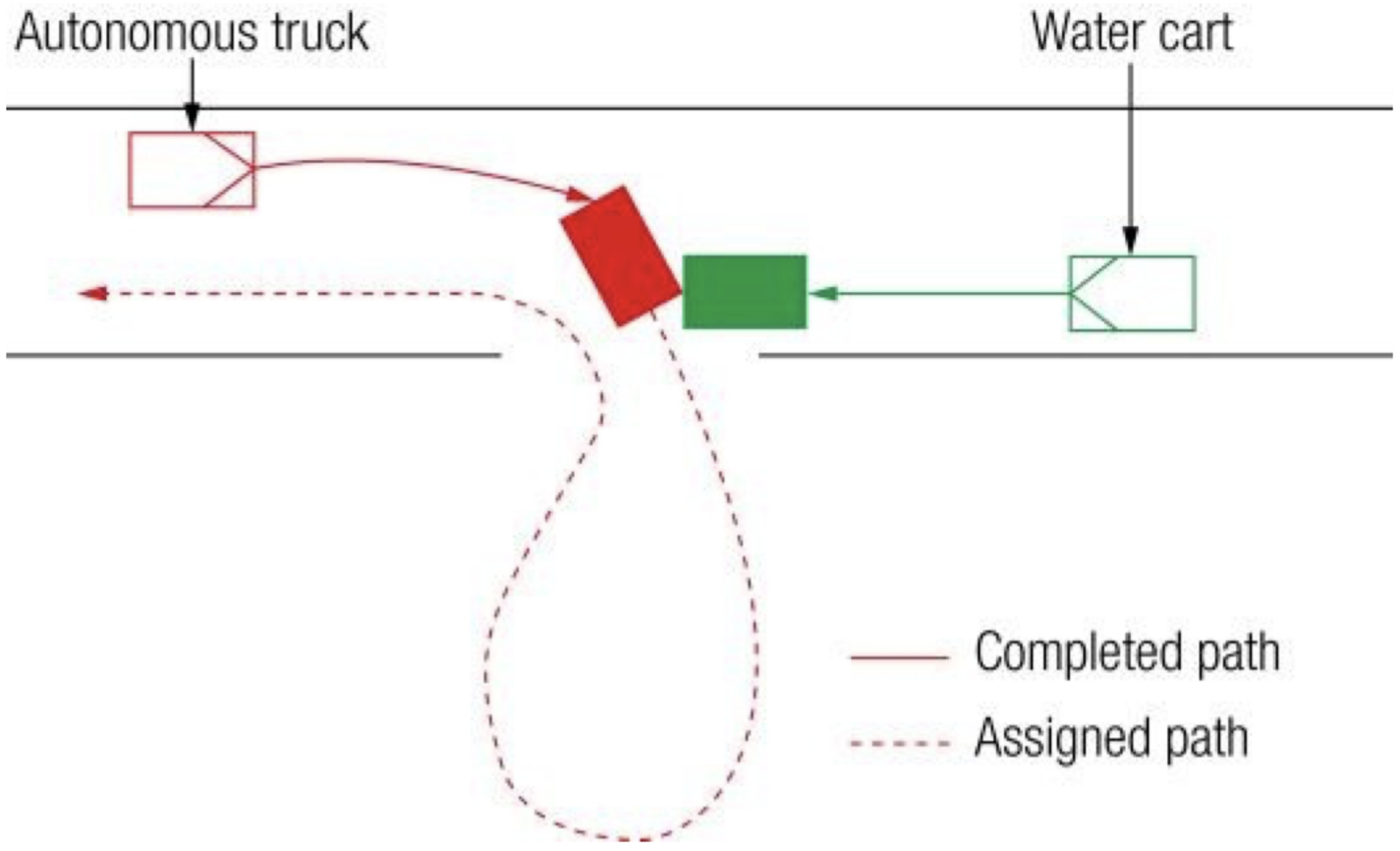
- operational environment (e.g. scale, complexity and physical environment of mining activities)
- operational processes (e.g. maintenance systems, work practices, interaction, separation)
- autonomous systems (e.g. functionality, safety features).

Something is missing here!

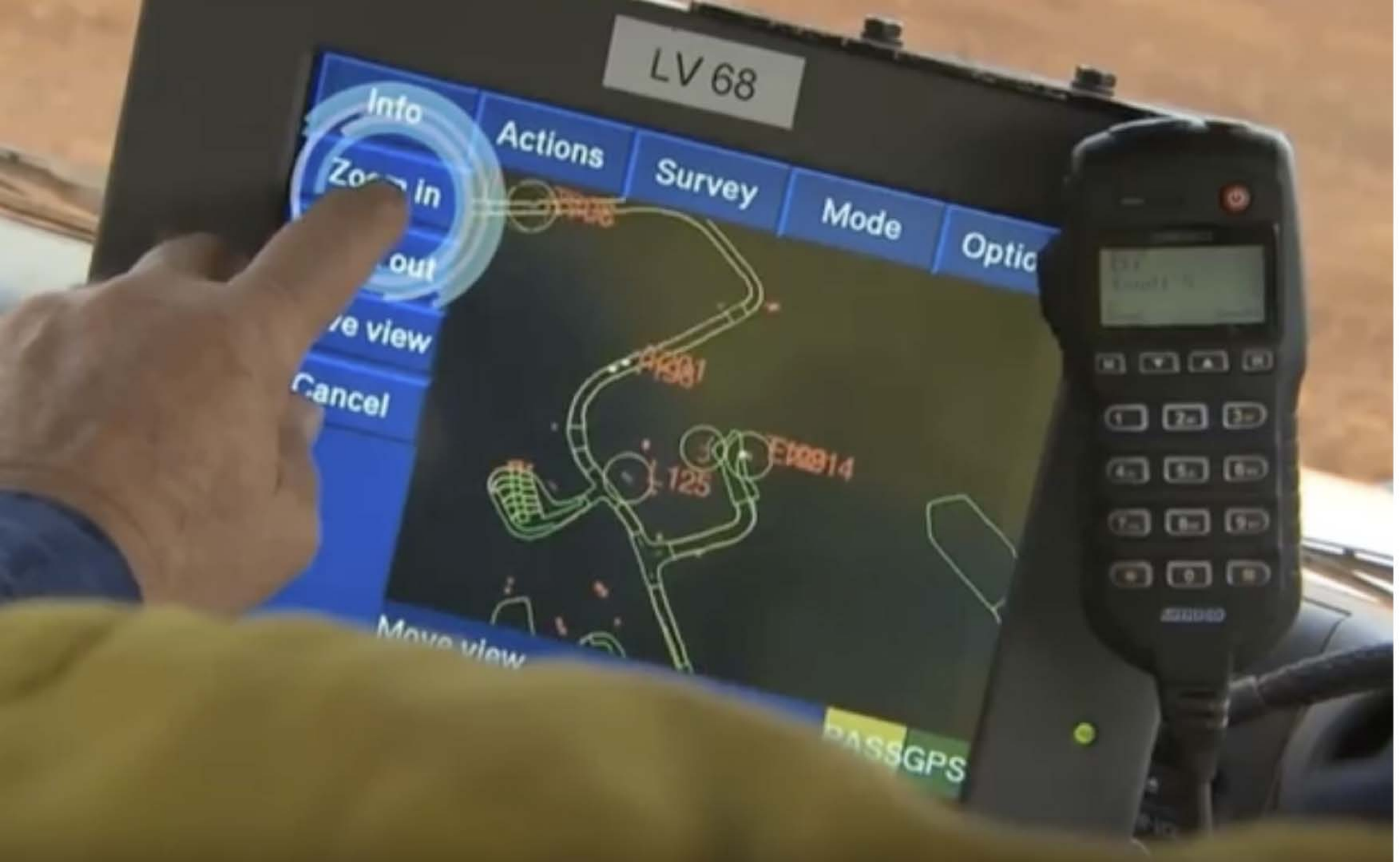
2.6 Risk evaluation and management

All hazards related to mobile autonomous mining need to be identified and controlled. This is best done by applying the hierarchy of control. Higher-order control measures eliminate or reduce the risk more effectively than administrative controls or personal protective equipment.

A manned water cart was travelling in the opposite direction when the autonomous truck was about to turn to right. The water cart driver was not aware of the autonomous truck's assigned path and, on recognising it, tried to take evasive action. The two vehicles collided, resulting in significant damage to the autonomous truck. The water cart driver received minor injuries.



"An awareness system was set up in the water cart to allow the driver to monitor the autonomous truck's path. However, at the time of the collision, the water cart driver was not fully aware of the intended path of the autonomous truck."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COLLISION BETWEEN SEMI-AUTONOMOUS DOZER AND AN EXCAVATOR

Figure 1 Overview of the SATS operator camera display screen immediately before the incident

Potential human-related issues include:

- Reliance on a human "safety driver" during testing
- Degradation of manual skills
- Loss of situation awareness leading to delayed or inappropriate response to abnormal situations
- Nuisance alarms leading to failure to respond to abnormal situations
- Errors during human input
- Increased span of control
- Fewer operators leading to decreased probability of abnormal event detection
- Supervisor cognitive overload
- Over-trust
- Under-trust
- Deliberate circumvention of automation

Mining, Metallurgy & Exploration
https://doi.org/10.1007/s42461-020-00248-z

ORIGINAL ARTICLE

Human-Systems Integration for the Safe Implementation of Automation

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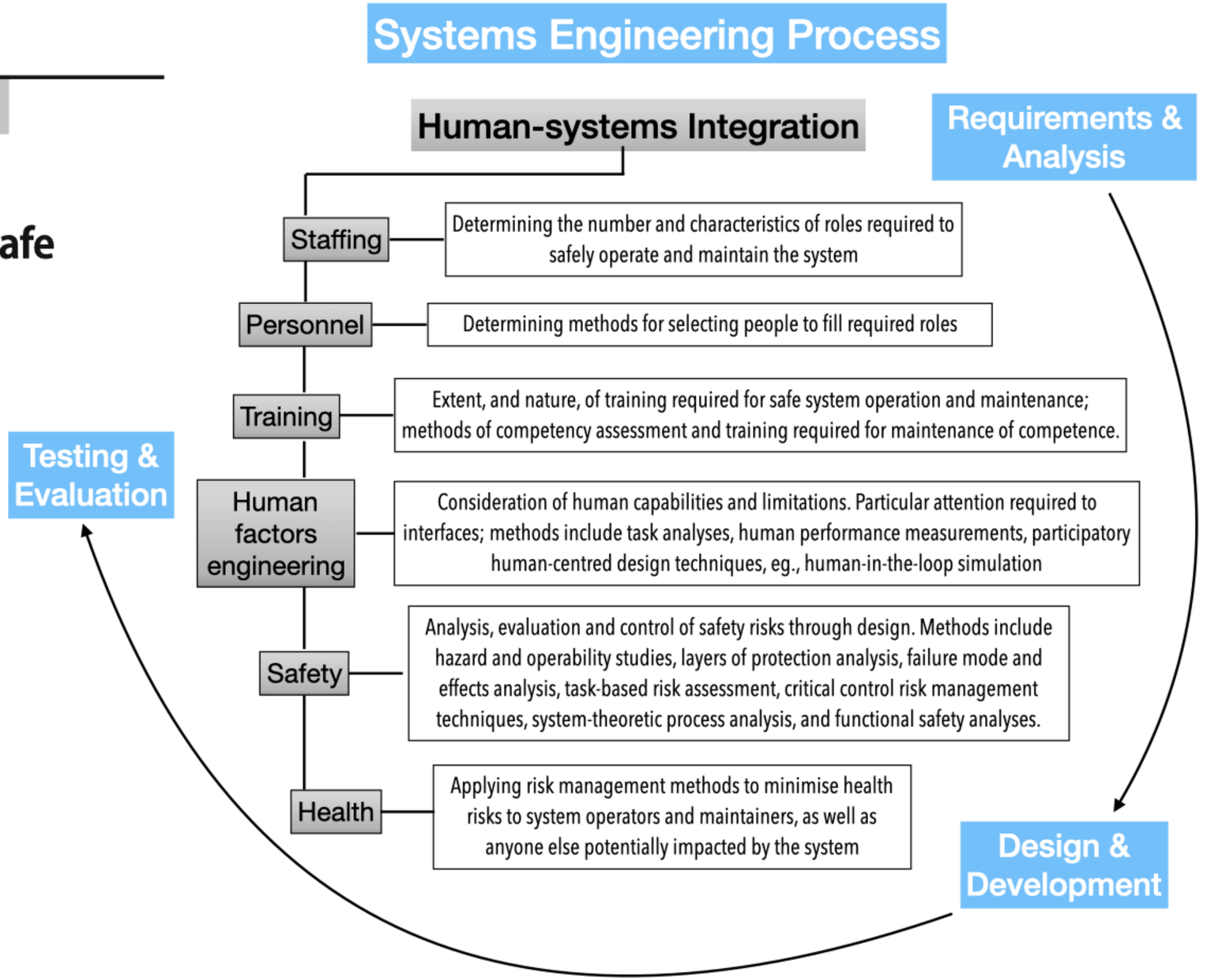

Where to next?

Four inter-related priority areas identified for future research:

(i) systems-based methods for analysing human-technology interaction risks;
(ii) human-centred design of new technology in mining;
(iii) selection, training, and competency assessment
(iv) physical and psychosocial health risks associated with control room work.

Work is currently underway in these areas funded by BHP and Whitehaven Coal

ISO 17757 (ISO/TC 127/SC 2/WG 22 – Convenor Dan Roley)

ISO 17757: 2017 “Earth-moving machinery and mining — Autonomous and semi-autonomous machine system safety

Identifies safety risks associated with associated with autonomous earth-moving equipment.

Ideas for revisions / additions to the standard currently being sought