EMESRT

Earth Moving Equipment Safety Round Table

TYRE AND RIM MANAGEMENT

Industry Project Presentation for AusIMM New Zealand 2023

August 2023

Alcoa

AngloAmerican

BHP

AngloGoldAshanti

Kiewit

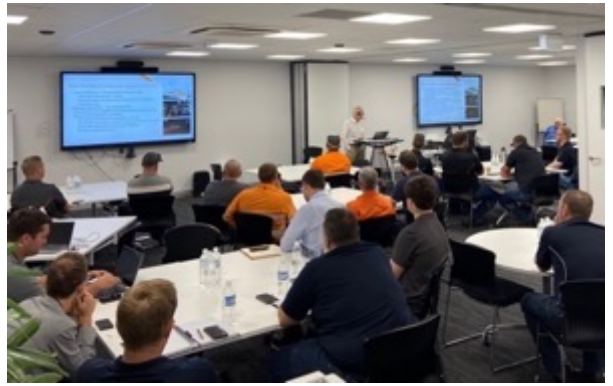
RioTinto

Teck

Vale

INTRODUCING EMESRT

- A mining industry body formed in 2006 to influence how Original Equipment Manufacturers (OEM's) design and build their products
- It presents a common industry voice and is focused on:
  - Reducing health and safety risks from operating and maintaining mining equipment
- It delivers practical outcomes by:
  - Connecting a community of; end users, OEM's, researchers, and third party suppliers
  - Setting industry level goals and then coordinating their delivery, project by project



WHY EMESRT WAS FORMED

- The **design gap** between OEM's and users required a change from past methods of improving designs
- Only the **OEM can shrink** the design gap that third party suppliers work to fill
- **Marketing controls the research and development spend** therefore working through engineers does not achieve optimal change in OEM designs
- **Common industry voice** approach to **defining problems not solutions** provides a business case for the marketing to fund research and development

Thinking differently

- ***Engage marketing*** *to influence product development*
- *Establish a* ***critical mass*** *to influence marketing*
- ***Define 'problems'*** *rather than stipulate 'solutions'*
- *Help the* ***OEM designers*** *develop their* ***solutions***
- *Review, critique and* ***improve solutions*** *step by step*

VISION, PURPOSE AND KEY PRINCIPLES

EMESRT Key Principles

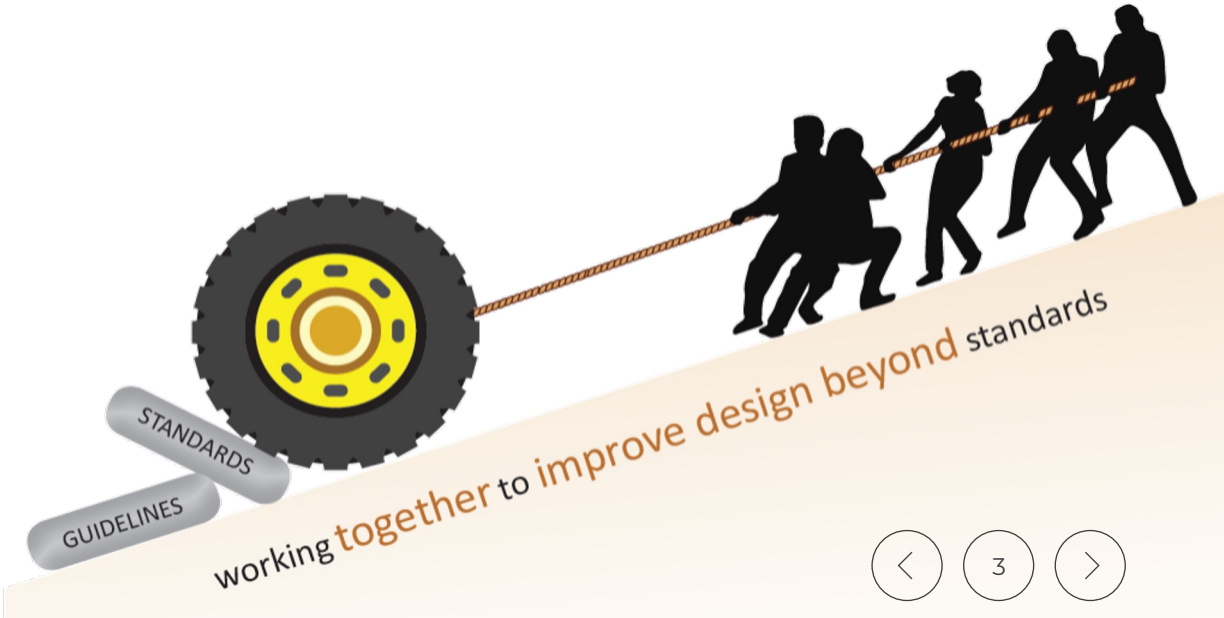
- Designing beyond standards
- Balancing engineering and behaviour (human factors)
- Recognising the value of task based design review
- Appreciating that the OEM does its best with the end user involved
- Open genuine two-way engagement is key

EMESRT Vision

A mining industry free of fatalities, injuries and occupational illnesses associated with operating and maintaining earth moving equipment.

EMESRT Purpose

Accelerate development and adoption of leading practice design to minimise the risk to health and safety through a process of Original Equipment Manufacturer, contractor and user engagement.



WHAT EMESRT WILL AND WILL NOT DO

In scope, EMESRT **WILL**:

- Focus on design of earth moving equipment in surface and underground mines
- Provide aligned design expectations based on risk
- Involve interested mining companies in the industry
- Share openly with all interested OEM's and third-party supplier contributions
- Provide information on leading practice to OEM's and third-party suppliers
- Share leading practice to assist mining equipment users in achieving health, safety and environmental compliance goals

Out of scope, EMESRT **WILL NOT**:

- Discuss commercial issues or anything of an anti-trust nature
- Provide approval for OEM or third-party designs
- Share OEM confidential information with other OEM's or third-party suppliers
- Impose adoption of solutions on member company sites

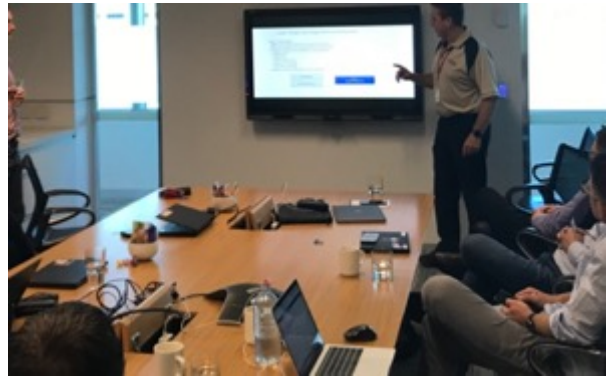
EMESRT – FIVE FACTORS FOR SUCCESS

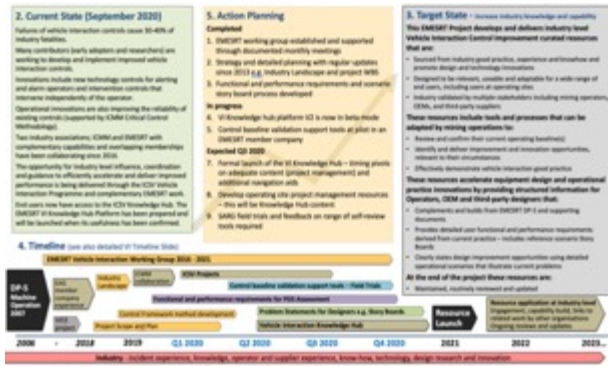
1. Working with an industry-level focus
2. Having a real-world business understanding of financial drivers and leverage
3. Understanding that innovation is market-driven, not pushed by technology
4. Good governance process to cover structure, funding, risk management, renewal and continuity
5. Senior management (decision maker) endorsement

WORK PLAN PROCESS

Each year the EMESRT Advisory Group meets to discuss the progress of each current project, strategically plan, and document, next industry project opportunities by:

- Identifying and defining the problem and explaining it from the perspective of mining equipment users
- Prepare draft industry project landscape that identifies stakeholders, confirms current knowledge and articulates project goals
- Build project communities – Technical Working Groups
- Coordinate resources to leverage industry level innovations and improvements
- Monitor and report progress to Advisory Group and Technical Working Groups





DESIGN PHILOSOPHIES: THE EMESRT BACKBONE

- The EMESRT approach is based around our eight Design Philosophies:
  DP1: Access and working at heights
  DP2: Tyres and rims
  DP3: Exposure to harmful energies
  DP4: Fire
  DP5: Machine operation and control
  DP6: Health impacting factors
  DP7: Manual tasks
  DP8: Confined space and restricted work areas

- Each Design Philosophy states objectives and design outcomes
- Relevant ***potential unwanted events*** are grouped and illustrated

WHY THE INDUSTRY FOCUS ON TYRES AND RIMS?

- Industry experience
  - Ongoing significant events including fatalities
- Tyre and Rim problems
  - Inherent design – reliance on unseen components
  - Stored pressure
  - Assembly, removal and replacement hazard
  - Line of fire
- Industry level opportunities – working through EMESRT
  - Develop a common and structured control framework
  - Provide problem definitions for OEM and designers
  - Identify other opportunities from working at an industry level

EMESRT DESIGN PHILOSOPHY 2 – TYRES AND RIMS

Objective: *to prevent harm related to tyre and rim events to as low as reasonably practical, including consideration in design for foreseeable human error and material failures.*

General outcome: The intended design outcome should include/consider:

- Physical size and weight of tyres
- Stored pressure
- Tyre handling equipment and tools

With respect to handling, affixing to the vehicle, and assembly of wheels (tyre and rim) of rubber-tired equipment

WHO IS INVOLVED IN THIS PROJECT?

The Tyre and Rim Management Project Technical Working Group has 48+ members representing 24 organisations:

1. Alcoa
2. Anglo American
3. AngloGold Ashanti
4. ATMS Technology
5. BHP
6. BUMA Australia
7. Construction Mining Equipment Industry Group
8. Evolution Mining
9. Glencore
10. Kal Tire
11. Kamoto Copper Company
12. Newmont
13. NSW Resources Regulator
14. Otraco
15. Pacific Mining Parts
16. RIMEX
17. Rio Tinto
18. Risk Mentor
19. Resource Safety and Health Queensland
20. Sustainable Minerals Institute, The University of Queensland
21. South32
22. Thiess
23. Viva Health Group
24. Whitehaven Coal

EMESRT CONTROL FRAMEWORK APPROACH

Required Operating States (ROS)

For safe and productive operations, we must maintain these required operating states.

Credible Failure Modes (CFM)

These are the multiple ways that the ROS, can be compromised.

Business Inputs (BI)

These Business Inputs prevent or mitigate the CFM from compromising the ROS.

- Specify
- Implement
- Monitor

Verify

1. Map compliance requirement to existing business inputs
2. Close gaps
3. Compliance monitoring can then be integrated with normal operations

Organising questions for the Control Framework approach

1. What is the *required operating state?*
2. What *credible failure modes* can cause the loss of that required operating state?
3. What are the *business inputs* that prevent or mitigate potential losses from the credible failure mode?
4. How are these business inputs
   - Specified
   - Implemented
   - Monitored
   - Verified

"The Control Framework (CFw) approach was developed by EMESRT as a practical way to apply new control thinking."

TYRE HANDLER PROJECT

PROBLEM STATEMENT

Tyre fitters are the highest fatality occupational group in vehicle servicing in mining. The tasks assumed by operating and maintaining tyre handling equipment are associated with several Credible Failure Modes leading to fatalities and serious injuries. There are diverse mechanisms of injury and fatality arising from different tyre handling equipment.

Empirical evidence is needed to understand the factors within the work system and human-equipment interface that impact on safety performance. This information is needed to enrich a Control Framework approach to improve the design of tyre handling equipment and operating methods.

AIM

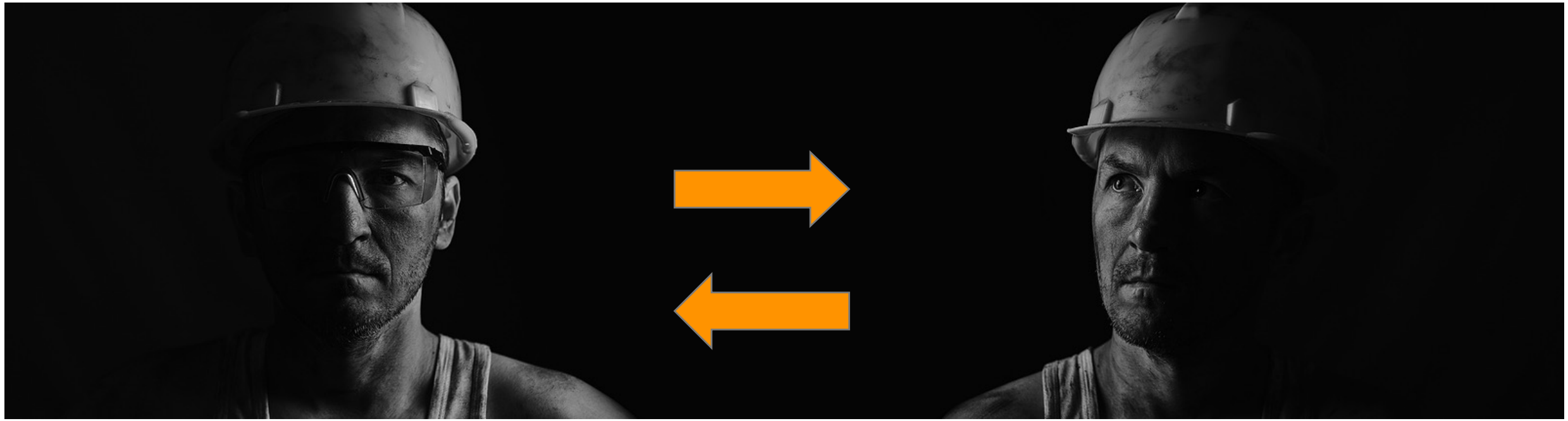
To contribute to **resilient tyre maintenance work systems** in the global mining community through a **human factors analysis** of accessible and effective hazard education about tyre handling equipment operation with **known fatal hazards.**

Video Analysis and Site Visits: 2020: ACARP PROJECT C33005: 15 Workflows and 17 recurring tasks

Vision, Decision Making, Communication: Two-Person Work

ACARP C33005: Human factors aspects of tyre handling

MICRO SOCIOTECHNICAL SYSTEMS



Trust, Rapport, Belief in Capabilities, Experience

MACRO SOCIOTECHNICAL SYSTEMS

- Service contract relationships with mining operator
- Cost centre versus revenue centre
- Perception of questionable priority
- “Gladiator” perception
- Preventative maintenance of machinery
- Purchase of fit-for-purpose best equipment
- Job decision:
  - Pay
  - Location
  - Management
  - Covered bay

EQUIPMENT AND CONDITIONS: CRICITAL FITMENT DECISIONS

- OTR tyre assemblies: multi-component: tyre, rim, wheelbase, components: flange rings, bead seat band, O-ring, and lock ring
- Nut/stud or cleat/wedge/wheel nut attachment
- Work around heavy mobile plant equipment in a restricted tyre bay
- Equipment configurations vary vs ‘fit-for-purpose’ design
- All weather, 24/7 work, covered/uncovered bays

Rasche, T., & Klinge, T. (May 2007). ACARP Project C15046: *Tyre-Related Accidents and Incidents – A Study with Recommendations to Improve Tyre & Rim Maintenance and Operational Safety of Rubber-Tyred Earthmoving Equipment*. Australia: ACARP

CREDIBLE FAILURE MODES

- Operator in the line of fire
- Loss of load in transit or mid operations
- Direct and indirect interactions
- Equipment failure mid operation
  - Teeth wear
  - Hydraulics
  - Handbrake – roll back

TYRE HANDLING OPERATIONS

DIRECT AND INDIRECT INTERACTIONS

SCENARIO 1 - TYRE HANDLER UNPLANNED RELEASE OF LOAD (E.G., TYRE ASSEMBLY) ON FITTER (SPOTTER)

INDIRECT INTERACTION WITH HUMAN. Hazards: poor pad grip; hydraulics fail; or wet tyre, rim, or wheel assembly.
Indirect interaction can also occur with equipment.

Fitter standing under the suspended load

Fitter standing within the arms

Fitter standing outside of arms

SCENARIO 2 - TYRE HANDLER MACHINERY CONTACTS FITTER

DIRECT INTERACTION WITH HUMAN. Hazards: poor visibility, work within proximity

Spotting near the loaded arms and a haul truck

Walking astride the handler, same direction

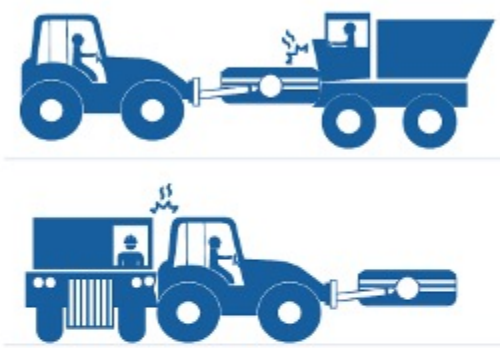
Walking in opposite direction of tyre handler

Walking perpendicular or at an angle within range of the tyre handler

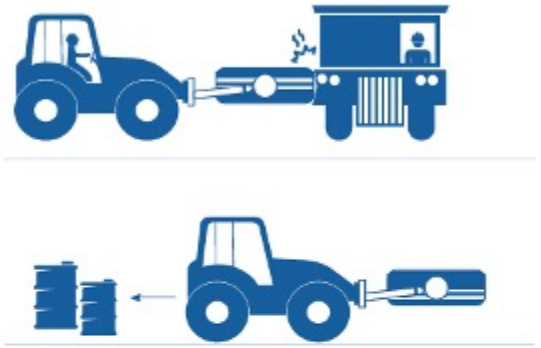
Operator not in the cab. Tyre handler rolls away, not chocked, handbrake fails, etc.

SCENARIO 3 - TYRE HANDLER CONTACTS EQUIPMENT/MACHINERY

DIRECT INTERACTION WITH EQUIPMENT. Hazards: poor visibility, compromised working space



Tyre handler collides with haul truck or equipment at rear when reversing



Operator not in the cab. Tyre handler rolls away, not chocked, handbrake fails, etc

SCENARIO 4 - TYRE BURST, CATASTROPHIC WHEEL/RIM FAILURE/DISASSEMBLY – DURING INFLATION

INDIRECT INTERACTION WITH HUMAN. Hazards: air blast, projected components, standing in line-of-fire or within 5 metres of tyre – during inflation. *Indirect interaction can also occur with equipment.*

Air blast strikes fitter – outside line-of-fire but within 5 metres of tyre

Air blast or projected tyre/wheel/rim component strikes fitter – within line-of-fire

STANDARD EQUIPMENT

EQUIPMENT CONFIGURATIONS

		EQUIPMENT				
		Industrial Lift Truck	Loader	Vehicle Mounted Slewing Crane	Telescopic / Mobile Crane	Misc (Integrated)
ATTACHMENT	Parallelogram					
	Fixed Arm Telescopic Slide					
	Cradle/Hook					

TYRE TECHNICIANS

PERSONA

Mic Lee - Mining Tyre Fitter

"My role is hugely important and not easy. Not everyone on the site understands that."

Earnest | Diligent | Collaborative | Dedicated | Efficient

Age: 32
Work: Tyre Fitter - Mining
Family: Married, 2 Children
Location: Kalgoorlie, WA
Character: Down to earth, amicable

Goals

- Keep me safe, and get my job done efficiently
- Stay on good terms with the maintenance manager and other staff on site
- Operate at a job that lets me use my hands and keeps me outdoors
- Work in covered, sheltered tyre bays
- Stockpile good wages in a short time that will benefit my family and me

Frustrations

- Perceived workload versus staffing ratios and constant interruptions
- Paperwork for the sake of paperwork versus meaningful mentoring and teamwork
- Little direct supervision by team leaders who are positioned in a crib room that is out of sight from the tyre bay doing paperwork
- Fear of maintenance manager and other staff in reporting hazards
- Lack of trust and competitiveness with some other crew, e.g., a nightshift crew

Bio

Mic signed up to learn and become employed as a tyre fitter in the mining industry at 25. The ability to work outside, use his hands, and make a good amount of money attracted him to the profession.

He was married at 21 and loves his wife and two young boys. He is goal-driven and wants to amass enough money to buy a home in a regional area close to his and his wife's family.

Personality

Introvert	Extrovert
Thinking	Feeling
Sensing	Intuition
Judging	Perceiving

Key Influencers

Motivation

- Incentive
- Fear
- Growth
- Power
- Social

Brands

KTM, KingGee, Parramatta Eels, DeWALT, Ford, Great Northern, BCF, SHIMANO

Preferred Channels

- Traditional Ads (TV, Radio)
- Online & Social Media (Facebook, Instagram)
- Referral (word of mouth)
- Email
- Mobile

EMAPTHY MAP

SAID

- "If a work team has good morale and communicates well, then hazards are managed, and we avoid collisions"
- "Tyre handling exclusion areas depend on the task type and the equipment, as well as the nature of experience and relationship among the fitters."
- "Visibility is poor in the cab. It's difficult to see the interaction of the arms, grabs, and tyres"
- "I don't know if there is a standard procedure for chocking"

FELT

- Nervous about driving a light vehicle in the pit around haul trucks and other large mobile plant.
- Tyre handler operation is best done by "feel" since visibility is poor.
- Overwhelmed by the workload vs staffing levels, interruptions, and spontaneous repair work (vs preventative work schedules).

DID

- Jumped back in a handler that was rolling back with the hand brake not properly secured.
- Leaned to the side in the cab to view the grabs and tyre interface.
- Communicated with a spotter with hand signals, through the cab window, and per visual confirmation of gestures, nods.
- Climbed atop a tyre that was held horizontally mid-air to work on the bead seat band.

THOUGHT

- Sometimes there is an "us" and "them" mentality with the mine site operators.
- A better job would be one with a covered tyre bay. Also, I consider whether it is closer to a home base with a shorter roster away – they matter more than pay.
- We are the gladiators at the mine site. We know that we are in the line of fire of a rapid deflation of a tyre.
- We know that we are seen as a cost centre, and we do not believe that the operator wants to invest in our work.

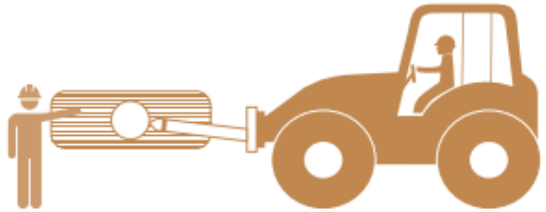
PAIN

- Conflict with the maintenance manager; fear to report hazards
- Perceived workload versus staffing ratios; constant interruptions
- Lack of trust with other teams, e.g., a nightshift crew
- Safety protections always a concern
- Paperwork for the sake of paperwork versus meaningful mentoring and work
- Little direct supervision by team leaders who are positioned in a crib room that is out-of-sight from the tyre bay (and they are burdened by paperwork)

GAIN

- Trust among immediate crew
- Favoured working in sheltered, covered tyre bays
- Favoured working a 7/7 roster with a residential town for family nearby
- Financial savings opportunity not available in other non-FIFO work arrangements or with commensurate training qualifications/education levels
- Satisfaction knowing that work leads to mining productivity, even if that is not always recognised by those viewing fitters as a cost centre
- Satisfaction working with one's hands and being active on the job

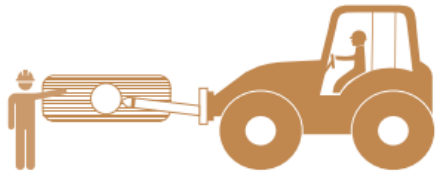
PROBLEM-BASED DESIGN STATEMENTS



TYRE HANDLER OPERATOR STATEMENT

PROBLEM-BASED DESIGN STATEMENT	CATEGORY(IES)
As an operator, I want meaningful and timely warnings if someone is standing in an unsafe location	Feedback Hazard response time
As an operator, I want meaningful and timely warnings if the tyre, grab arms, pads, and attachments are not secure during lifting or holding tyres/rims	Feedback Hazard Response Time
As an operator, I want to see the contact of the grab pads and tyre/rim	Visibility Feedback
As an operator, I want visual confirmation and clear verbal communication with the fitter/spotter	Visibility Communication Feedback
As an operator, I want meaningful and timely warnings if the load is beyond the maximum rated capacity and/or could affect machine stability	Feedback Hazard response time
As an operator, I want to be shielded from an air blast, wheel/rim disassembly, tyre drop, or an uncontrolled movement while a tyre is clamped	Safety protections
As an operator, I want to be shielded from a tyre drop or uncontrolled movement when handling wheel/rim components	Safety protections
As an operator, I want to know that I am protected from erroneous control activation while operating a truck-mounted tyre handler with direct or remote controls	Human error safeguards Feedback Hazard response time

PROBLEM-BASED DESIGN STATEMENTS



TYRE FITTER/SPOTTER STATEMENTS

PROBLEM-BASED DESIGN STATEMENT	CATEGORY(IES)
As a fitter, I want meaningful and timely warnings if I am standing in an unsafe location	Feedback Hazard response time
As a fitter, I want to know that the tyre or rim are held securely, and the tyre handler arms, pads, and attachments are secure when I stand nearby	Feedback
As a fitter, I want to be protected from uncontrolled movement of the tyre handler and its attachments	Safety Protection

TYRE HANDLER EQUIPMENT MAINTAINER STATEMENTS

PROBLEM-BASED DESIGN STATEMENT	CATEGORY(IES)
As a handler, I want to know the specifications for the tyre grab pads and attachments (teeth) and the indicators if they are eroded (i.e., what is the threshold tolerance?)	System resilience

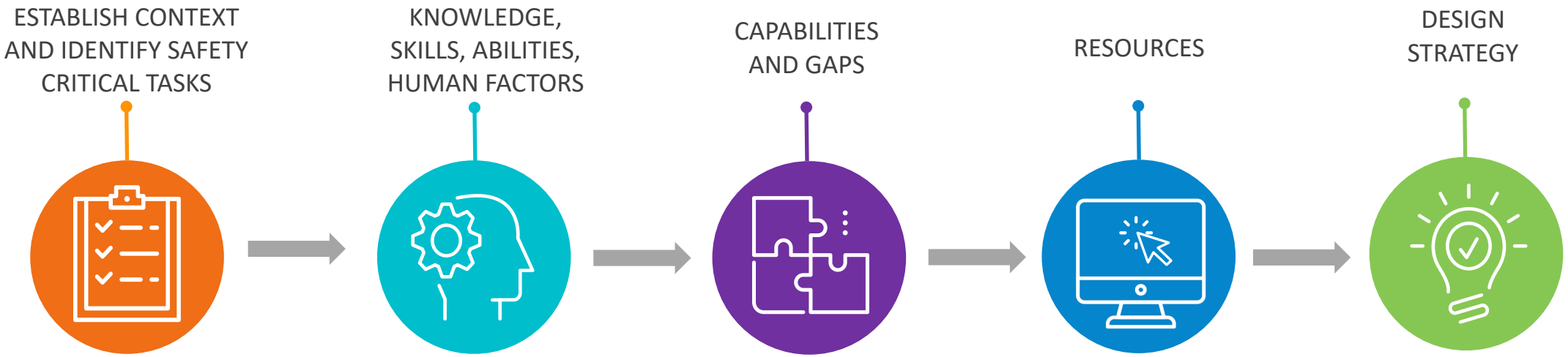
TYRE MAINTENANCE MANAGER STATEMENTS

PROBLEM-BASED DESIGN STATEMENT	CATEGORY(IES)
As a manager, I want to know that agreed controls are implemented, effective, and complete	System resilience
As a manager, I want to know that the maintenance procedures have been followed	System resilience
As a manager, I want actionable information to learn from the Credible Failure Modes that inform a process of continual improvement	System resilience

METHODS:
ACARP C35020
CURRENT PROJECT

METHODS: HAZARD EDUCATION GAP ANALYSIS SAFETY-CRITICAL TASKS

AUR21920 CERT II – AUTOMOTIVE TYRE SERVICING TECHNOLOGY (R 2)

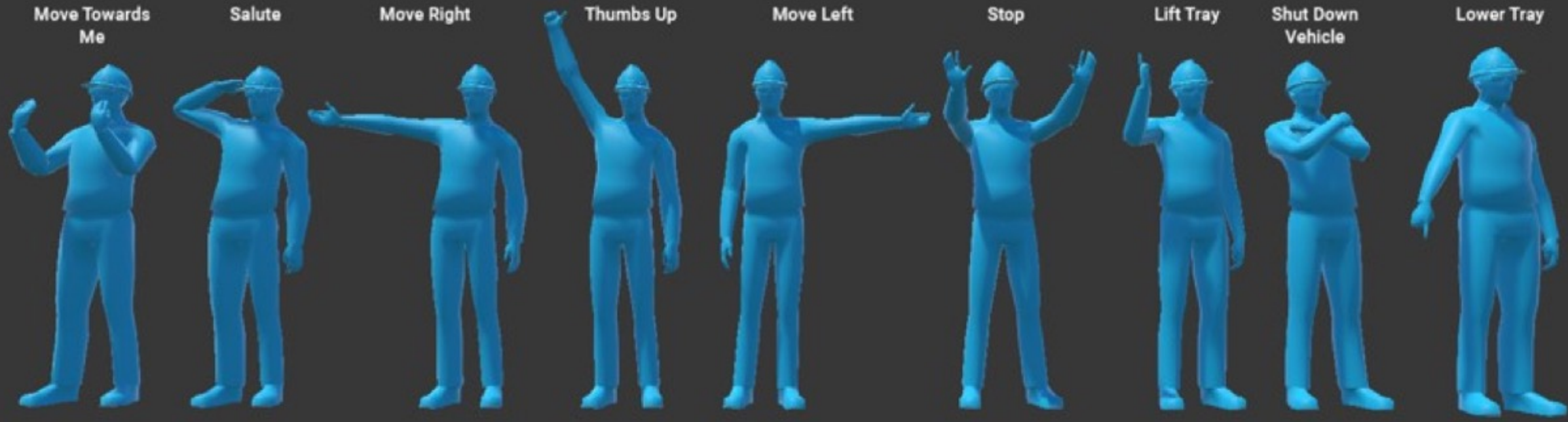


ROLE PLAY AND ‘THINK-ALOUD’ PROCEDURES

DIGITAL TWIN ENVIRONMENT

The digital twin: a replica, a model, with digitally animated assets that provide a high-fidelity, agile, visual storytelling medium

DIGITAL TWIN ENVIRONMENT



Tyre handling equipment ompilation video

Removing wheel or rim retaining hardware

INTERACTIVE PRODUCT VIEWER

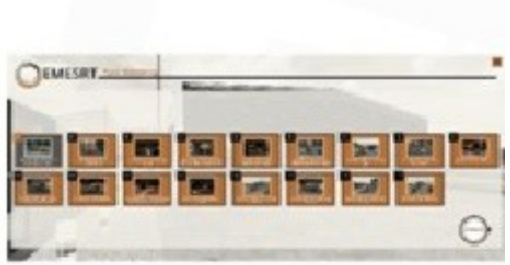
Homepage
17 Tasks

Content

Task
Introduction

Cinematic
Points-of-View

Task
Summary



Quiz

Q1 Incident

Q2 Credible
Failure

Q3 Hazard
Exposure

NEXT STEPS

Evaluating the impact of the hazard education, e.g. qualitative reviews, concept maps

EMESRT industry resources:

- 17 plus 1 compilation scenario animated videos
- Tyre handler problem-based design statements
- Direct and indirect interactions poster
- Tyre handling equipment and attachment option matrix poster
- Fatality serious injury, or damage to machine and equipment danger poster
- Tyre and rim knowledge hub - Available shortly

QUESTIONS?

EMESRT

Earth Moving Equipment Safety Round Table

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