EMESRT

Earth Moving Equipment Safety Round Table

2020 ACTIVITY REPORT

Working with industry since 2006

EMESRT

EMESRT is a global 'safety by design' initiative established by mining companies to fill the functional performance expectations gap between earth moving equipment users and equipment designers.

VISION

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

PURPOSE

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

ACKNOWLEDGEMENT

The EMESRT Advisory Group acknowledges and greatly appreciates the individual contributions of member company representatives and others from the broader EMESRT community of: Mine Operators, Original Equipment Manufacturers (OEM), third party equipment suppliers, Researchers, Industry Groups and others.

Since 2006, their contributions at meetings, workshops, webinars and other activities have directly supported the delivery of the EMESRT vision and they are part of the EMESRT success story.

ACTIVITY REPORT

This 2020 Activity Report provides a summary of the work on the planned industry project objectives and outcomes.

It provides the readers with highlights from 2020, focus area milestones, next steps and information about how EMESRT operates.

Its intended audience is:

- EMESRT member companies, both specialists and senior leaders
- Original equipment manufacturers, third party providers, particularly of proximity detection systems
- EMESRT working groups
- Industry organisations with overlapping missions and memberships, e.g., the ICMM ICSV working groups
- Non-EMESRT member mining companies and contract mining organisations
- Regulators
- Researchers
- All other interested parties

The EMESRT Advisory Group hope you find the report informative, readily useable and relevant.

MEMBERS FOR 2020

Alcoa

BHP

RioTinto

AngloAmerican

GLENCORE

Teck

EAG INTRODUCTION

EMESRT operates as a high influence global organisation, its effectiveness on delivering industry level outcomes pivots on membership credibility and active stakeholder engagement. While challenged by the restrictions of the COVID-19 pandemic response in 2020, the industry engagement was still delivered through a mix of webinars, monthly project meetings, teleconferences and email engagements.

EMESRT exists to close the functional design gap between Original Equipment Manufacturers, designers and mining equipment users. EMESRT presents a common industry voice, focused on reducing risks from operating and maintaining mobile earth moving equipment. EMESRT endeavours to deliver practical outcomes by connecting a community of; end users, OEM's, researchers, and third-party suppliers to establish industry level improvement goals and then coordinate their delivery, project by project.

The EMESRT Advisory Group (EAG) is made up of member representatives and its role is to confirm strategy, prepare work plans including budgets, and to support the industry project leads. Each member contributes based on their diverse experience, individual skills and availability.

This clear purpose combined with a volunteer structure, demands operating and project management processes that are both effective and efficient. The setting of the annual membership fee charges is directly based on providing the underlying resources for these work plans.

EMESRT's approach follows this simple and effective sequence: beginning by rigorously defining the problem and explaining it from the perspective of mining equipment users. The EAG then prepares a draft industry project landscape that identifies stakeholders, confirms current knowledge and articulates project goals. EMESRT then builds project communities and coordinates resources to leverage industry level innovations and improvements.

Project selection is framed by member company and industry experience and concern, the development of a compelling case for improvement, and the ability of EMESRT to influence. The EAG members lead and coordinate each of the EMESRT Technical Working Groups.

Technical Working Groups (TWG) are established by the EAG and are made of multiple member representatives, OEM's, third party suppliers, industry experts and others with relevant expertise. The EAG and TWG meet on a regular basis to discuss the progress of each industry project covering next steps including industry engagement and information sharing opportunities.

Since 2017, EMESRT has reported on progress towards the improvement goals through the Annual Reports. For 2020, this has been renamed as The EMESRT 2020 Activity Report reflecting the commitment to freely share useful and useable information across the industry.

This report provides updates on the current industry projects:

1. Vehicle Interaction
2. Tyres and Rims Management
3. Mobile Equipment Fires Management
4. Human Factors Design for Diversity (Scoping phase to understand the breadth of issues)

EMESRT is committed to sharing good practice information that can be adapted by operational site users to address real-world issues, and in late December 2020, the Vehicle Interaction (VI) Knowledge Hub was launched. This resource is an information management application that can be accessed through a web environment. It supports operational site users with a range of tools, case studies, reference information, and useful links. It also provides the templates that can be adapted by operating sites to assist in the planning and execution of vehicle interaction improvement projects.

More information on the VI project and Knowledge Hub can be found on page 5 and 6.

These four industry projects are complex and require careful management and coordination. EMESRT project management approach is based on creating system level understanding, engineering logic, wide engagement and an unrelenting focus on delivering practical outcomes. In 2021 EMESRT expects to deliver further industry project Knowledge Hubs.

Combined, they illustrate the evolution of EMESRT over the last 15 years. While the intent to improve equipment design remains, the recent experience is that equipment and technology design improvement for complex issues cannot be addressed in isolation. More simply, successful equipment design innovation is informed by and must integrate with operations baseline controls design and practice.

BROADENING INDUSTRY ENGAGEMENT

Throughout 2020, EMESRT has continued to collaborate with the ICMM Innovation for Cleaner Safer Vehicles - Vehicle interaction programme by attending multiple virtual workshops and the development of the EMESRT VI Knowledge Hub to complement the 2019 ICMM Knowledge Hubs. This complementary approach with industry will continue in 2021.

During 2020, industry engagement expanded with several new organisations contributing to the current industry projects. At the end of the year, 196 individuals representing 68 organisations have contributed to multiple technical working groups.

EMESRT acknowledges and thanks all our working group members for their time and commitment to deliver the EMESRT vision and purpose and look forward to your continued support in 2021.

EMESRT also acknowledge the direct financial and in-kind input from the respective member companies and their ongoing support for their representative's contributions. On their behalf, the EAG are committed to continually improving the value that EMESRT strives to provide for the industry.

EMESRT Advisory Group
March 2021

ACRONYMS

ACARP	The Australian Coal Industry's Research Program
BI	Business Inputs
CAS	Collision Avoidance System
CFM	Credible Failure Modes
CFw	Control Framework
DP	Design Philosophies
EAG	EMESRT Advisory Group
EDEEP	EMESRT Design Evaluation for EME Procurement
EMESRT	Earth Moving Equipment Safety Round Table
HFDD	Human Factors Design for Diversity
ICMM	International Council on Mining and Metals
ICSV	Innovation for Cleaner Safer Vehicles
MEI	Mobile Equipment Interaction
OEM	Original Equipment Manufacturer
OMAT	Operability and Maintainability Analysis Technique
PDS	Proximity Detection Systems
PR	Performance Requirement
ROS	Required Operating States
UQ	University of Queensland
VI	Vehicle Interaction

CONTENTS

1. WORKING WITH AN INDUSTRY LEVEL FOCUS

Since early this century, mining companies have jointly discussed the contribution of earth moving equipment design to unwanted incidents. The initiative was driven by the desire to fill the functional performance knowledge gap between mining equipment users and equipment designers, focusing on new designs where the opportunity for major change was not only possible, but made economic sense.

For six global mining companies, these discussions evolved into a formal global initiative in 2006 – the Earth Moving Equipment Safety Round Table (EMESRT).

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

The next step was to develop and implement a strategy for mining equipment users to engage with OEM's. The first meetings were with eight surface mining OEM's and these discussed the EMESRT design philosophies to develop an understanding of each other's perspective.

Once this approach was confirmed as adding value the design challenges were expanded from surface mining equipment to underground coal and hard rock mining, along with exploration drilling.

In 2006, serious injuries and fatalities from access and working at height incidents from mobile equipment were common occurrences across mining companies and all regions.

Working with OEM's, EMESRT confirmed customer equipment access and working at height requirements and these became the basis for improved design. By 2012, this approach had largely eliminated equipment access and working at heights hazards in new mining equipment.

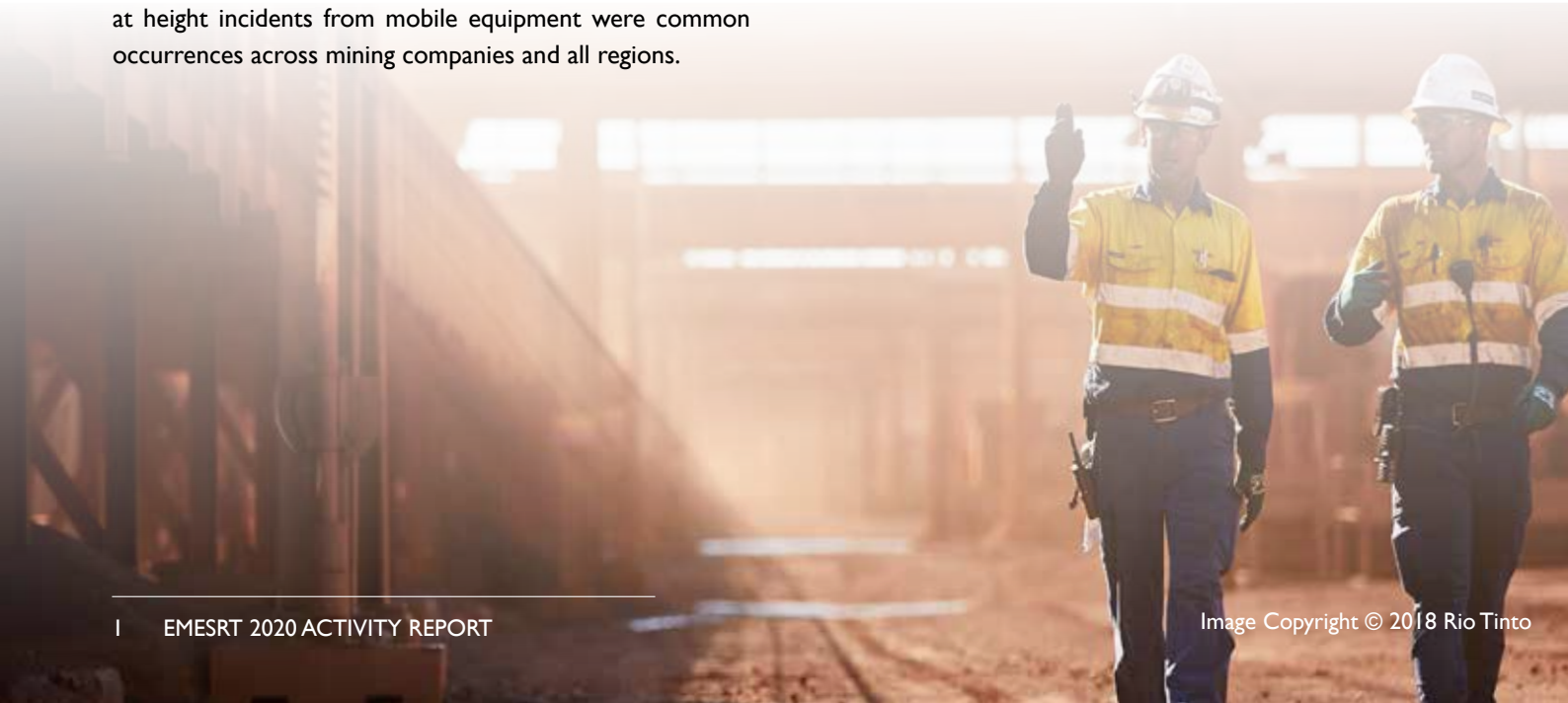
Following OEM requests in 2007, EMESRT developed OMAT (Operability Maintainability Assessment Technique). OMAT leverages the use of EMESRT Design Philosophies by engaging mining equipment users in a structured task-based assessment methodology.

This was followed up in 2011 with the development of EMESRT Design Evaluation for Earth moving equipment Procurement (EDEEP) process for evaluating OEM equipment design during mining company equipment procurement. OEM's who apply this process can demonstrate that they are designing beyond standards are applying task-based design reviews and are linking design features to priority issues.

The vehicle interaction project commenced in 2013 continues. This complex industry level work is based on Design Philosophy (DP-5) - Machine Operation and Control and Performance Requirement 5A (PR-5A). The current work is further explained in this report.

After a decade of engendering improvement in design, the EAG undertook a formal strategic review in 2017, that saw the implementation of several important actions to sustain EMESRT. This work included confirming the factors that had brought about improvement, standardising industry project management processes, and updating the strategic plan.

In 2018, EMESRT built on a new process shared by a member company and conducted a development pilot of the Control Framework approach, and this approach is now being used to support all the industry projects.



1.1 DESIGN PHILOSOPHIES: THE EMESRT BACKBONE

BACKGROUND

The foundation of the EMESRT approach comes from eight Design Philosophies.

These design philosophies underpin the engagement with OEM and third-party equipment designers, manufacturers and suppliers, the industry focus projects and the development of EMESRT tools, processes and other resources.

Each Design Philosophy states an overall objective, expected design outcomes and categorises relevant potential unwanted events.

The eight EMESRT Design Philosophies are:

1. ACCESS AND WORKING AT HEIGHTS
   Prevent harm related to access and working at heights specifically where there is a risk of falling including slip/trip hazards, sprains/strains, falls and failure to egress in emergency events to as low as reasonably practical including design considerations for gender diversity and foreseeable human error.

2. TYRES AND RIMS
   Prevent harm related to tyre and rim handling, mounting, material failures and installation to as low as reasonably practical including design considerations for gender diversity and foreseeable human error and material failures.

3. EXPOSURE TO HARMFUL ENERGIES
   Prevent harm related to exposure to moving machine parts, failure of hydraulic equipment or systems, and other energy sources, such as compressed air, heat, electricity, kinetic and gravity to as low as reasonably practical design considerations for gender diversity and foreseeable human error.

4. FIRE
   Prevent harm related to equipment fires incorporating suppression systems, safety equipment and placement of hydraulic and fuel lines to as low as reasonably practical including design considerations for human diversity (variability, capability and limitations) and foreseeable human error.

5. MACHINE OPERATION AND CONTROL
   Prevent harm during machine operation and control to as low as reasonably practical including design considerations for human diversity and foreseeable human error.

6. HEALTH IMPACTING FACTORS
   Prevent harm from exposure to health impacting factors to as low as reasonably practical including consideration in design for human diversity and for foreseeable human error.

7. MANUAL TASKS
   Prevent harm related to manual tasks during installation, maintenance and the operation of equipment to as low as reasonably practical including design considerations for human diversity and foreseeable human error.

8. CONFINED SPACES AND RESTRICTED WORK AREAS
   Prevent harm to people working in confined spaces and restricted work areas to as low as reasonably practical including design considerations for human diversity and for foreseeable human error.

Further information including full text files are available on the EMESRT website - emesrt.org.

1.2 CURRENT INDUSTRY PROJECT FOCUS

OVERVIEW

At the end of 2020, EMESRT is supporting four industry areas of focus and despite the pandemic management restrictions, there continues to be worthwhile industry outcomes delivered. Project details follow.

1.2.1 INDUSTRY PROJECT 1:VEHICLE INTERACTION CONTROL IMPROVEMENT

This industry project is led by Glencore representative Tony Egan and AngloAmerican representative Matthew Clements.

BACKGROUND

Industry Vehicle Interaction Experience

A significant mining industry fatality challenge is to systematically and reliably improve controls for managing mobile equipment operation and people and materials transport.

Each year, between 30-40% of industry deaths are attributable to failures of vehicle interaction controls and of these about half involve pedestrians, mostly in underground operations.

The EMESRT Facilitation Role 2013 - 2020

Based on *Design Philosophy 5 (DP-5) – Machine Operation and Control*, EMESRT initiated an industry project in 2013 to improve vehicle interaction controls. The drivers for this work was the rapid development and marketing of Collision Avoidance Systems (CAS).

The first step was to define the problems that the project would address and to illustrate these using operational scenarios. The next step was to build a set of performance requirements for evaluating commercial Proximity Detection System (PDS) technologies.

After two years, the project focus on awareness, advisory and intervention technologies was expanded to include mine design and operational controls. This was driven by a systems level understanding that vehicle interaction controls are multi-level, interconnected, dynamic and that many are dependent on the decisions and actions of people.

The EMESRT facilitative approach has created an industry level project community made up of 150+ individuals representing Mining companies, OEM's, Third party PDS providers and other stakeholders. This group has developed an interoperability protocol between third-party PDS providers and equipment supplied by OEM's to establish a platform for the implementation of PDS controls in mixed equipment fleets - Refer ISO 21815. They also assisted with the design and content of ACARP Project C26028 to confirm a methodology for validating proximity detection technology, an international project with Australian and South African researchers.

The International Council on Mining and Metals (ICMM) was identified in 2017 as a key stakeholder and EMESRT actively engaged with them in the formation of the Innovation for Cleaner, Safety Vehicles (ICSV) programme. The ICSV VI ambition statement is, *"The programme aims to promote collision avoidance technology capable of eliminating fatalities from vehicle interactions so that it is available to mining companies by 2025."* The ICSV initiative is focused at the higher level engagement in enabling broad change. EMESRT has a complementary technical level focus.

MAKING AN INDUSTRY PROJECT BUSINESS CASE

The industry business case for EMESRT to facilitate a project to improve Vehicle Interaction Controls was established in 2013. The project drivers pivoted on new technology costs, complexity and uncertainty of outcomes, the rapid development of options and technology interoperability concerns.

Since then, EMESRT has influenced, coordinated, supported, and guided project activities at an industry level. Core to this work has been engaging with ICMM to leverage their peak industry association status and directly contribute to the "Initiative for Cleaner Safer Vehicles."

Contributors from EMESRT member companies have applied engineering approaches and logic to develop resources that include comprehensive and adaptable project plans, tools and processes that consider human factors and prepare operations for successful technology implementations.

This wide range of information and experience is now being curated and has been made available for industry use in Knowledge Hubs.

Extensive research and development of new technology **react controls** that alert and alarm operators (Level 8) and intervene independently of the operator (Level 9) has been undertaken over the last decade. While these **react control** developments are progressing, there are few examples of successful operational deployments.

EMESRT member company and industry experience is that scoping, implementing, integrating and maintaining collision avoidance systems is complex because:

- During operations there is an ongoing dynamic interdependence between **design**, **operate** and **react** controls (reference EMESRT Level 1-9 Model)
- The successful implementation and integration of **react** controls requires a comprehensive baseline understanding of **design** and **operate** controls
- Success requires precisely understanding what technology does and does not do, taking a project approach
- The potential for error due to the lack of human factors considerations in design
- Proximity Detection System (PDS) technologies on the market are best evaluated using functional performance requirements based on interaction scenarios and unwanted event categories
- There are already legislative requirements for the introduction of new technology intervention controls in some jurisdictions

PROJECT PROGRESS

Project work continued throughout 2020 and has delivered these milestones:

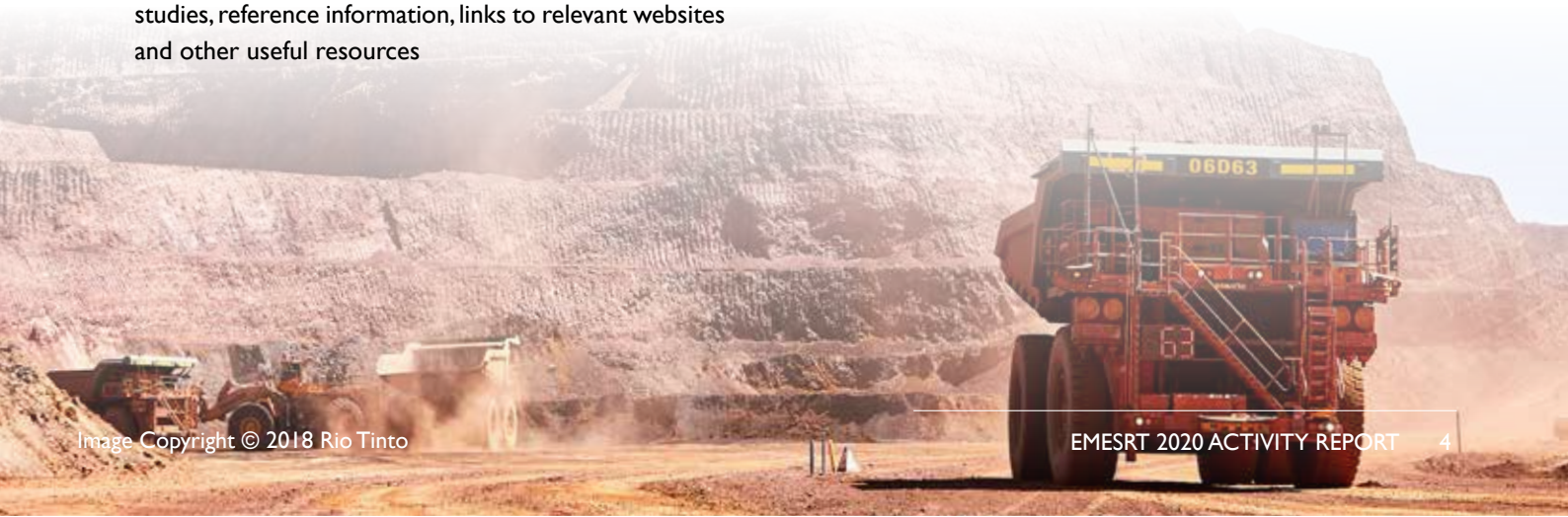
- Further development and application of the EMESRT VI Control Baseline Assessment approach in member companies
- Development and launch of the VI Knowledge Hub providing the industry with a curated collection of case studies, reference information, links to relevant websites and other useful resources
- Developed a Project Work Breakdown Structure for initiating and executing a Vehicle Interaction Improvement project for operating sites (key Knowledge Hub content)
- Supporting the completion of the ACARP Proximity Detection System Validation Framework Project C26028 that includes alignment and collaboration with the University of Pretoria PDS testing work
- Supporting the ACARP Intelligent Camera Systems in Project 33007 to assess its application in VI
- Ongoing EMESRT support for the ICMM ICSV VI programme including presenting at and attending virtual workshops

The EMESRT vehicle interaction community is supported by monthly meetings and as required face-to-face workshops, although during 2020 this was impossible due to COVID-19. Currently the community extends to over 150+ individuals representing 50 multiple organisations from mining companies, researchers, OEM's, third-party equipment suppliers, e.g., PDS and other interested parties.

NEXT STEPS

- Broader industry communication of the VI improvement strategy materials and guidance
- With ICMM, deliver regular topic specific webinars that support vehicle interaction control improvement projects at operating sites
- Publish the Vehicle Interaction Control Framework and the associated baseline assessment process including the Self-Assessment Review Guideline (SARG)
- Providing support and resources that enable capacity building for industry project delivery

For more information regarding this industry project please visit the EMESRT website - emesrt.org.



1.2.1.1 VI KNOWLEDGE HUB

ABOUT THE VI KNOWLEDGE HUB

EMESRT is committed to making operational site user information available to the industry to assist in addressing real-world occupational health and safety problems.

In December 2020, EMESRT launched the VI Knowledge Hub, a curated online collection of resources and templates to assist in the planning and execution of improvement projects at operating sites. The collection contains case studies, reference information, links to relevant websites and other informative resources. The Hub also provides users with templates to assist in the planning and execution of improvement projects at operating sites.

The collection will continue to grow as new resources become available. EMESRT encourages industry to contribute to the collection via the contribution form, available on the site, if a suitable resource becomes available and does not breach any intellectual property or copyright issues.

WHAT IS IN THE VI KNOWLEDGE HUB?

As well as resources, the Knowledge Hub provides the industry with templates to assist in the planning and execution of improvement projects at operating sites. The Knowledge Hub will enable users to:

- Find information relevant to their operations
- Improve understanding of site vehicle interaction scenarios
- Systematically review current vehicle interaction controls
- Scope up and successfully deliver improvement projects

ACCESSING THE VI KNOWLEDGE HUB

Accessing the VI Knowledge Hub can be done via the EMESRT website (emesrt.org).

There are two main areas of the VI Knowledge Hub that are connected:

1. Journey Model (curated content)
2. Work Breakdown Structure (content for project management)

Both areas contain graphic navigation aids to assist users in quickly finding information relevant to them where they can adapt the information for their circumstances.

The Journey Model is a road map based graphic (Figure 1) that guides the user through a one to four step journey. Each step provides the user with a pop-up summary containing information that can be obtained a particular step along the journey.

The final step in the Journey is to move into a project phase. The project phase is represented by a Work Breakdown Structure (WBS) graphic (Figure 2) that takes the user to information and relevant usable templates.

For more information regarding the VI Knowledge Hub please visit the EMESRT website - emesrt.org.

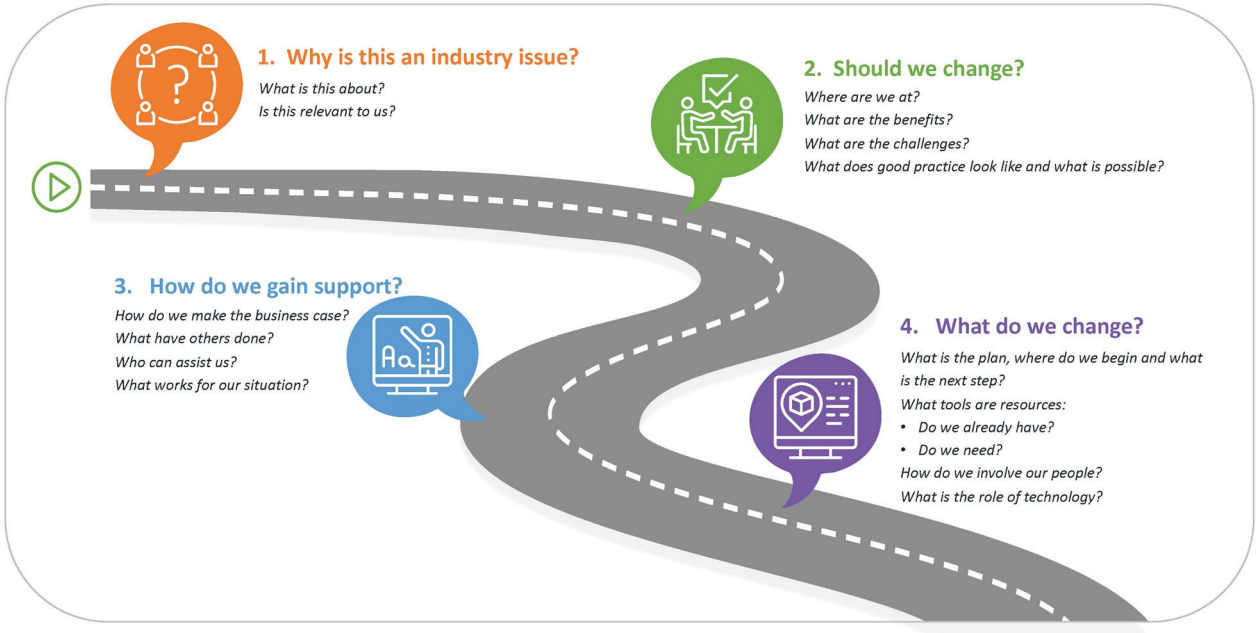


Figure 1: The Journey Model navigation aid.

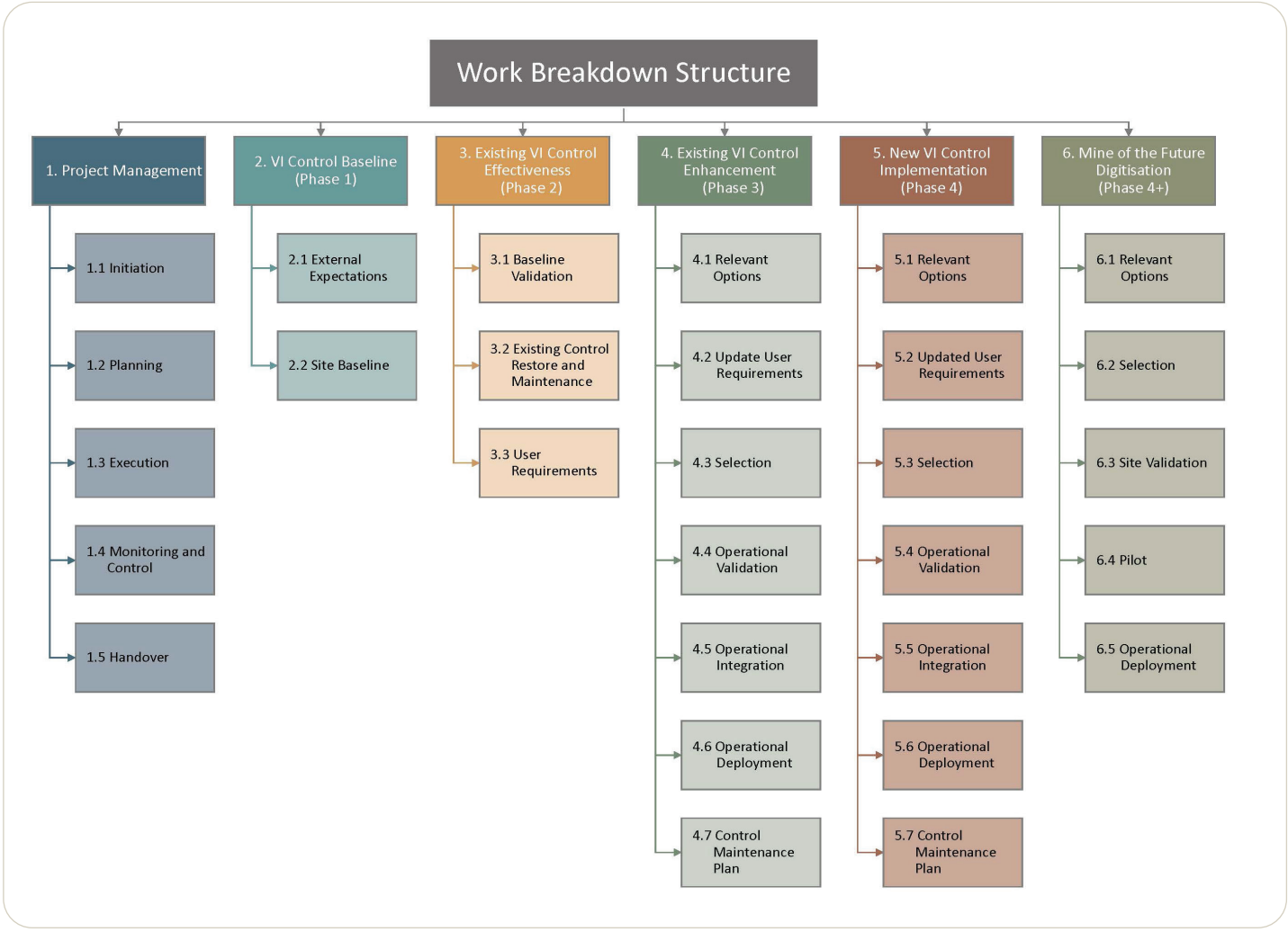


Figure 2: The Work Breakdown Structure navigation aid.

1.2.2 INDUSTRY PROJECT 2: TYRES AND RIMS MANAGEMENT

This industry project is led by representatives Tony Egan from Glencore and Iain Curran from BHP.

BACKGROUND

Tyre and Rim incidents involve stored energy release or crush scenarios and include the catastrophic disassembly of wheel assemblies, tyre explosions from pyrolysis and crush injuries when moving tyres and wheels or working with mobile equipment.

The EMESRT *Design Philosophy 2 (DP-2) – Tyres and Rims* was published in 2007 and provides visual operational scenario information for the designers of wheel assembly components and mining operators. It has this objective: to prevent harm related to tyre and rim events to as low as reasonably practical, including consideration in design for foreseeable human error.

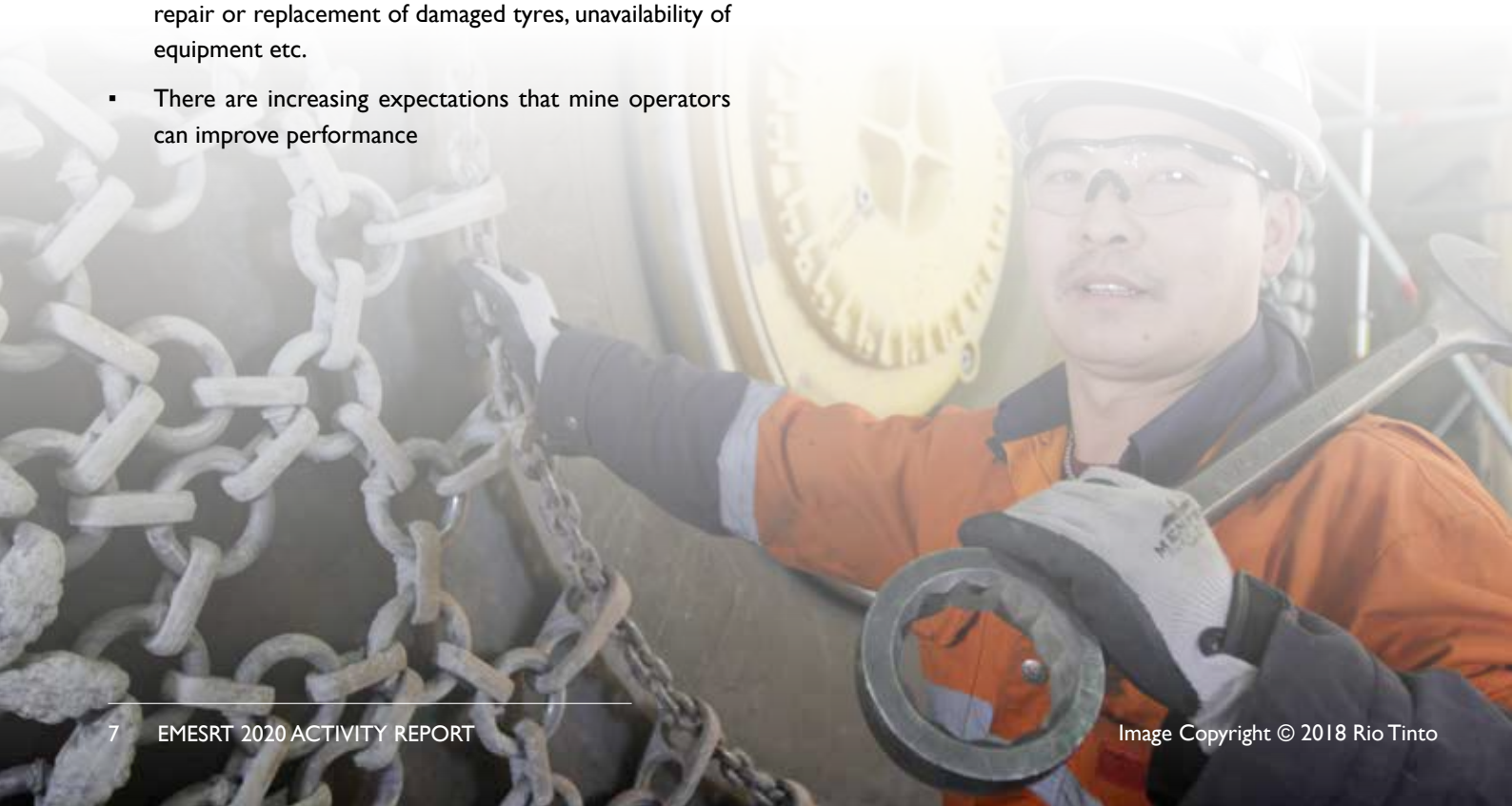
In 2018, EMESRT Advisory Group (EAG) members initiated an industry project to improve Tyre and Rim management. This decision was based on these drivers:

- Significant fatality exposures for tyre maintenance technicians, mobile equipment operators, mobile equipment maintainers and emergency responders
- Inadequate maintenance and operational practices causing early service failures incur considerable costs e.g., repair or replacement of damaged tyres, unavailability of equipment etc.
- There are increasing expectations that mine operators can improve performance

In 2019, this EMESRT Project was scoped and developed at two industry workshops, using the EMESRT Control Framework (CFw) approach.

Twenty-three experienced and well qualified participants, representing 14 organisations (both member and non-member), including a regulator representative confirmed five aspirational Required Operating States (ROS) as the minimum set necessary for consistently safe and productive mining operations working with rubber tyre mobile equipment:

- ROS-TR-01: Tyre maintenance practices for load shifting, component storage and mobile equipment interactions are effectively managed
- ROS-TR-02: Wheel assemblies remain intact, and equipment performs to expectations during tyre changes and all other tyre and rim maintenance activities
- ROS-TR-03: Safe and productive operational use of earth moving equipment with inflated rubber tyres
- ROS-TR-04: Tyre recycling and disposal practices for load shifting, storage, mobile equipment interactions and interaction with plant are effectively managed
- ROS-TR-05: Tyre maintenance, repair, reconditioning, recycling and disposal practices do not compromise the health of the people undertaking the work



Based on actual incidents, participants considered adequacy of the specific business inputs intended to prevent or mitigate compromise to relevant Required Operating States. Workshop participants also noted:

- While tyre fitters (maintenance technicians) are the highest fatality occupational group in mining, not all tyre related fatal injuries involve specialists
- Tyre and rim event fatality causes, and their prevention and mitigation controls, are well understood
- Most tyre and rim events occur through the inconsistent application of known business inputs, e.g., through a lack of knowledge or inadequate monitoring

This work identified these industry level opportunities:

- Developing industry validated content for operational site reviews of the business inputs that prevent or mitigate significant tyre and rim events including maintenance and operational practices, maintenance equipment and work environment design
- Providing comprehensive and well-structured information that can be applied by industry to review and update training resources and competency requirements for both tyre and rim maintainers and supervisors
- Preparing problem statements for OEM and third-party designers, supported by detailed operational scenarios, to improve the design of wheel assembly maintenance equipment, e.g., for tyre handling equipment, robot removal of wheel assembly attachments, etc
- Preparing problem statements for OEM and third-party designers to that confirm opportunities for step-change innovations in wheel assembly design

PROJECT PROGRESS

In 2020, EMESRT coordinated a working group to develop and deliver a work plan to realise these industry level opportunities. The Tyres and Rims working group, made up of 39 experienced individuals representing 19 organisations, meet monthly to review work plan progress.

The CFw was based on industry information, guidance, operation experience and know-how and included review of:

- EMESRT Design Philosophy 2 - Tyres and Rims
- Regulator information from multiple jurisdictions incident reports, bulletins, publication analysis, position papers, etc
- Operating site, company and industry documents
- Research and technical information, e.g., incident taxonomies
- Relevant Standards and Guidelines

Project outs include a Tyre and Rim Management Control Framework (CFw), draft self-review tool and a beta version Knowledge Hub.

This EMESRT work led to two research projects:

- Equipment design ACARP project Tyre Handling Equipment and System Design (Project C33005)
- Work environment monitoring ACARP project Real-time Safety Monitor and Alert System for Tyre and Rim Handling Maintenance EYECUE™ (Project C33007)

In 2021, the EMESRT Tyre and Rim Management Knowledge Hub will be launched and will contain curated collection of tools, case studies, reference information, links to relevant websites and other informative resources.

For more information regarding this industry project please visit the EMESRT website - emesrt.org.

1.2.3 INDUSTRY PROJECT 3: MOBILE EQUIPMENT FIRES MANAGEMENT

This industry project is led by Rio Tinto representative Mark Geerssen.

BACKGROUND

Mobile equipment fires occur regularly in the mining and resources industry and there are clear health and safety drivers to improve the understanding and application of fire prevention and mitigation controls.

The EMESRT *Design Philosophy 4 (DP-4) – Fire* was published in 2007 and provides visual operational scenario information for the designers of mobile equipment and fire detection and suppression systems. It has this objective: to prevent harm related to equipment fires to as low as reasonably practical, including consideration in design for foreseeable human error.

In 2018 EMESRT Advisory Group (EAG) members committed to facilitating an industry project to improve mobile equipment fire management. This decision was based on:

- Present significant fatality risks for operators, maintainers and emergency responders
- Can be catastrophic in underground operations
- Incur considerable direct and indirect costs, e.g., equipment repair or replacement, disruption to operations, litigation, increases in insurance premiums, etc
- Are formally reported in most mining jurisdictions and event patterns and their prevalence has been extensively analysed and reviewed
- Regulators now expect that mine operators can improve performance
- The range and complex interdependency of the business inputs necessary for effective and reliable fire prevention and mitigation controls

In 2019, this EMESRT Project was scoped and developed at two industry workshops, using the EMESRT Control Framework (CFw) approach. Experienced and well qualified participants from both member and nonmember companies confirmed six aspirational Required Operating States (ROS) as the minimum set necessary for consistently safe and productive mining operations, without significant mobile equipment fire events:

- ROS-EF-01: Mobile plant design prevents interactions between flammable materials, fuel and ignition sources
- ROS-EF-02: Mobile plant is maintained to a schedule and to OEM standards. Specific fire prevention and mitigation checks are part of the maintenance process. There are no early operational failures
- ROS-EF-03: Mobile plant is operated productively and safely within operating design limits, avoiding fire or potential fire incidents
- ROS-EF-04: Local response to fires or potential fires on mobile equipment is effective with early detection and prudent local response
- ROS-EF-05: Maintenance activities on or around mobile equipment do not cause fires
- ROS-EF-09: Effective emergency response, beyond local response, limits fire losses

Based on actual fire incidents, participants considered adequacy of the specific business inputs intended to prevent or mitigate compromise to relevant Required Operating States. This work identified these industry level opportunities:

- Using fire triangle logic and working with multiple stakeholders, there are significant opportunities to design future mobile equipment that has increased fire resistance and has adequate and integrated fire detection and suppression systems
- Using fire triangle logic and working with multiple stakeholders, there are opportunities to increase the fire resistance of existing mobile equipment and improve fire detection and suppression systems

- Producing mine operator information about the fire potential and required controls for new technology mobile equipment, e.g., battery, fuel cell power sources, etc
- Improving minimum standards for mobile equipment fire risk analysis, e.g., ensuring that assessment assumptions and minimum standard maintenance information is provided for mine operators
- Improving the detection and alerting for fire, or potential fire situations, on mobile equipment
- Developing industry validated content for operational site reviews of the business inputs that prevent or mitigate mobile equipment fires, e.g., operating, maintenance, and emergency response practices

PROJECT PROGRESS

During 2020, EMESRT coordinated a working group to develop and deliver a work plan to realise these industry level opportunities. The Equipment Fires Working Group, made up of 32 experienced people representing 17 organisations, meet monthly to review work plan progress.

The CFw was based on industry information, guidance, operation experience and know-how and included review of:

- EMESRT Design Philosophy 4 – Fire
- Regulator information from multiple jurisdictions - incident reports, bulletins, publications analysis, position papers, etc
- Operating site, company and industry documents
- Research and technical information, e.g., incident taxonomies
- Relevant Standards and Guidelines, e.g., ISO 19296 Mining - Mobile machines working underground - Machine Safety First edition 2018-11

In 2021, this industry project expects to:

- Continue to collaborate, sort and share information at an industry level on:
  - Equipment design
  - Good maintenance practices
  - Detection and suppression system design, installation and maintenance
- Refine the draft industry self-review tool
  - Comprehensive good practice resource to adapt for internal company use
  - Use to baseline and then improve performance
- Confirm industry innovation projects and engagement schedule
- Formally launch the Equipment Fires Management *Knowledge Hub - timing pivots on adequate content and additional navigation aids*
- Develop project management templates for operating sites (key Knowledge Hub content)

NEXT STEPS

- Review and update DP-4: Mobile Equipment Fires Management
- Continue to collaborate, sort and share information at an industry level on:
  - Equipment design
  - Good maintenance practices
  - Detection and suppression system design, installation and maintenance
- Refine the draft industry self-review tool
  - Comprehensive good practice resource to adapt for internal company use
  - Use to baseline and then improve performance
- Confirm industry innovation projects and engagement schedule
- Formally launch the Equipment Fires Management Knowledge Hub - timing pivots on adequate content and additional navigation aids
- Develop project management templates for operating sites (key Knowledge Hub content)

For more information regarding this industry project please visit the EMESRT website - emesrt.org.

1.2.4 INDUSTRY PROJECT 4: HUMAN FACTORS DESIGN FOR DIVERSITY

This industry project is led by BHP representative Iain Curran.

BACKGROUND

In 2018, multiple EMESRT companies recognised that an increase in the diversity of their mining workforce was creating a potential exposure to health and safety hazards when operating and maintaining earth moving equipment. This led to a review to characterise the range and extent of exposure issues that culminated in a Human Factors Design for Diversity (HFDD) scoping workshop with 20 individuals representing 12 organisations.

In 2019, EMESRT recognised that further problem definition work on this complex and broad reaching issues was required. This was the catalyst behind a successful funding application for ACARP Project C28034, led by Prof Burgess-Limerick from the University of Queensland with this scope.

Mining equipment human factors design for workforce diversity with these objectives:

- To identify and describe design issues with current mining equipment which are a barrier to workforce diversity
- To document and evaluate remedial control measures currently undertaken at sites
- To communicate the results of the investigation to equipment designers and mine sites

In 2020, the research project report was published with following significant observation:

"The considerable consistency observed across focus groups and workshop observations undertaken during this project confirms that the concerns regarding the current design of mining equipment which prompted the project were justified in that aspects of earth moving equipment designs may unnecessarily restrict the range of potential employees who can operate and maintain the equipment, and in turn create elevated risks of injury for those who currently undertake tasks associated with operating and maintaining the equipment. The observations also confirm the concerns are not limited to one particular mine operator, mine site or original equipment manufacturer."

ACARP Project C28034 Mining Equipment Human Factors Design for Workforce Diversity

In 2021, EMESRT will reference this resource for scoping an industry project, the EAG anticipate that this may require reviews of:

- Known design standards
- Equipment design for operations and maintenance
- Current operational practice

For more information regarding this industry project please visit the EMESRT website - emesrt.org.

2. THE EMESRT CONTROL FRAMEWORK APPROACH

Since 2017, EMERST has been developing the Control Framework (CFw) approach and this is now a core operational process used for all new Industry projects. A CFw is highly iterative and adaptive process that begins with asking:

'What has to be in place for work to go right?'

It uses these organising questions to organise the knowledge and experience of contributors:

1. What is the business purpose?
2. What safe and productive operating states are required to deliver the business purpose?
3. What can cause failure?
4. What are the business inputs that prevent or mitigate failure?
5. What is the expectation of these business inputs and how are they?
    - Specified
    - Implemented, and
    - Monitored

The CFw approach is aligned with Failure Modes and Effects Analysis, Human Factors, and the definition elements of the ICMM Critical Control Methodology. It allows real-world inputs and experience to be mapped to the safe and productive operating states required to deliver business purpose.

The mapping step uses these interlinked hierarchical components to develop a deep understanding of complicated problems:

- **Required Operating States** (ROS) that deliver business purpose
- The **Credible Failure Modes** (CFM) that can compromise Required Operating States - these are validated by incident experience
- The **Business Inputs** (BI) that support the establishment and maintenance of the required operating states by preventing or mitigating the credible failure modes – these are mapped into the CFw from operational practice

Each Business Input has a clear title, an expectation it should deliver upon, a specification, a description of how it is implemented, and details of how its status is monitored and verified.

Using the CFw approach establishes both a 'whole of system' overview and a structure that is linked to detailed operational practice. Working this way provides information and insights about the dynamic interconnects between personnel, equipment, the work environment, workgroups carrying out different tasks and overall coordination. This promotes the systematic identification of improvement opportunities.

It is also flexible approach that allows the ongoing updating of all CFw component descriptions, content, and links as new information becomes available and new insights develop.

Applying the CFw approach produces the networked and hierarchical structure represented in the figure below:

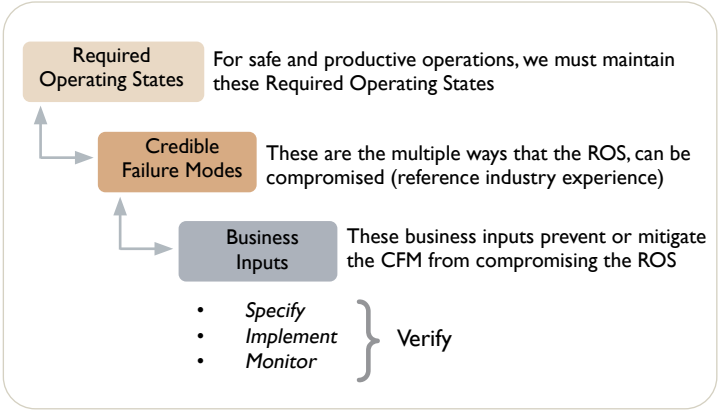


Figure 3: The hierarchy and components of a CFw.

Developing a CFw requires the systematic review and assessment of the robustness and reliability of business inputs. It follows these steps:

1. Confirm the safe and productive outcomes relevant at an enterprise level, these Required Operating States (ROS) are the basis of CFw organisation, e.g., Operators Give Way
2. Identify and catalogue the credible failure modes that can compromise each required operating state
3. Based on each credible failure mode, identify the business inputs that prevent or mitigate the required operating states being compromised
4. Using site documentation and knowledge, map how each business input is specified, implemented, and monitored to prepare CFw Version 1
5. Present CFw Version 1 to knowledgeable employees for review, updating and validation to CFw Version 2 (baseline)
6. From the validation workshop, confirm the opportunities for improvement required to achieve nameplate Mobile Equipment Interaction (MEI) Control Performance and present for senior management review
7. Use the CFw information as a reference when considering further improvements to MEI controls

3. HOW EMESRT OPERATES

3.1 THE SCOPE OF EMESRT ACTIVITIES

EMESRT membership is limited to mining companies with contracted financial management and secretariat support provided by third parties on a needs basis.

The EAG is aware of managing anti-trust issues and the below dot points are communicated in all of the workshops and other industry forums. This process has been in place since OEM engagement work commenced in 2006.

EMESRT foster candid dialogue, transparent industry level collaboration, open sharing of non-commercial information, and active stakeholder engagement.

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 other third-party suppliers
- Listen, consider and value OEM 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

3.2 ANNUAL WORK PLAN PROCESS

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

- The progress of current industry projects, outstanding activities and the potential end date
- Identify burning industry issues
- Work out what to do within EMESRT's remit
- Assign project lead(s)
- Identify support personnel
- Map out project plan, including objectives and deliverable
- Allocate budget(s)
- Determine the following year's membership fees based on work plan identified and budget allocated
- Monitor progress on a regular basis

3.3 CONTINUITY AND RENEWAL

One of the significant strengths is the continuity of representatives from member organisations. A core group of company representatives were responsible for establishing EMESRT and remain involved in 2020.

Over that time, they have each made significant contributions to developing the reach and profile of the organisation and have developed and evolved the operational processes that can deliver successful industry level projects. Importantly, they have also established and maintained good relationships with senior managers in OEM and industry third-party supplier organisations.

One of the most important challenges has been capturing the decades of effective work so that EMESRT can continue beyond its original cohort of volunteers. Meeting this challenge has required formalising and updating EMESRT operational processes.

3.4 SENIOR MANAGEMENT (DECISION MAKER) ENDORSEMENT

The effectiveness of EMESRT's approach for engaging with and influencing organisational decision-makers is reviewed at each EMESRT strategy and planning review meeting.

While EMESRT's role within the industry is well understood and regarded by senior OEM leaders and other industry supplier organisations, it has a lower profile in mining companies, including those that are members. This uneven profile was reconfirmed during ongoing collaboration with the ICMM ICSV programme through 2020 where senior OEM manager participants consistently and publicly endorse EMESRT successes and its ongoing relevance.

This situation reflects the underpinning philosophy of focusing on the delivery of useful outcomes. However, the EAG are working to increase the profile and influence with all stakeholders to increase the capacity and support the achievement of project outcomes.

The stakeholders include research organisations from around the globe, regulators, industry associations along with senior managers through to CEO level in operating mining companies, including EMESRT members.

APPENDIX 1: EMESRT 2020 SUCCESS FACTO

SUCCESS FACTORS		EMESRT SUCCESS FACTOR DETAIL *(Adopted with permission from the Carbon Trust[1])*
1.	Working at an industry level	EMESRT promotes collaborative industry projects that deliver sector-wide benefits. Decisions on project areas are identified through rigorous, objective, fact-based analysis and engagement with stakeholders across the mining sector.
2.	Real world business understanding of financial drivers and leverage	The EMESRT approach is to define problems so that OEM and third-party providers recognise the commercial opportunities. This indirect, non-commercial approach is achieved through influencing supplier product design and appropriate mine site customer alignment. The success of this approach pivots on the engineering and commercial expertise and experience of EAG members and their relationships with OEM and third-party suppliers.
3.	Understanding that innovation is market-driven not pushed by technology	The well-accepted EMESRT approach is technology agnostic and identifies the potential market by defining improvement opportunities. This approach allows OEM's and other providers to then develop their own business case for further research, development, manufacturing, and marketing.
4.	Governance - structure, funding, risk management, renewal and continuity	EMESRT has established financial and operational governance processes that meet the requirements of member companies. EMESRT has active anti-trust processes and maintains the confidence of OEM and other third-party industry suppliers. It has an active risk management process based around an annual review of performance against its Success Factors. This annual review includes operating processes, purpose project delivery and organisational renewal and continuity. There are also regular reviews through the year on progress with industry projects.
5.	Senior management (decision maker) endorsement	EMESRT is working to increase its influence with all stakeholders to increase its capacity to deliver industry projects and other outcomes. EMESRT stakeholders include research organisations from around the globe, regulators, industry associations along with senior managers through to CEO level in operating mining companies, including our own members.

OR PERFORMANCE SNAPSHOT

SUMMARY OF EMESRT 2020 PERFORMANCE

In 2020 EMESRT industry project progress continued supported by monthly meetings, workshops and webinars.

Each project was chosen based on an analysis of member company and broader industry performance and for each a compelling case for improvement and innovation has been developed.

EMESRT continues to actively support the ICMM Innovation for Cleaner Safer vehicles programme - a global collaboration between mining companies, OEM's and third-party suppliers and industry associations.

EMESRT continues to be recognised as the 'trusted voice of the industry' based on active industry wide engagement since 2006.

For the EMESRT vehicle interaction control improvement project, EMESRT provided ongoing support for key enabling projects such as industry standards setting.

Each EMESRT industry project has involved stakeholders in the Control Framework validation workshops and the establishment of subsequent workgroups.

The CFw approach systematically identifies innovation opportunities, as these projects develop, they are shared with all interested stakeholders who can then make their own decisions about potential commercial opportunities.

In 2020 the outputs from EMESRT processes and working groups have been shared across the industry. This has included further development of business input functional requirements that are available for review by OEM's and other industry suppliers for commercial opportunities.

EMESRT member companies have committed to remain with the organisation through 2021.

This positive position is underpinned by long term relationships between EMESRT member company representatives and OEM organisations.

EMESRT position as the credible and trusted voice of the industry has been confirmed by industry project workshop attendance and ongoing requests to contribute to industry level work such as the ICMM ICSV programme.

There is ongoing project oversight and contributions from all advisory group members. Project milestones are being achieved. Governance structures and common project management approaches are in place for all industry projects.

EMESRT remains financially viable, and processes have been developed to actively manage Secretariat and consultant support.

In 2020 EMESRT finalised an effective, professional, and consistent stakeholder management processes.

The is process is being applied and includes engaging with senior managers in member companies.

The basis of the EMESRT approach is to provide value adding industry level resources and information.

In 2020 the creation and deployment of the VI Knowledge Hubs and development of a Knowledge Hub for each industry project areas in 2021.

[1]The Carbon Trust is an independent, mission-driven, expert partner of leading organisations around the world, helping them contribute to and benefit from a more sustainable future (find out more: www.carbontrust.com).

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