EMESRT

Earth Moving Equipment Safety Round Table

2022 ACTIVITY REPORT

WORKING WITH INDUSTRY SINCE 2006

EMESRT.ORG

Glossary of Terms

ACARP	The Australian Coal Industry's Research Program
BI	Business Inputs
CFM	Credible Failure Modes
CFw	Control Framework
DP	Design Philosophy
EAG	EMESRT Advisory Group
EME	Earth Moving Equipment
EMESRT	Earth Moving Equipment Safety Round Table
FMCE	Fire Management Control Effectiveness
ICMM	International Council on Mining and Metals
ICSV	Innovation for Cleaner Safer Vehicles
ISO	International Organisation for Standardisation
OEM	Original Equipment Manufacturer
OTR	Off The Road
PDS	Proximity Detection System
PR	Performance Requirement
ROS	Required Operating States
TWG	Technical Working Group
VI	Vehicle Interaction

Contents

EMESRT

EMESRT is a global 'safety by design' initiative established in 2006 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.

KEY PRINCIPLES

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

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's), 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.

MEMBERS FOR 2022

TIER 1

1. Alcoa
2. AngloAmerican
3. AngloGold Ashanti
4. BHP
5. Glencore
6. Kiewit
7. Rio Tinto
8. Teck Resources
9. Vale

TIER 2

1. Tronox
2. Whitehaven Coal

INTRODUCTION

EMESRT is a global initiative involving major mining companies and remains the 'common voice' of the mining industry. EMESRT engages with key mining industry Original Equipment Manufacturers to advance the design of equipment to improve safe operability and maintainability beyond Standards.

Throughout its 16-year history, the mining company membership-based entity has focussed on health and safety problems of real relevance to the mining industry.

EMESRT is a respected high-influence global organisation that delivers industry-level understanding of complex health and safety problems. Its effectiveness rests on trusted relationships with OEM's and third parties. This trust is vital to sustain EMESRT's relevance and ability to influence the design outcomes. EMESRT interacts by genuine two-way engagement with all stakeholders.

During 2022, EMESRT continued its pursuit of the vision for: *A mining industry free of fatalities, injuries and occupational illnesses associated with operating and maintaining earth moving equipment* and will continue to do so into the future.

This report provides a summary of EMESRT activities including industry level project progress, engagement with industry, and how EMESRT operates. It also highlights a number of milestones achieved in collaboration with industry during 2022.

The EMESRT Advisory Group hope that this 2022 Activity Report is useful and relevant to EMESRT member companies, the wider EMESRT community, and others who might find the content of interest.

ADVISORY GROUP

The EMESRT Advisory Group (EAG), comprised of one representative from each Tier One member company, provides strategic direction for all EMESRT Technical Working Group activities to ensure consistency in the messaging to the OEM's, and third party manufacturers and suppliers. The EAG identifies and agrees to prioritise industry work areas. The EAG then confirms the project strategy, identifies key industry stakeholders, develops work plans, allocates budget and identifies support resources required to deliver on the agreed priority work areas.

Each member contributes to the EAG based on their diverse experience, skills and availability and may lead one or more agreed priority work areas.

EMESRT's clear purpose and volunteer structure is enabled by effective and efficient project management processes. EMESRT sets an annual membership fee to provide the resources necessary to implement it approved work plans.

EMESRT work plans follow a simple and effective four-step sequence:

1. Rigorously defining and documenting the problem to be addressed from the perspective of mining equipment users
2. Preparing a draft industry project landscape diagram based on the gap between the current and future required state. It identifies stakeholders, confirms current knowledge and articulates project deliverables
3. Building project communities through subject focused technical working groups
4. Coordinate resources to leverage industry-level innovations and improvements

The EAG meets monthly to discuss membership, finances, current industry project progress, engagement opportunities and industry emerging issues.

Industry project selection is based on member and industry experience and concern, a compelling case for improvement, and EMESRT's ability to influence change. EAG members lead and coordinate the technical working group formed for each project.

CURRENT PROJECT FOCUS AREAS

- Vehicle interaction control improvement
- Tyre and rim management
- Mobile equipment fire management

More information on the above project focus areas is available in the following sections of this report.

EMESRT pays tribute to the individual project leads and respective technical working groups for achieving a number of milestones during 2022.

The outcomes of the practical EMESRT initiatives are globally recognised, from the Design Philosophies developed in 2007, Control Framework approach developed in 2017 and Performance Requirement 4 – Mobile Equipment Fire Management published in 2021.

MILESTONES ACHIEVED DURING 2022

- Continued Vehicle Interaction Control Effectiveness baseline mapping completed at EMESRT member mine sites
- Fire Management Control Effectiveness baseline mapping pilot completed at one EMESRT member mine site
- Launch of the Mobile Equipment Fire Management Knowledge Hub
- Engaged with users and designers in several global webinars focusing on fire management
- Vehicle interaction control improvement project guide developed, print and web version
  - To be published for the EMESRT / ICMM ICSV workshop planned for Q2 2023
- Vehicle Interaction Functional Performance storyboards for Surface and Underground reviews continued and will be finalised in 2023
- Developed and matured the 18-tyre and rim fatality exposure scenario storyboards
- Developed realistic animations for all storyboards and tested their validity with user groups in several workshops
- Developed tyre handler problem-based design statements
- Developed the Fatalities, serious injury, or damage to machine and equipment poster
- Developed the Tyre handler mobile equipment and tyre handling attachment options matrix poster
- Drafted the mobile equipment fire management project report 2018-2023
- Continued to develop the working relationship between the ICMM ICSV VI team and EMESRT Vehicle Interaction improvement team
- Hosted the ICMM ICSV Vehicle Interaction global workshop in Brisbane attended by 77 industry representatives from Miners, OEM's, Third Parties and other industry stakeholders
- Presented at the Queensland and New South Wales mining industry forums
- Gained Category C overarching liaison status with ISO/Technical Committee 127/Sub Committee 2/Joint Working Group 28 and were active in the Collision Warning and Avoidance ISO 21815 standards development

ADVISORY GROUP *cont...*

EMESRT maintains a concentrated focus, prioritising and working on industry-level high consequence issues to make genuine progress. For each focus area, the involvement of key industry stakeholders is actively sought. EMESRT's mature engagement process, experience and flexible approach guide the work plans and bring the industry stakeholders together to focus mitigating and or eliminating high consequence safety and health problems.

The success of EMESRT is based on good relationships, open and honest two-way dialogue, and a practical industry-level approach that:

1. Defines the landscape of the problem
2. Identified the stakeholders who can influence design changes
3. Stimulate stakeholders to work on industry level improvements through educating stakeholders about the root causes

The EAG extends its appreciation to all involved for their time and commitment in delivering EMESRT's vision and purpose and looks forward to continuing the collaborative approach in 2023.

MEMBERSHIP AND MEMBER RELATIONSHIPS

In 2022, three tier one (AngloGold Ashanti, Kiewit, Vale) and two tier two (Tronox, Whitehaven Coal) members joined EMESRT.

Existing member companies Alcoa, AngloAmerican, BHP, Glencore, Rio Tinto and Teck Resources welcomed the five new members, and together they continued to pursue EMESRT's purpose to: *Accelerate development and adoption of leading practice designs to minimise the risk to health and safety through a process of Original Equipment Manufacturer, contractors and user engagement.*

EMESRT member company representatives bring a wealth of knowledge and experience to the table and are committed to working together to achieve a collective influence to improve health and safety outcomes. They actively promote the EMESRT engagement process at industry forums to a wide audience around the globe and have introduced resource materials developed by EMESRT to help understand the risks faced by operators and maintainers of earth moving equipment.

Resource materials introduced by EMESRT included:

- Performance Requirement 4 - Mobile Equipment Fire Management
- Mobile Equipment Fire Knowledge Hub
- Control Framework
- Vehicle Interaction Control Effectiveness baseline mapping process

The latter gained significant momentum during 2022 with several EMESRT member companies adopting the approach at several sites.

TECHNICAL WORKING GROUPS

During 2022, EMESRT experienced a significant growth in technical working group member numbers, in particular in the mobile equipment fire management group.

This growth is attributed to the relevance of the informative resource materials developed by this technical working group and stakeholder engagement through one-on-one discussions, monthly reoccurring meetings, webinars and attendance at engineering forums.

The mobile equipment fire management technical working group has grown through new EMESRT member representatives and through increased interest from the wider industry globally. This was the catalyst for the introduction of an afternoon session of the reoccurring monthly meeting. This way, everyone can participate, no matter what time zone they are in.

In summary, EMESRT continues to maintain its relevance to industry through an extended its global reach in 2022 with new members joining and additional technical working group patronage.

INDUSTRY ENGAGEMENT

As in previous years, EMESRT continued broad industry engagement as it remains central to how EMESRT works with stakeholders on its industry project objectives. EMESRT's work requires effective two-way industry collaboration to progress its work plan activities and relevant outcomes.

EMESRT acknowledges that effective collaboration and engagement is paramount in achieving the desired outcomes to very complex problems. The EAG thanks all who have participated or contributed to EMESRT industry initiatives during 2022 and the preceding years.

EMESRT fosters honest and open dialogue, while not breaching anti-trust requirements, builds transparent industry level collaboration, shares openly non-commercial information, and encourages active engagement.

During 2022, EMESRT presented at several industry coordinated forums in person and delivered global online webinars on current industry initiatives. There is no doubt that presenting at these industry events contributed to increased interest in EMESRT and growth of EMESRT technical working group member numbers. That said, member company representatives also actively promote EMESRT activities internally, at public forums and industry events.

Throughout the year, EMESRT continued to collaborate with the ICMM Innovation for Cleaner Safer Vehicles (ICSV) initiative and in October hosted the EMESRT / ICMM ICSV Vehicle Interaction (VI) resources confirmation workshop.

The three-day workshop was attended by 77 participants representing 37 organisations with delegates from surface and underground miners, OEM equipment companies, original technology providers, contractors, researchers, consultants and industry organisations. Many travelled from overseas to be in Australia for this important step in moving the ICSV VI strategy forward.

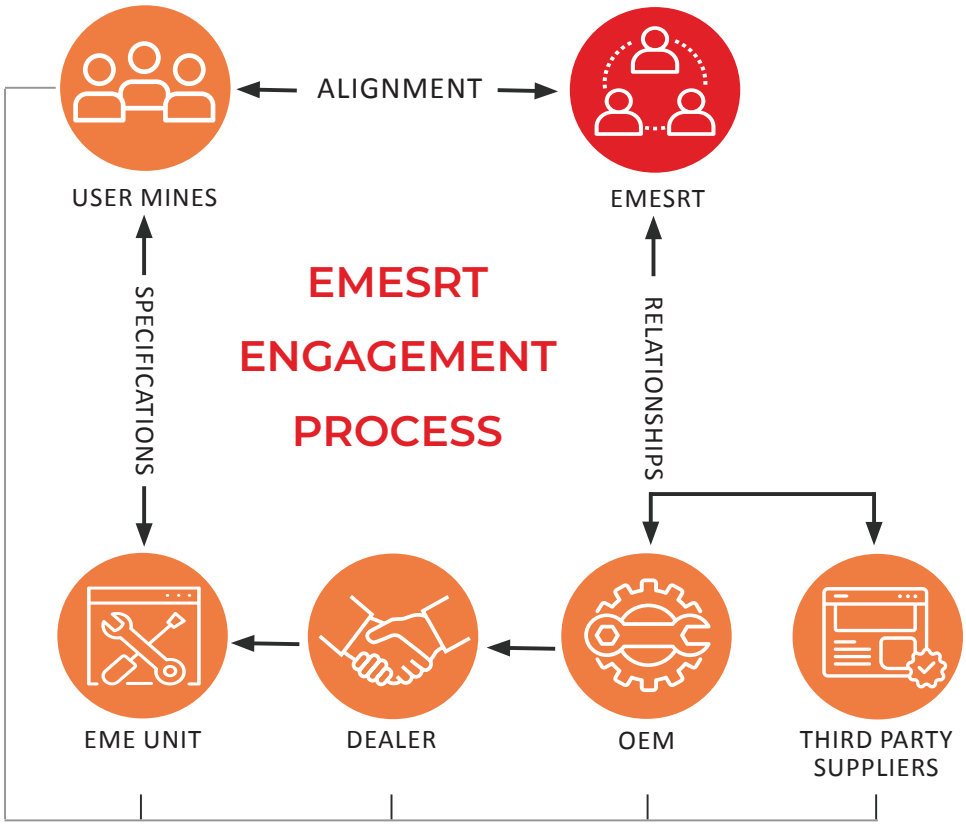
The participants focused on challenging the validity of the Vehicle Interaction (VI) improvement resources and processes developed by EMESRT. There was considerable alignment and great suggestions on further improvement in some of the resources, including both surface and underground functional performance storyboards.

In January 2022, EMESRT gained Category C liaison status with ISO/TC 127/SC 2/JWG 28 committees and has been active in the ISO21815 Collision Warning and Avoidance standard review process. Although EMESRT is not eligible to vote, it does provide a path for the broader industry stakeholders to contribute collectively and provide relevant industry developed information to the ISO Committee.

The EMESRT Advisory Group looks forward to continuing its engagement with industry to drive positive project initiative outcomes in 2023 and beyond.

Image on left page: Mark Geerssen and Tony Egan presenting at the Mine Engineering Forums held in New South Wales and Queensland, Australia.

Figure 1: The EMESRT engagement process.



DESIGN PHILOSOPHIES

EMESRT's approach to the design challenges in large surface earth moving equipment is based on eight design philosophies. These design philosophies were initially developed in 2007 to present EMESRT's aligned views on objectives, general design outcomes, hazards to be mitigated and examples of industry attempts to mitigate unwanted events.

Through the design philosophies, EMESRT presents an aligned industry voice that assists OEM's in designing equipment that reduces the exposure to unwanted events to an acceptable level (including foreseeable human error).

EMESRT's design philosophies are not technically prescriptive. They are intended to support OEM equipment design processes in considering problems and identifying design controls or features that effectively address unacceptable exposure to users.

EMESRT's eight priority design philosophies focus on problem areas where improved human factors design could reduce unwanted events associated with equipment operation or maintenance.

Mining companies generally manage risk to ALARP, or As Low As Reasonably Practicable, through the use of the Hierarchy of Controls. This approach to managing risk underpins the format in which the EMESRT Design Philosophies are presented; to assist with risk analysis and control measure identification.

Further information about the Design Philosophies is available on the EMESRT website - emesrt.org.

EMESRT DESIGN PHILOSOPHIES

DP-1 ACCESS AND WORKING AT HEIGHTS

The objective is to prevent harm related to access and working at heights (where there is a risk of falling at least 6' (1.8m) or if serious injury may result) on equipment; to prevent slip/trips, sprains/strains, falls from height and failure to egress in emergency events to as low as reasonably practical, including consideration in design for foreseeable human error. For example, injury during access to equipment and its routine service and inspection points, work platforms and operator workstations due to poor location of service and inspection points, lack of fall-from-height protection, premature failure of components due to corrosion, slippery surfaces, accumulation of dirt or other material, or poorly lit environments.

DP-2 TYRES AND RIMS

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. For example, harm due to uncontrolled release of pressure from the tyre and rim assembly during operation and maintenance.

DP-3 EXPOSURE TO HARMFUL ENERGIES

Prevent harm related to exposure to moving machine parts, failure of hydraulic equipment or systems, or other energy sources, such as compressed air, heat, electricity and gravity to as low as reasonably practical, including consideration in design for foreseeable human error. For example, harm from exposure to energies such as heat, electricity, radiation, compressed air, high pressure fluids (including hydraulic fluids) and falling objects.

DP-4 FIRE

Prevent harm related to equipment fires to as low as reasonably practical, including consideration in design for foreseeable human error. For example, harm from fire arising from damage (including heating, melting and chaffing) to electrical cables and components, hydraulic hoses and fuel lines due to design inadequacies including poor location, inadequate separation of fuel and ignition sources, and flaws in clamping or restraints.

DP-5 MACHINE OPERATION AND CONTROL

Prevent harm, during machine operation and control, to as low as reasonably practical, including consideration in design for foreseeable human error. For example, musculoskeletal injury or illness due to workstation design (including seat and seatbelt design, openings and cab height) that promotes biomechanically compromised postures for the 5th percentile female to 95th percentile male body dimensions.

DP-6 HEALTH IMPACTING FACTORS

Prevent harm from exposure to health impacting factors to as low as reasonably practical, including consideration in design for foreseeable human error. For example, harm from exposure to health hazards such as extreme temperatures, excessive vibration and noise levels, particulates, gases and vapours within the operating workspace; and musculoskeletal factors due to poor ergonomic design of equipment and controls.

DP-7 MANUAL TASKS

Prevent harm due to manual tasks during installation, maintenance and operations of equipment, to as low as reasonably practical, including consideration in design for foreseeable human error. For example, musculoskeletal injury from exposure to risk factors such as forceful exertion, awkward or static posture, repetition or prolonged duration, and hand-arm and/or whole-body vibration due to manual tasks associated with installing, operating and maintaining the equipment.

DP-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 consideration in design for foreseeable human error. For example, asphyxiation from irrespirable atmosphere due to lack of adequate ventilation.

DESIGN PHILOSOPHIES IN REVIEW

In 2022, the EAG commenced reviewing all DP content for gaps with respect to future design opportunity considering:

- Human factors design diversity
- Introduction of alternative energy/powered earth moving equipment and their associated platforms as they migrate from their existing platforms to new designs, e.g.:
  - Error proofing
  - Fire mitigation
  - Elimination of live work
  - Isolation
  - Routine interactions and checks, etc

The DP review process will continue in 2023, and updated DPs will be distributed to members of the EMESRT technical working groups for comment. This will be followed by OEM engagement to finalise the DPs.

Updated DPs will be made available on the EMESRT website - emesrt.org.

INDUSTRY LEVEL PROJECTS

Top image: Mark Geerssen and Tony Egan presenting at the tyre handler workshop held in Brisbane, Australia.

Each EMESRT industry project has a defined objective and is led by an Advisory Group member who is responsible for achieving specified outcomes. EMESRT uses a formal project management methodology for all industry projects. This, along with the control framework approach, provides users with practical results.

CONTROL FRAMEWORK APPROACH

Since 2017, EMESRT has developed and refined its Control Framework approach, which is now a core operational process used for all industry projects. The control framework is a highly iterative and adaptive process that begins with asking:

What has to be in place for the task to go right?

More information on the control framework is available on page 12.

CONTROL FRAMEWORK

Since 2017, EMESRT has developed and refined its Control Framework approach, which is now a core operational process used for all industry projects. The control framework is a highly iterative and adaptive process that begins with asking:

What has to be in place for the task to go right?

The control framework uses five organising questions to sort and pattern the knowledge and experience of participants:

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:
   a. Specified
   b. Implemented
   c. Monitored

> *The Control Framework approach has been developed by EMESRT as a practical way to apply new control thinking*, EMESRT Advisory Group.

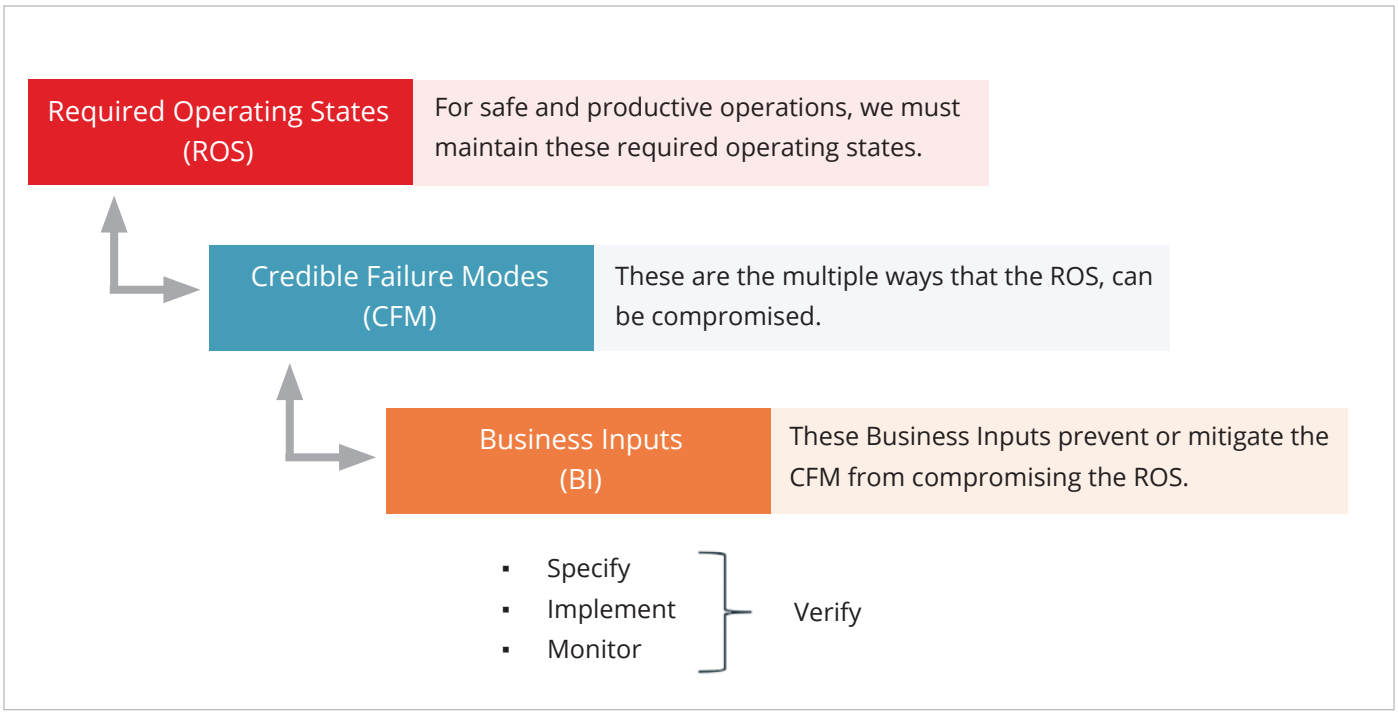
Using these questions, EMESRT maps real-world inputs and examines their interlinked hierarchies to develop a deep understanding of complicated problems (Figure 2, page 13):

1. **Required Operating States** that deliver the business purpose
2. **Credible Failure Modes** that can compromise the required operating states – these are validated by incident experience
3. **Business Inputs** that help establish and maintain the required operating states by preventing or mitigating the credible failure modes – these are mapped into the control framework from site systems (work as documented) and then validated based on operational practice (work as done)

EMESRT's control framework approach provides a whole-of-system overview and structure that is linked to operational practice. It develops insights into the dynamic connections between people, equipment, environments and work teams.

More detailed information about the EMESRT control framework approach is available on the EMESRT website – emesrt.org.

Figure 2: The hierarchy and components of a control framework.



CURRENT INDUSTRY PROJECTS

At the end of 2022, EMESRT was leading three active industry-level projects, each with an established Technical Working Group working on agreed project objectives.

Each project is led by an EAG member who provides strategic oversight, coordinates activities and leads discussions on project progress/roadblocks at the technical working group monthly meetings.

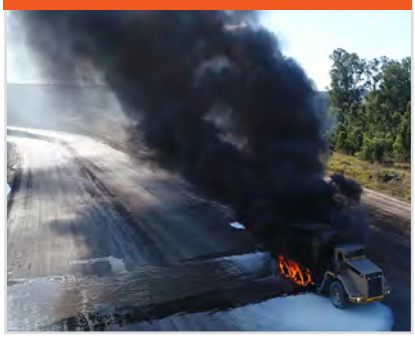
An overview of each project is provided in the following sections of this activity report.

THE THREE CURRENT EMESRT PROJECTS

INDUSTRY PROJECT 1
Vehicle Interaction Control Improvement

INDUSTRY PROJECT 2
Tyre and Rim Management

INDUSTRY PROJECT 3
Mobile Equipment Fire Management



INDUSTRY PROJECT 1:

VEHICLE INTERACTION CONTROL IMPROVEMENT

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

INTRODUCTION

Based on the EMESRT Design Philosophy 5 – Machine Operation and Control published in 2007, EMESRT initiated an industry project in 2013 to improve vehicle interaction controls.

The motivation for this project was the continued high number of unwanted vehicle interaction incidents with high potential for fatalities and serious injuries. This combined with the complexity and uncertainty of outcomes from existing technology, rapid development of options and interoperability concerns meant an industry user driven response was needed.

Since 2013, 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 Innovation for Cleaner Safer Vehicles (ICSV) program.

THIS INDUSTRY PROJECT

The vehicle interaction control improvement project seeks to eliminate or mitigate unwanted vehicle interactions on site. Understanding your current baseline control effectiveness through applying the vehicle interaction control framework, promotes the systematic identification of vehicle interaction opportunities for improvement in the management system elements involved.

INDUSTRY PROJECT 1: *cont...*

During 2022, several EMESRT member companies based in the United States, South Africa and Australia, completed the vehicle interaction control improvement baseline mapping process.

The process provides an opportunity for operational people to understanding their current control effectiveness and to confirm if there are discrepancies between work as documented and work as done in practice.

The process also identifies and documents opportunities for improvement in five key areas, and they are:

1. Personnel
2. Equipment
3. Operating environment
4. Mobile equipment interfaces
5. System optimisation

A part of the baseline mapping process, EMESRT produced an comprehensive vehicle interaction control improvement project guide that focusses on the preparation and delivery of a baseline validation workshop and subsequent process improvement steps. It lays a logical foundation to assess vehicle interaction technology controls in their operations by selecting and operationally integrating new technology 'react' controls.

The Guide focuses on Phase 1 and 2 of the Vehicle Interaction Control Improvement project guide:

1. Understand vehicle interaction control baseline i.e., know where you are starting from
2. Identify and correct any gaps between the baseline design and current operations

The objective of the Guide is to provide consistent structured guidance for resource industry operating sites, so that they can deliver projects that improve vehicle interaction controls.

Both the hard copy and web versions will be launched during the EMESRT / ICMM ICSV planned workshop in Q2 2023.

The surface functional performance scenario storyboards, developed two and a half years ago, helped with the implementation of some baseline work being done in both surface and underground environments. Numerous discussions with designers were held on content, format and usability during the year. More discussions will be scheduled in early 2023 to crystalise the storyboards into a final surface version.

During 2022, there was parallel development of a draft set of underground functional performance storyboards by two groups of users involved in technology applications at sites.

Significant focus in early 2023 is planned to bring the work together into a single underground storyboard set similar to the level of the surface scenarios.

> *The intent of the Guide is to build industry capability whereby reliance on consultants to facilitate the workshops is made redundant,* EMESRT Advisory Group.

EMESRT has developed a wide range of support material, available on the EMESRT Vehicle Interaction Control Improvement Knowledge Hub. The Hub is accessible through the EMESRT website – emesrt.org.

In early 2022, Mining3 granted EMESRT permission to use some or all of the content from the ACARP Project C26028 - PDS Validation Framework: Phase 3 final report in developing an appropriate industry technical document. A sub-group was formed to continue discussions on taking the research content and converting it into a usable guideline without compromising the intent. More discussions are planned in the first half of 2023 to progress the guideline.

In January 2022, EMESRT gained Category C liaison status with ISO/TC 127/SC 2/JWG 28 committees and has been active in the ISO21815 Collision Warning and Avoidance standard review process. Although EMESRT is not eligible to vote, it does provide a path for the broader industry stakeholders to contribute collectively and provide relevant industry developed information to the ISO Committee.
The EMESRT vehicle interaction community is supported by monthly meetings and as required face-to-face workshops. Currently the community extends to over 180+ individuals representing 59 organisations from mining companies, OEM's, researchers, third-party equipment suppliers and other interested parties.

PROJECT NEXT STEPS

- Continue to collaborate with the ICMM ICSV program to influence users around the globe
- Update and distribute vehicle interaction control improvement resources and materials
- Finalise the surface and underground functional performance scenario storyboards
- Progress development of the PDS Validation Framework guideline into an industry resource

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

INDUSTRY PROJECT 2:

TYRE AND RIM MANAGEMENT

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

INTRODUCTION

Tyre handling and maintenance of large earthmoving tyre assemblies is the second most significant source of fatal events in surface mining operations after unwanted vehicle interactions.

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

THIS INDUSTRY PROJECT

The EMESRT Design Philosophy 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.

Following a series of significant incidents in member companies during 2018, the EMESRT Advisory Group (EAG) members committed to facilitating an industry project to improve tyre and rim management.

In 2018, EMESRT established a Technical Working Group consisting of a broad range of industry stakeholders and includes 41 individuals representing 21 organisations. The Group meets on a regular basis to further progress this industry project.

EMESRT recognised that further problem definition work on this complex problem was required. EMESRT engaged with industry researchers to better understand the human factors aspects of the tasks and environment. This was the user motivation behind approving several rounds of research funding for two ACARP projects.

ACARP (Australian Coal Industry's Research Program) is a unique and highly successful mining research program that has been running in Australia since 1992.
The two ACARP funded projects are:

1. C33005 - Human Factors Aspects of Tyre Handling Equipment Design and Operation Examined within an EMESRT Control Framework Approach
2. C33007 - Real-time Safety Monitor and Alert System for Tyre Handling

In late 2022, a further ACARP Project C35020 - Human-Centred Interactive Hazard Experiences in OTR Tyre Handling was approved by the ACARP board.

More information on the three ACARP projects can be found on page 27.

In 2021, EMESRT formed a tyre handler sub-group comprising 9 subject matter experts representing 7 entities. This sub-group was instrumental in providing information and categorisation of tyre handling operational activities that populated the tyre handler workflow analysis online tool developed that same year.

The output from the online tool was used to further develop workflows and during a face-to-face workshop held in March 2022, there were 18 high consequence workflows and associated tasks mapped against the EMESRT Control Framework process were developed.

The initial workshop was followed by several online workshops where the opportunity to animate the workflows was discussed. This discussion resulting in the development of 17 scenario-based storyboard animations.

STORYBOARD ANIMATION TITLES	
1.	Aligning the wheel, rim or tyre assembly with the hub
2.	Lifting wheel or rim components
3.	Placing a tyre in a storage location
4.	Removing the tyre assembly from an earth moving vehicle
5.	Removing the wheel-rim retaining hardware
6.	Standing a tyre assembly vertically on the ground while held in the grabs
7.	Fitting the tyre assembly to the hub
8.	Fitting a tyre to a wheel rim horizontally
9.	Installing retaining hardware
10.	Lifting wheel, rim, or tyre assembly components
11.	Lifting a tyre
12.	Placing components on a rim
13.	Placing a tyre assembly on the stand
14.	Placing a tyre on a transport vehicle
15.	Placing a tyre on wheel or rim vertically
16.	Raising and flipping a tyre
17.	Releasing tyre restraints
18.	Tyre handling equipment summary

Scenario storyboard animation number 18 provides a summary of what tyre handling equipment is used for, type of equipment and credible failure modes that need to be managed, e.g. unplanned releases of loads, rapid deflation and sudden wheel rim disassembly, etc.

INDUSTRY PROJECT 2: *cont...*

In September 2022, a face-to-face workshop was held in Brisbane with 19 technical working group members representing 11 entities (10 entities participating in person and one entity online). The workshop provided the working group with the opportunity to review and comment on each of the 18 scenario storyboard animations developed.

Several improvement opportunities/ amendments were identified and documented during the workshop for all animations.

Once finalised, the scenario storyboard animations will flow into the newly funded ACARP Project 35020 Human-centred Interactive hazard experiences in off the road tyre handling. This project will commence in January 2023 with a series of face-to-face workshops with tyre fitting personnel and subject matter experts to further review the scenario storyboard animations to further understand from the user's perspective what actual on the job decisions are made and what needs to be translated to operations and design teams. Participants will review the animations in a guided, facilitated way to pause and reflect on the contributing failure modes that lead to unwanted events.

EMESRT is committed to sharing information with industry in an open and transparent manner to increase industry knowledge and capability. EMESRT developed several posters and is developing a Tyre and Rim baseline control effectiveness review guideline.

PROJECT NEXT STEPS

- Finalise and publish the 18-tyre handler scenario storyboard animations based on tasks identified
- Finalise navigation and content for the launch of the Tyre and Rim Knowledge Hub
- Identify and recognise the parameters around each scenario documented by project C33005
- Publish tyre handler problem-based design statements
- Publish the Fatality, serious injury, or damage to machine and equipment danger poster
- Publish the Tyre handling equipment and attachment option matrix poster

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

> *We are reaching a point where a substantial body of knowledge is going to be available to industry in a form that is readily explainable to all stakeholders*, Tony Egan, Project Lead and EMESRT Advisory Group member.

ACARP FUNDED PROJECTS

ACARP Project C33005
Human factors aspects of tyre handling equipment design and operation examined within an emesrt control framework approach.

The project has undertaken a detailed human factors analysis of the design and use of tyre handling equipment to contribute to the potential improvements in the design of tyre handling equipment. A scenario storyboard, instructional videos, and animated experiences are being developed, which will help provide high-fidelity learnings while translating real-world equipment applications to inform designers, project partners for database development and knowledge-sharing, and operational teams to prop their safety initiatives. The project will continue to develop and demonstrate the way in which human factors approaches can influence design in a useful and meaningful way, incorporated within the Control Framework. This project will support the ongoing implementation of the Fingermark EYECUE system (ACARP Project C3300).

ACARP Project C33007
Real-time safety monitor and alert system for tyre handling.

To install a real-time tyre and rim maintenance safety monitoring system that reduces hazardous exposure to workers by identifying and alerting workers to the potential for significant harm. The overall objective is to develop user-driven designed technology to a commercially viable standard that is readily applicable across the mining industry.

ACARP Project C35020
Human-centred interactive hazard experiences in OTR tyre handling.

To support safety in off-the-road tyre handling operations and equipment design innovations by translating real world high-consequence, material unwanted events (like direct and indirect equipment interactions that result in fatalities) into high-fidelity, interactive hazard awareness experiences. The existing training pathways vary and the education methods for off-the-road tyre servicing do not uniformly or adequately address these safety-critical events. Further, equipment and system designers can benefit from learning about these circumstances. This has been identified by EMESRT Tyre and Rim Technical Working Group. This is important because these tasks can lead to catastrophic and fatal events and tyre fitters are among the highest fatality occupational group in maintenance and trade roles in mining.

INDUSTRY PROJECT 3:

MOBILE EQUIPMENT FIRE MANAGEMENT

This industry project is led by Rio Tinto representative Mark Geerssen and Alcoa representative Peter Hasler.

INTRODUCTION

Despite ongoing improvements, there is still a high incidence of mobile equipment fires in both surface and underground mining equipment. There is a need for the hazards to be controlled through appropriate designs and management practices. In turn, regulators are requiring mandatory statutory reporting in most mining jurisdictions and now expect that mine operators will improve their mobile equipment fire management performance.

Mobile equipment fire events:

- Present significant fatality exposure for operators, maintainers and emergency responders
- Can be catastrophic in underground operations
- Create wider operational and commercial issues for earth moving equipment owners and operators

THIS INDUSTRY PROJECT

EMESRT first turned its attention to mobile equipment fires in 2007, when it published an initial design philosophy (DP-4). DP-4 is a high-level overview of problems that can lead to adverse consequences from mobile equipment fire events. It provides visual operational scenario information to assist OEM's in designing equipment to reduce the exposure to and the consequences of unwanted equipment fires.

This project is an extension of the original work of developing DP-4.

This project was motivated by EAG discussions that recognised and identified issues with fundamental original equipment design, e.g., separation of fuel from heat sources and ongoing issues with routine maintenance practices including hot work.

Furthermore, fire detection and suppression systems design and installation are not integrated between original equipment manufacturers and third-party suppliers. Maintenance of fire suppression systems once installed can be ineffective.

The mobile equipment fires management project is focused is on ways to understand and mitigate harm related to equipment fires as much as reasonably practical, including using design to address foreseeable human error.

When the project commenced in 2019, the technical working group included 17 individuals representing 9 entities. At the end of 2022, the Group numbers grew to 76+ individuals representing 45 entities. The Group meets on a regular basis to further progress this industry project.

The growth in member numbers resulted from industry webinars held and presentations delivered at regulator engineering forums. The interest in this industry project necessitated the scheduling of a second monthly meeting session to accommodate different time zones.

FIRE EVENT TAXONOMY

Using the heat, fuel and oxygen fire triangle, the technical working group discussed and documented fire event areas of influence using the Control Framework approach. This process unearthed five areas of influence:

1. Mobile equipment design
2. Mobile equipment maintenance
3. Fire system detection and suppression design
4. Operation*
5. Local and emergency response*

*Local and site emergency response is out of scope for this project. However, initial operational response to fires, asset operation and site emergency response capability remain relevant to effective mobile equipment fire management.

Based on the above areas of influence, the TWG developed Performance Requirement 4 (PR-4) – Mobile Equipment Fire Management in 2021. PR-4 provides comprehensive information for mobile equipment designers, mining companies, fire detection and suppression system designers, and third-party suppliers and maintainers. PR-4 was published following several iterations, and one-on-one meetings with major OEM's.

It is recommended that DP-4 and PR-4 be read in concert. Together they provide structured and comprehensive information for mobile equipment designers, mining companies and fire detection and suppression system designers, suppliers and maintainers.

INDUSTRY PROJECT 3: *cont...*

EMESRT is committed to making operational site user information available to the industry. In August 2022, EMESRT publicly launched the Mobile Equipment Fire Management Knowledge Hub.

REQUIRED OPERATING STATES FOR PREVENTING AND MITIGATING FIRE RISKS

EMESRT identified the required operating states that need to be in place to provide consistent safe and productive mining operations that also reduce the risk of mobile equipment fire.

These required operating states address:

1. Equipment design that prevents interactions between flammable materials and ignition sources
2. Maintenance schedules and standards that include specific fire prevention and mitigation checks
3. Mobile equipment that operates within design limits
4. Effective local responses to fires and potential fires
5. Effective emergency responses

PROJECT NEXT STEPS

In 2023, further industry engagement will:

- Focus on OEM equipment design improvement opportunities for fire prevention / mitigation
- Engage with OEM designers to provide an understanding of the potential unwanted events
- Finalise the Fire Management Control Effectiveness (FMCE) process
- Finalise and publish updated Design Philosophy 4 – Mobile Equipment Fire Management
- Develop and publish project management templates on the Knowledge Hub
- Publish the EMESRT Fire Management Project Report 2018-2023
- Continue Control Framework updates when there is new incident information

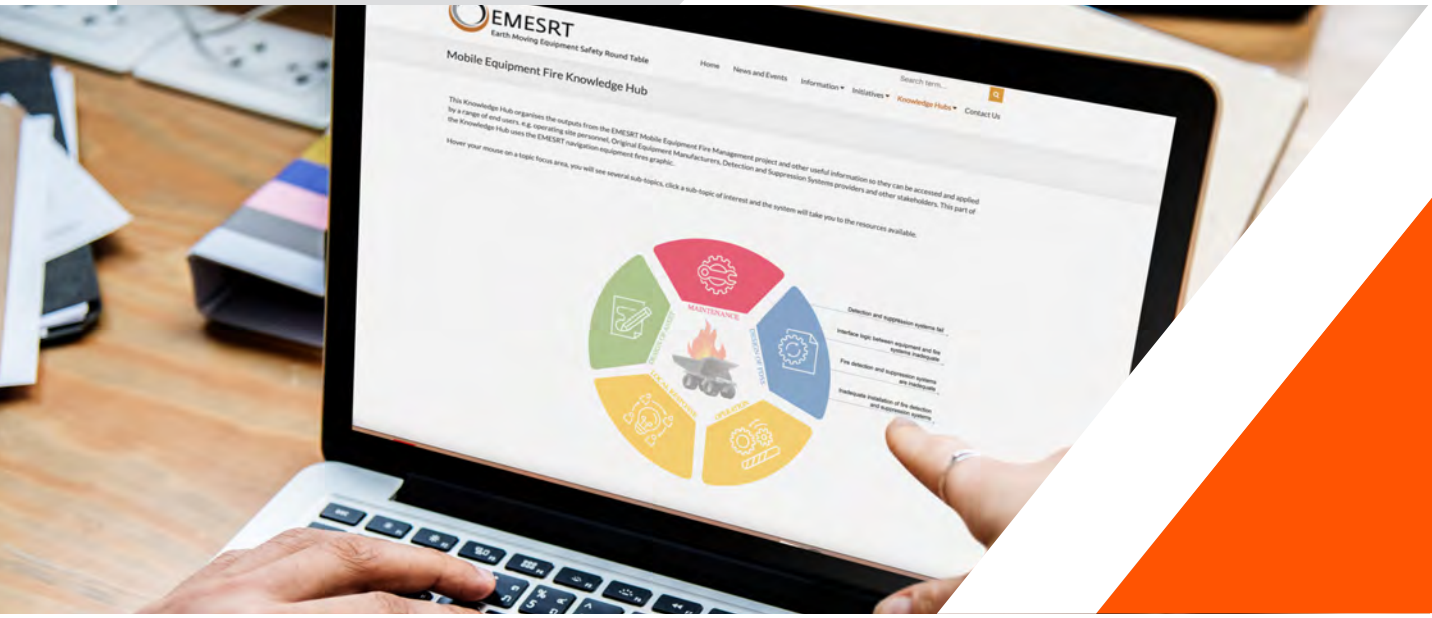
Apart from the initiatives detailed above, fire event taxonomy is regularly updated onto the Knowledge Hub, capturing industry knowledge and keeping it relevant for use within the FMCE process.

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

> *The project objective was to provide mobile equipment designers and users with structured information that enables the prevention of mobile equipment fires and the mitigation of the consequences of fire events.* Mark Geerssen, Project Lead and EMESRT Advisory Group member.

PROJECT SPOTLIGHT:

MOBILE EQUIPMENT FIRE MANAGEMENT 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 August 2022, EMESRT publicly launched the Mobile Equipment Fire Management Hub.

The development of the Hub was a direct result of the Control Framework developed and Event Tree five areas of influence identified by the technical working group during this project.

The Knowledge Hub is a curated online collection of tools, case studies, reference information, links to relevant websites and other informative resources available to all stakeholders via the EMESRT website - emesrt.org.

The Event Tree groupings are represented in a navigation aid graphic (Figure 3 and 4, page 26) that provide users with an easy-to-use process to locate reference material of interest in the Knowledge Hub.

The Knowledge Hub will grow over time as new resources become available. The EMESRT Advisory Group encourages the industry to contribute to the collection by sending any proposed resources to enquiries@emesrt.org for consideration.

PROJECT SPOTLIGHT: *cont...*

Figure 3: The top layer navigation aid depicting the five focus areas.

Figure 4: Hovering over a focus area, e.g. Design of Asset, the sub-topic focus areas will be displayed.

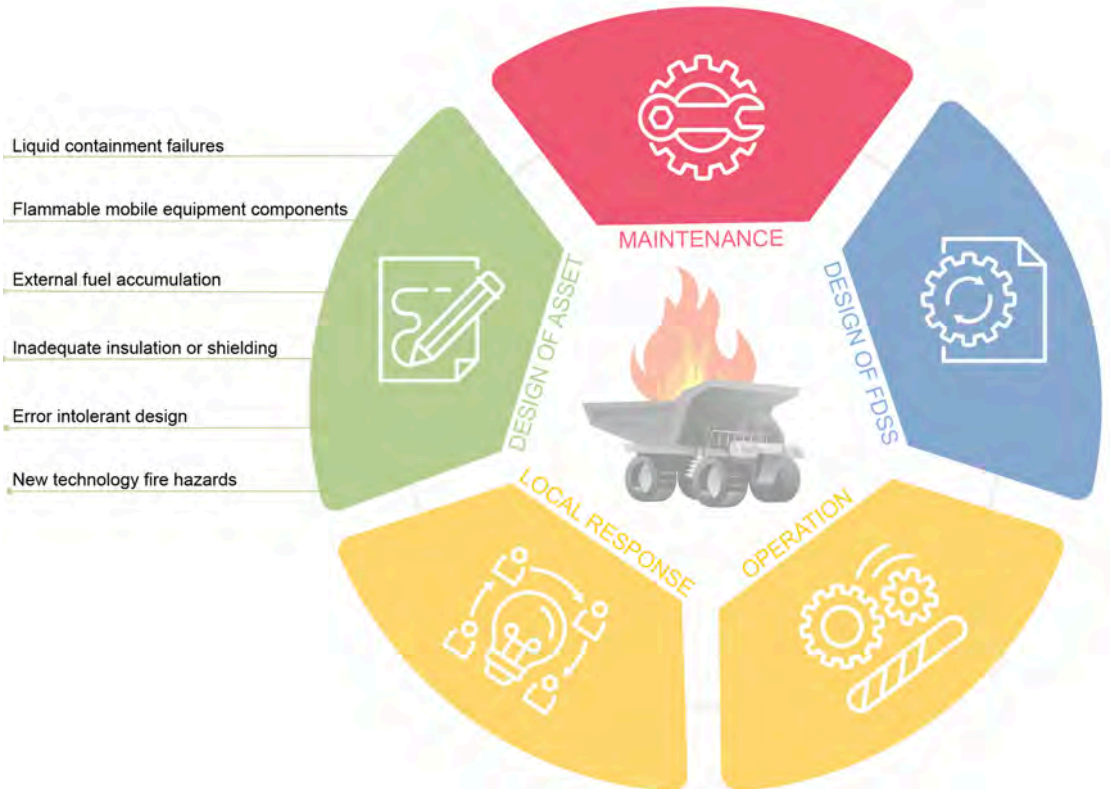


Table 1: All navigation aid focus areas and sub-topics.

TOPICS	SUB-TOPICS
Design of asset	Liquid containment failures Flammable mobile equipment components External fuel accumulation Inadequate insulation or shielding Error intolerant design New technology fire hazards
Maintenance	Component failures that release liquid fuel Compromised thermal protection and solid fuel External fuel is introduced during maintenance Hot work system failures In service component failures cause an increase in temperature
Design of fire detection and suppression system	Detection and suppression systems fail Fire detection and suppression systems are inadequate Inadequate installation of fire detection and suppression systems Interface logic between equipment and fire systems inadequate
Operation	Excessive heat Operating environment Over loading Tramming distance
Local response	Fire suppression not activated Fire suppression not sequenced with equipment operation Not able to shut down equipment

HOW EMESRT OPERATES

GOVERNANCE FRAMEWORK

Whilst EMESRT is not a registered entity, it is committed to ensuring that its practices reflect good governance.

EMESRT aims to deliver practical outcomes at an industry level, with a work program that involves delivering specific projects. EMESRT's Advisory Group members, who are senior managers in their respective organisations, make contributions based on their availability, experience and expertise.

Secretariat and financial management support is provided on a fee-for-service basis by a third-party provider. Expert consultant support is sourced as required.

FUNDING

EMESRT membership is open to mining companies and the members provide the direct funding for EMESRT activities through an annual membership fee. The fee is set based on a 24-month rolling activity and project plan, which is reviewed annually.

Significant value is contributed from the in-kind involvement of all stakeholders in the many related project activities. This includes coordinating and connecting work already in progress by other organisations. Indirect funding is accessed via groups such as ACARPs coal industry research, university research, and other technical research and development conducted by other organisations.

SCOPE OF ACTIVITIES

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

The EAG is aware of managing anti-trust issues and clearly communicates EMESRT's scope in all workshops and other industry forums. This process has been in place since OEM engagement work commenced in 2006.

In scope; EMESRT **will**:

- Focus on the 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

ANNUAL WORK PLAN

The EAG meets annually to discuss the progress of current projects, review and amend the strategic plan and document future focus areas.

The work plan process includes:

- Reviewing the progress of current industry projects (including outstanding activities and the potential end date)
- Identifying prevalent industry issues that members are highlighting
- Structuring responses that are within EMESRT's stated scope of operation
- Appointing project lead(s)
- Confirming the strategy and plans
- Setting timelines and allocate resources
- Allocating budget(s)
- Determining the following year's membership fees based on the identified work plan and allocated budget

The EAG establishes a TWG for each project. Each TWG includes multiple member representatives, OEM's, third-party suppliers, industry experts and others with relevant expertise. The EAG and TWGs meet regularly to discuss the progress of each industry project.

CONTINUITY AND RENEWAL

One of EMESRT's significant strengths is the continuity of its representatives from member organisations. A core group of company representatives were responsible for establishing EMESRT and have remained involved.

Each has made significant contributions to developing the reach and profile of EMESRT and supported the evolving operational processes that can deliver successful industry-level projects. Importantly, they have established and maintained good relationships with senior managers in OEM's and industry third-party supplier organisations.

One of the most important challenges facing EMESRT is capturing the core representatives' decades of effective work so EMESRT can continue beyond its original cohort of pioneers. Meeting this challenge has required formalising and updating EMESRT's operational processes as well as documenting the journey of current and past projects to provide insights into the activities that made a real difference in improving outcomes for users.

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 highly 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 program in 2021, where senior OEM manager participants consistently and publicly endorsed EMESRT's successes and ongoing relevance.

This situation reflects EMESRT's underpinning philosophy of focusing on delivering useful outcomes. However, the EAG is working to increase EMESRT's profile and influence with all stakeholders, to increase capacity and support project outcomes.

Relevant stakeholders include research organisations internationally, regulators, industry associations and senior managers in operating mining companies (including EMESRT members).

More information about EMESRT is available on the website - emesrt.org.

TIER 1 MEMBERS FOR 2022

TIER 2 MEMBERS FOR 2022

enquiries@emesrt.org

emesrt.org

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