EMESRT

Earth Moving Equipment Safety Round Table

MOBILE EQUIPMENT FIRE MANAGEMENT

PROJECT REPORT 2018-2023

Working with industry since 2006

DOCUMENT CONTROL

1. REVISION HISTORY

Rev	Date	Description	Prepared by	Checked by	Approved by
0.4	October 2022	Draft developed for issue to working group	Eve McDonald Mark Geerssen	Working Group	Working Group
0.5	November 2022	Updated draft issued to EMESRT Advisory Group	Eve McDonald Mark Geerssen	Mark Geerssen	EMESRT Advisory Group
1.0	January 2023	First published	Eve McDonald	Mark Geerssen	EMESRT Advisory Group

2. CONDITIONS OF USE

EMESRT has an ambition to reduce the Health and Safety risks from operating and maintaining mobile earth moving equipment. This is achieved by sharing leading practice information that can be referenced by users and designers when seeking to reduce the level of risk to personnel. Connecting through a community collaboration of; end users, OEMs, researchers, and third-party suppliers it allows a deep understanding of the problems needed to be addressed to support industry level improvement.

This project report has been developed to provide the industry with an insight into how the industry has worked together in the project journey.

2.1 TRANSLATIONS

This project report was developed and reviewed in English only. If the content, in part or in its entirety is translated, only the English version published by EMESRT is the approved version.

2.2 USAGE

- EMESRT makes this project report accessible to all of industry at no cost
- No financial gain is to be made by using this project report in part or in its entirety
- EMESRT makes this report freely available, it is not intended for sale or rent, in part or in its entirety, in any form including print, digital or other

3. DISCLAIMER

While every attempt has been made to validate the contents of this Mobile Equipment Fire Management Project Report, the content has been collated from the project journey which has changed over time. For this reason, EMESRT reserves its right to update and re-issue this report.

ACRONYMS

BI	Business Input
CFM	Control Failure Mode
CFw	Control Framework
DP	Design Philosophy
EAG	EMESRT Advisory Group
EMESRT	Earth Moving Equipment Safety Round Table
FDSS	Fire Detection and Suppression System
FMCE	Fire Management Control Effectiveness
ISO	International Standards Organisation
OEM	Original
PR-4	Performance Requirement 4 - Mobile Equipment Fire Management
ROS	Required Operating States
TWG	Technical Working Group

Cover: Grader destroyed by fire. *Image sourced from Resources Safety and Health Queensland.*

CONTENTS

1. INTRODUCTION

Despite ongoing improvements, the potential for mobile equipment fires exists in both surface and underground mines if not well controlled through adequate equipment designs, operational and maintenance practices.

Undetected fires can spread rapidly. Fires can cause serious injuries or fatalities, damage equipment and lead to significant business impacts. Serious fire risk exists in all forms of mining. In underground mining, the potential for a catastrophic fire event is significantly higher.

The industry's depth of understanding that surrounds how to design, build, operate and maintain equipment to sustain the desired outcomes is acknowledged but there are still fire events occurring, so we need to do more.

2. BACKGROUND

EMESRT first turned its attention to mobile equipment fires in 2007, when it published an initial Design Philosophy (DP-4) focussing on fire. DP-4 is a high-level overview of problems that can lead to adverse consequences from mobile equipment fire events. Its purpose is to provide an understanding of the problems through succinct written examples with visual scenario information to assist Original Equipment Manufacturers in designing equipment to reduce the risks of potential unwanted equipment fire events.

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

3. WHY THE FOCUS ON FIRE?

In 2018, EMESRT noted in industry data that the level and consistency of the fire related incidents were still compelling and recognised that the mining industry needed a step change to improve its performance in mobile equipment fire management.

In the same year, the EMESRT Advisory Group members committed to facilitating an industry project to improve mobile equipment fire management. This decision was based on the following factors:

- Fire events present significant fatality risks for operators, maintainers and emergency responders
- Fire events can be catastrophic in underground operations
- Fire events incur considerable direct and indirect costs, e.g., equipment repair or replacement, disruption to operations, litigation, increases in insurance premiums, etc
- Fire events 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 reduce fire events
- The range and complex interdependency of the business inputs necessary for effective and reliable fire prevention and mitigation controls

This Mobile Equipment Fire Management 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.

4. PROJECT TIMELINE

2007 DESIGN PHILOSOPHY 4 - FIRE

- Published and launched publicly

2018 PROJECT COMMENCEMENT

- Mobile Equipment Fire Management project scoped
- Project plan developed
- Stakeholders identified
- Stakeholder engagement plan developed

2019 TECHNICAL WORKING GROUP ESTABLISHED

- Workshops scheduled
- Draft Control Framework developed
- Required Operating States confirmed
- Reoccurring technical working group monthly meetings scheduled - 8.00 am (AEST) the first Tuesday of each month

2020 RESOURCES

- Fire event tree developed
- Draft Performance Requirement 4 - Mobile Equipment Fire Management developed
- Design Philosophy 4 - Fire updated
- Draft Fire Management Control Effectiveness baseline developed
- Knowledge Hub structure, navigation aid and content developed

2021 ENGAGEMENT AND OUTPUTS

- Industry engagement strategy developed
- One on one OEM engagement completed
- Draft Mobile Equipment Fire Management Project Report 2018-2023 developed

2022 PROJECT ACTIVITIES

- Knowledge Hub publicly launched
- Finalise 2023 industry engagement strategy
- Global fire initiative industry webinars held
- Draft Project Report 2018-2023 developed and approved by the working group
- Second session of the reoccurring technical working group monthly meetings scheduled - 4.00 pm (AEST) on the first Tuesday of each month to accommodate different time zones

2023 PROJECT CLOSE

- Engage with OEMs to discuss fire mitigation design improvement opportunities
- Engage with OEM designers to provide an understanding of the potential unwanted events
- Finalise the Fire Management Control Effectiveness process
- Publish updated Design Philosophy 4 - Mobile Equipment Fire Management
- Publish Project Report 2018-2023
- Develop and publish project management templates on the Knowledge Hub
- Knowledge Hub continual updates
- Technical working group monthly meeting sessions continue until project close

5. CONSULTATIVE APPROACH

In early 2019, EMESRT established a Technical Working Group comprising a broad industry cross section including mining companies, original equipment manufacturers, regulators, fire detection and suppression system providers, fire system designers, academics and researchers.

The group had a mandate to:

1. Identify design inadequacies and industry leading practice
2. Review current research and identify gaps
3. Consult across the industry and share knowledge
4. Develop and promote documentation to support self-assessment and risk reduction

Having correlated the full spectrum of event triggers for fires on mobile equipment in 2019, the technical working group shifted the focus to a targeted set of triggers that focused on the major exposure areas with highest consequences.

Miners, suppliers, researchers and regulators attended the workshops in 2019.

6. TECHNICAL WORKING GROUP MEMBERS

The mobile equipment fires management technical working group included 17 experienced and well qualified people representing 9 entities:

1. Alcoa
2. Anglo American
3. BHP
4. Glencore
5. Peabody
6. Queensland Regulator
7. Rio Tinto
8. South32
9. Risk Mentor

At the time of publishing this project report the technical working group numbers grew to 76+ members representing 45 entities.

The EMESRT Advisory Group thanks the technical working group for their contribution and continued support throughout the project.

> The interest in this EMESRT industry initiative increased throughout the project and technical working group number grew.

7. PROJECT APPROACH

EMESRT commissioned the development of a draft Equipment Fire Control Framework (CFw) in early 2019.

The draft CFw build was based on industry information, guidance, operational experience and knowhow and included the review of:

- EMESRT Design Philosophy 4 – Fire
- Regulator information from multiple jurisdictions – incident reports, bulletins, publications analysis, and position papers, etc
- Operating site, company and industry documents
- Research and technical information, e.g. incident taxonomies
- Relevant Standards and Guidelines

The technical working group held a series of workshops during 2019 to examine and further develop the relevant design philosophy (DP-4). A key outcome of the workshops was the *EMESRT Performance Requirement 4 (PR-4) – Mobile Equipment Fire Management*. The performance requirement was developed using EMESRTs control framework approach.

The design philosophy and performance requirements together provide structured and comprehensive information for mobile equipment designers, mining companies and fire detection and suppression system designers, suppliers and maintainers.

In developing the performance requirement, the technical working group identified 5 areas for improvement:

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

EMESRT and the Mobile Equipment Fire Management Project is only focussing on area 1, 2 and 3.

Area 4 and 5 are outside of EMESRTs remit.

Note: An overview of the EMESRT Control Framework Approach is available via the EMESRT website - *emesrt.org*.

Dump truck travelling out of the underground caught fire as a result of engine bay covered in hydraulic oil. *New South Wales Resources Regulator Fires on Mobile Plant, October to December 2020.*

8. CONTROL FRAMEWORK DEVELOPMENT AND VALIDATION

The technical working group developed a baseline control framework, which was tested, further developed and validated through 5 days of face-to-face workshops between April and June 2019. The workshops included 20 participants representing 11 mining companies and stakeholder entities.

The Group prepared a draft control framework before the first workshop, based on evidence from multiple information sources including:

- EMESRTs Design Philosophy 4 - Fire
- Regulator information from multiple jurisdictions, including incident reports, bulletins, analysis and position papers
- Operating site, company and industry documents
- Research and technical information, including incident taxonomies
- Relevant standards and guidelines, including *ISO 19296 Mining – Mobile machines working underground – Machine Safety First edition 2018-11*

The group reviewed, tested and validated the draft Control Framework during the workshops in 2019.

Workshop participants discussed opportunities to:

- Improve standards for fire risk analysis (including implications for plant safety dossiers)
- Work with original equipment manufacturers and third-party suppliers to improve design, installation, maintenance and service requirements
- Improve fire detection and alerts on mobile equipment
- Share good design practice for equipment fire prevention
- Understand the fire potential of new generation mobile equipment

During the workshops, participants recognised that:

- Fire prevention and mitigation approaches across operating mining fleets are not integrated or consistent
- Equipment design for fire prevention is not clear
- Fire detection and suppression system design and installation is not well coordinated between equipment manufacturers and third-party suppliers

9. PREVENTING FIRES IN MOBILE MINING EQUIPMENT

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.

Mobile equipment fire events:

- Present significant fatality risks – for operators, maintenance staff and emergency responders
- Can be catastrophic in underground operations
- Create wider operational and commercial issues for earth moving equipment owners and operators
- Require mandatory statutory reporting in most jurisdictions
- Have been extensively analysed and regulators now expect that mine operators will improve their mobile equipment fire management performance

> Mine operators have ethical, financial, legal and regulatory reasons to improve fire prevention and mitigation.

Water truck totally destroyed by fire at an open cut coal mine. *New South Wales Energy Mine Safety, Alert No SA15-05.*

Underground fire fuelled by diesel and non-metallic materials. *New South Wales Resources Regulator Fires on Mobile Plant, April to June 2019.*

Drill rig catches fire. *Image sourced from Resources Safety and Health Queensland.*

10. DOES THE INDUSTRY NEED A CONSISTENT APPROACH TO FIRE PREVENTION AND MITIGATION?

Globally, mine sites are broad and varied in how they operate. What all mine sites have in common is mission critical equipment for safe and productive operations. The equipment typically operates day and night under extreme conditions and in remote and difficult to access environments - particularly underground mining.

The global mining industry does not have a consistent approach to fire prevention and mitigation across mobile operating fleets. It does however continue to have significant numbers of uncontrolled fire events.

Linking the fire events to the EMESRT Control Framework has identified underlying areas such as:

1. Error tolerant machine design – Eliminates how we as operators and maintainers get it wrong, separation of fuel and heat, specification of materials to minimise fire events
2. Fire system readiness ex-factory, including alarm reporting, discrimination interfaces
3. Fire suppression system design – What is required from the machine and what is required to trigger the system to meet the intent of the design of the fire risk assessment

Within the mining industry, OEM equipment design standards for fire prevention are not clear or consistent. The industry needs additional information on how to design equipment for fire prevention and mitigation. Ideally, this information should be independently produced and verified, and widely shared with all industry players.

The design and installation of fire detection and suppression systems is currently not well coordinated between equipment manufacturers and third-party suppliers. Problems are compounded by varying company specification documents and a lack of alignment between the information provided by equipment manufacturers, third-party suppliers and mining industry users.

Dozer engine damaged by fire. *Image sourced from Resources Safety and Health Queensland.*

The relevant international standard, ISO 19296 *Mining - Mobile machines working underground - Machine safety first edition 2018-11*, provides an excellent common platform.

11. EMESRT MOBILE EQUIPMENT FIRE MANAGEMENT PROJECT

In spite of recent safety improvements, the mining industry recognises that significant fatality and injury risks still exist from fires in mining. EMESRTs mobile equipment fire management project focused on ways to prevent harm related to equipment fires as much as reasonably practical, including using design to address foreseeable human error.

The project produced:

- An updated detailed design philosophy (DP-4) that clearly defines design outcomes and potential unwanted events
- A performance requirement (PR-4) to complement the design philosophy
- A fire management control effectiveness baseline that helps equipment manufacturers and operators to analyse potential failure points, preferred outcomes and implementation strategies
- A curated and dynamic online Knowledge Hub that contains international case studies, reference information, online tools, templates and links (the knowledge hub is updated regularly and EMESRT welcomes contributions from industry)

This project is an extension of the original work carried out by EMESRT in developing Design Philosophy 4 - Fire.

Fire ignited by a heat source. *New South Wales Resources Regulator Fires on Mobile Plant, January - March 2019.*

12. EMESRTs APPROACH TO INDUSTRY PROJECTS

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 work to go right?

The control framework uses 5 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

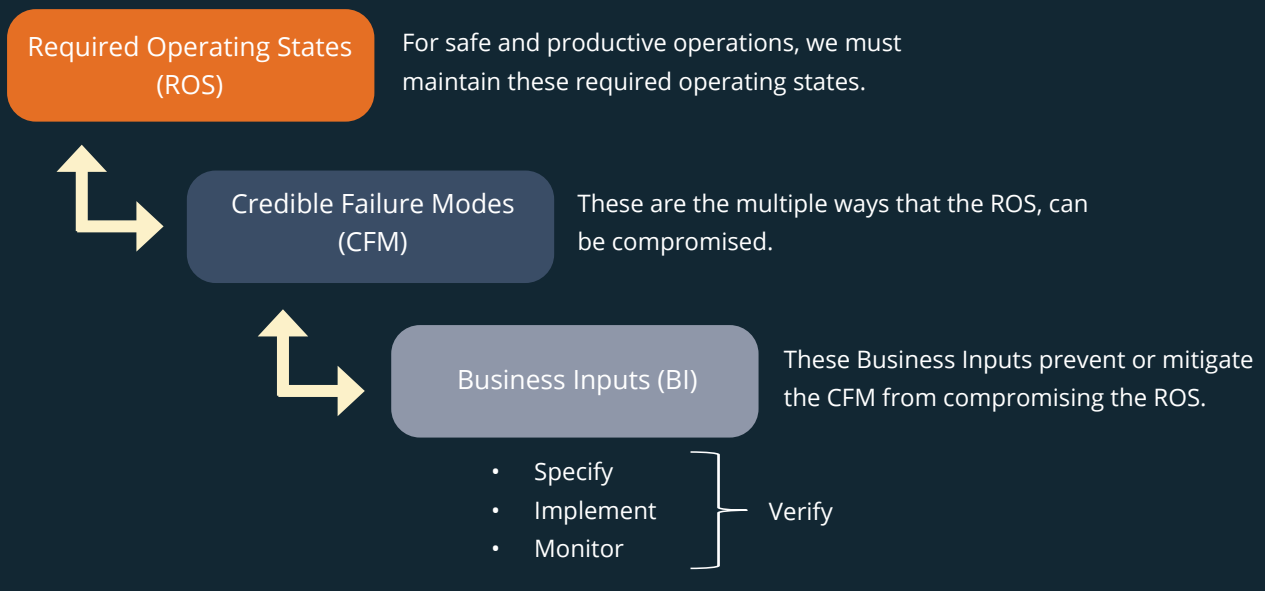
Using these questions, EMESRT maps real-world inputs and examines their interlinked hierarchies to develop a deep understanding of complicated problems (Figure 2, page 11):

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)

EMESRTs 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.

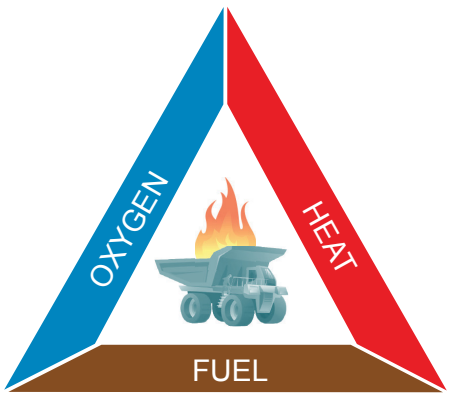
More detailed information about the EMESRT control framework approach is available on the EMESRT website – *emesrt.org*.

Figure 1: The hierarchy and components of a control framework.



13. EMESRTs APPLICATION OF THE CFw TO THE FIRE TRIANGLE

EMESRTs approach to fire prevention and mitigation is based on the fire triangle.



Fires happen when heat, fuel, and oxygen (air) combine and can be prevented or extinguished by removing one or more of the three.

Using the fire triangle logic, the technical working group discussed and documented fire event areas of influence using the control framework approach. The approach identified 5 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*

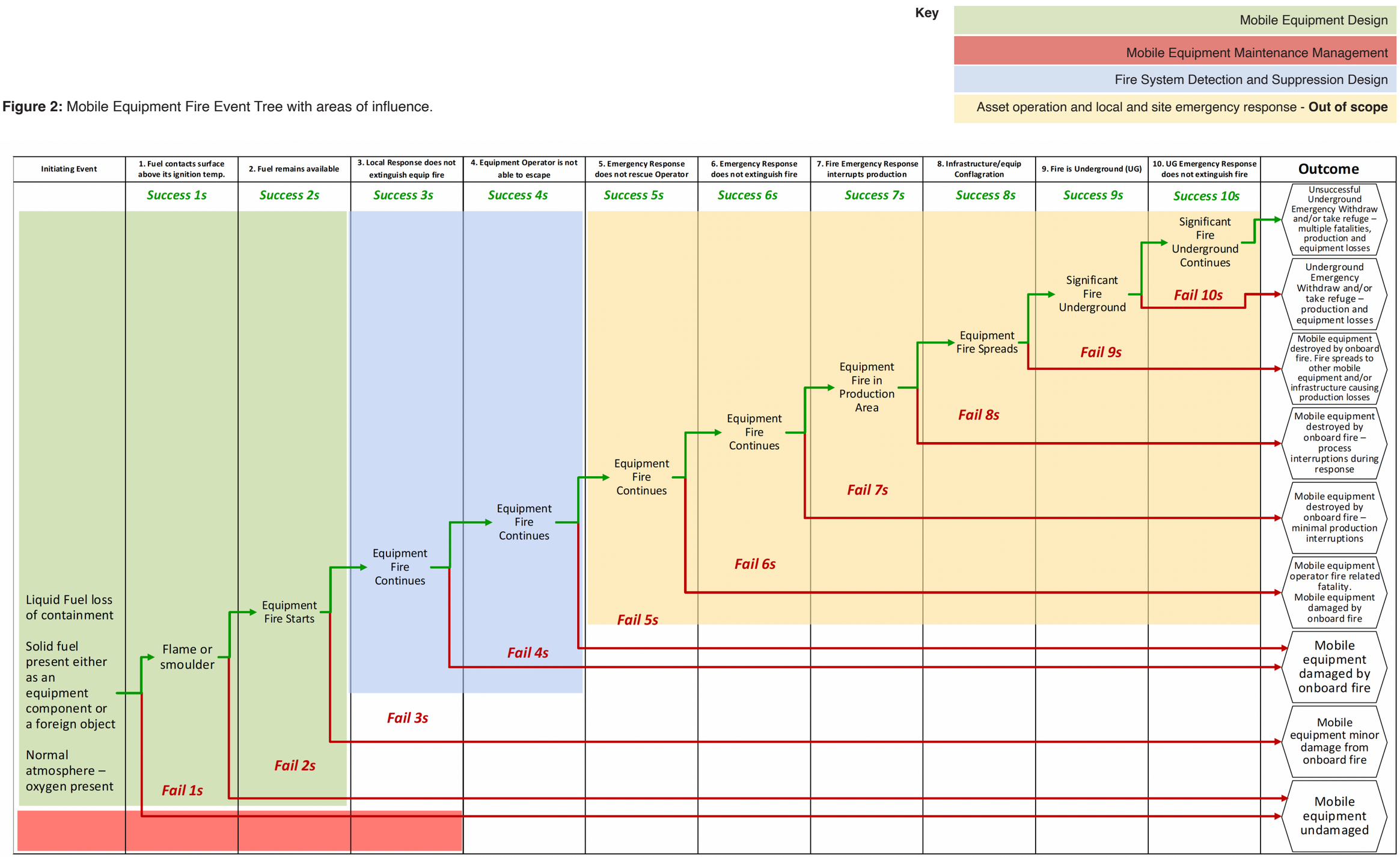
The areas of influence are developed in an event tree on page 11 and in credible failure modes on page 15.

**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.*

Underground fire caused by missing sealing grommet on outer pipe. *New South Wales Resources Regulator Fire on Mobile Plant, July to September 2019.*

Build-up of combustible materials in excavator engine bay causing fire at an open cut quarry. *New South Wales Resources Regulator Fires on Mobile Plant, October to December 2021.*

Figure 2: Mobile Equipment Fire Event Tree with areas of influence.



14. 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 (Table 1, page 14).

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

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

Watercart extensively damaged following drive shaft failure. *New South Wales Resources Regulator Safety Bulletin November 2019.*

Truck fully ablaze left to burn. *New South Wales Resources Regulator Fires on Mobile Plant, July to September 2020.*

New South Wales Resources Regulator Fires on Mobile Plant, July to September 2020.

Table 1: Required Operating States (ROS) identified through this project.

ROS	DESCRIPTION
ROS-EF-01	**Mobile plant design prevents interactions between flammable materials, fuel and ignition sources.** This required operating state applies for all mobile equipment. As required, additional design elements are included and approved for use underground applications. This includes fuel, flammable materials and any other items which could combust.
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.** Mobile equipment is maintained to OEM standards taking into account the operating environment e.g. more frequent maintenance and servicing if required. Maintenance standards extend to third party modifications. Maintenance tasks are well planned and executed e.g. hot work is well managed. Maintenance processes include quality checks before equipment is returned to service.
ROS-EF-03	**Mobile plant is operated productively and safely within operating design limits, avoiding fire or potential fire incidents.** Mobile equipment is operated within equipment design limits to avoid generating excessive heat or fuel loads.
ROS-EF-04	**Local response to fires or potential fires on mobile equipment - early detection with effective local response.** Mobile equipment operators and other workers are trained and capable to respond to mobile equipment fires. This includes following site emergency protocols if the fire cannot be extinguished.
ROS-EF-05	**Mobile equipment fires conditions are detected and managed before a fire occurs.** The circumstances that lead to mobile equipment fires during operations are well defined and actively monitored. The fire potential status of operating mobile equipment is continuously assessed, and pre-determined actions (alerts, alarms, advice) are applied as designed.
ROS-EF-06	**Maintenance activities on or around mobile equipment do not cause fires.** Hot work on or around mobile equipment does not cause fires on mobile equipment, infrastructure, or work environment.
ROS-EF-09	**Effective Emergency Response beyond local response limits fire losses.** If there is a fire, or potential fire, on or around mobile equipment, then there is an effective emergency response that protects lives and property.

15. CREDIBLE FAILURE MODES

EMESRT identified 18 credible failure modes relevant to fire hazards in mobile equipment.

These failure modes have been grouped into the following categories:

1. Liquid containment failures
2. External fuel accumulation
3. Error intolerant design
4. New technology hazards
5. External fuel introduced during maintenance
6. Detection and suppression systems failure
7. Inadequately designed fire detection and suppression systems

EMESRT developed control sheets to help the mining industry identify business inputs that prevent or mitigate credible failure modes without compromising the required operating states.

Credible failure modes were identified through a scenario mapping process in the initial workshops, and through extensive industry consultation.

The full list of credible failure modes for this project is available in *Performance Requirement 4 - Mobile Equipment Fire Management* available on the EMESRT website - *emesrt.org*.

> Credible failure modes are the multiple ways that required operating states can be compromised.

16. USING EQUIPMENT DESIGN TO MITIGATE FIRE RISK

The EMESRT project identified several ways that equipment design can mitigate fire risk, including:

- Designs that isolate fuel sources from heat sources
- Automatic engine shutdown
- Real-time notification of potential fires
- Early fire detection
- Fire suppression systems, such as cooling, oxygen deprivation or fuel elimination
- Providing connection points on mobile vehicles to increase the capabilities of site emergency responses
- Rapid and safe escape devices

Fire occurred during refuelling. *New South Wales Resources Regulator Safety Bulletin Number SB21.01*.

Oil made contact with hot surfaces of exhaust/ turbo components and ignited. *New South Wales Resources Regulator Fires on Mobile Plant, January to March 2019.*

17. PROJECT DELIVERABLES

17.1 DESIGN PHILOSOPHY 4 - FIRE

EMESRT regards operability and maintainability as major design challenges in large surface earth moving equipment. EMESRT agreed that their ability to align company requirements and expectations for human factors design would be critical for presenting a 'common voice' to OEMs.

In 2007, this need led to the development of Design Philosophies that present an aligned viewpoint on objectives, general design outcomes, risks to be mitigated and examples of industry attempts to mitigate risks.

The objective of each Design Philosophy is to provide information to help the OEM design equipment that reduces the risk of unwanted events to an acceptable level including consideration for foreseeable human error.

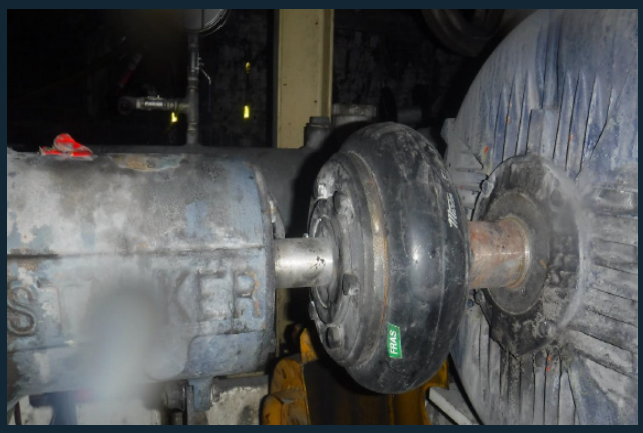
Design Philosophies are intentionally not technically prescriptive about solutions to allow the OEMs equipment design process to consider the issues and identify design controls or features that effectively address unacceptable risk.

At that time, EMESRT identified eight priority topics across the member group companies. These topics focus on where improved human factors designs would reduce unwanted events associated with equipment operation or maintenance.

One of the topic focus areas identified was fire. Design Philosophy 4 (DP-4) focussing on fire states objectives, design outcomes and categorises relevant potential unwanted events. DP-4 contains what the intended design outcomes should include, e.g. elimination of sources of ignition and fuel, protection of the operator should fire occur, etc.

The foundation of the EMESRT approach comes from all eight DPs not just DP-4.

The DPs are the basis of EMESRT engagement with OEM and third-party equipment designers, manufacturers and suppliers, EMESRT industry focus initiatives and the development of EMESRT tools, processes and other resources.



Underground pump fire. *Image sourced from Resources Safety and Health Queensland.*

> The eight Design Philosophies are the EMESRT backbone and foundation of the EMESRT approach to industry initiatives.

17.2 PERFORMANCE REQUIREMENT 4 - MOBILE EQUIPMENT FIRE MANAGEMENT

Performance Requirement 4 (PR-4) was developed by the EMESRT Technical Working Group comprising mining company representatives, original equipment manufacturers, regulators, fire detection and suppression system providers, fire system designers, academics and researchers.

In the third quarter of 2021, several one-on-one webinars were held with OEMs providing them with the opportunity to discuss PR-4 in detail, provide feedback or to discuss opportunities for improvement.

The final draft of PR-4 was tabled at the EMESRT Advisory Group November 2021 monthly meeting and unanimously approved for publishing.

PR-4 provides comprehensive information for mobile equipment designers, mining companies, fire detection and suppression system designers and third-party suppliers and maintainers. Several iterations of PR-4 were carried out before being distributed to major OEMs for review and input on its delivery format and technical relevance.

Finalising PR-4, in consultation with industry stakeholders, was an important milestone for the EMESRT Advisory Group and Technical Working Group.

PR-4 augments Design Philosophy 4 - Fire published by EMESRT in 2007. PR-4 should be read in concert with Design Philosophy 4. Both documents are available on the EMESRT website - *emesrt.org*.

17.3 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 Knowledge Hub.

The development of the Hub was a direct result of the Control Framework developed and Event Tree 5 areas of influence identified by the technical working group during this project (Section 13, page 10).

The Knowledge Hub is a curated online collection of tools, case studies, reference information, links to relevant websites and other informative resources for all stakeholders.

The Event Tree groupings (Figure 2, page 11) are represented in a navigation aid graphic (Figure 3 and 4, page 18) 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 industry is encouraged to contribute to the collection by sending any proposed resources to enquiries@emesrt.org for consideration.

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

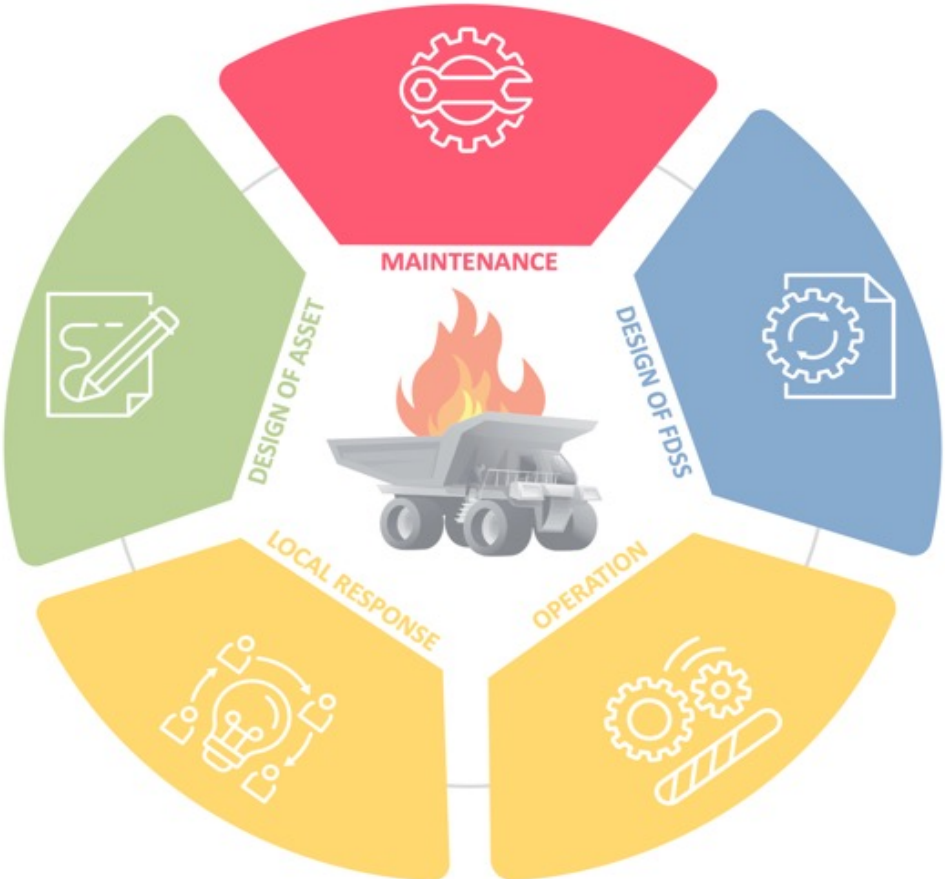


Figure 4: Hovering over a focus area, eg. Design of Asset, the sub-topic focus areas will be displayed.

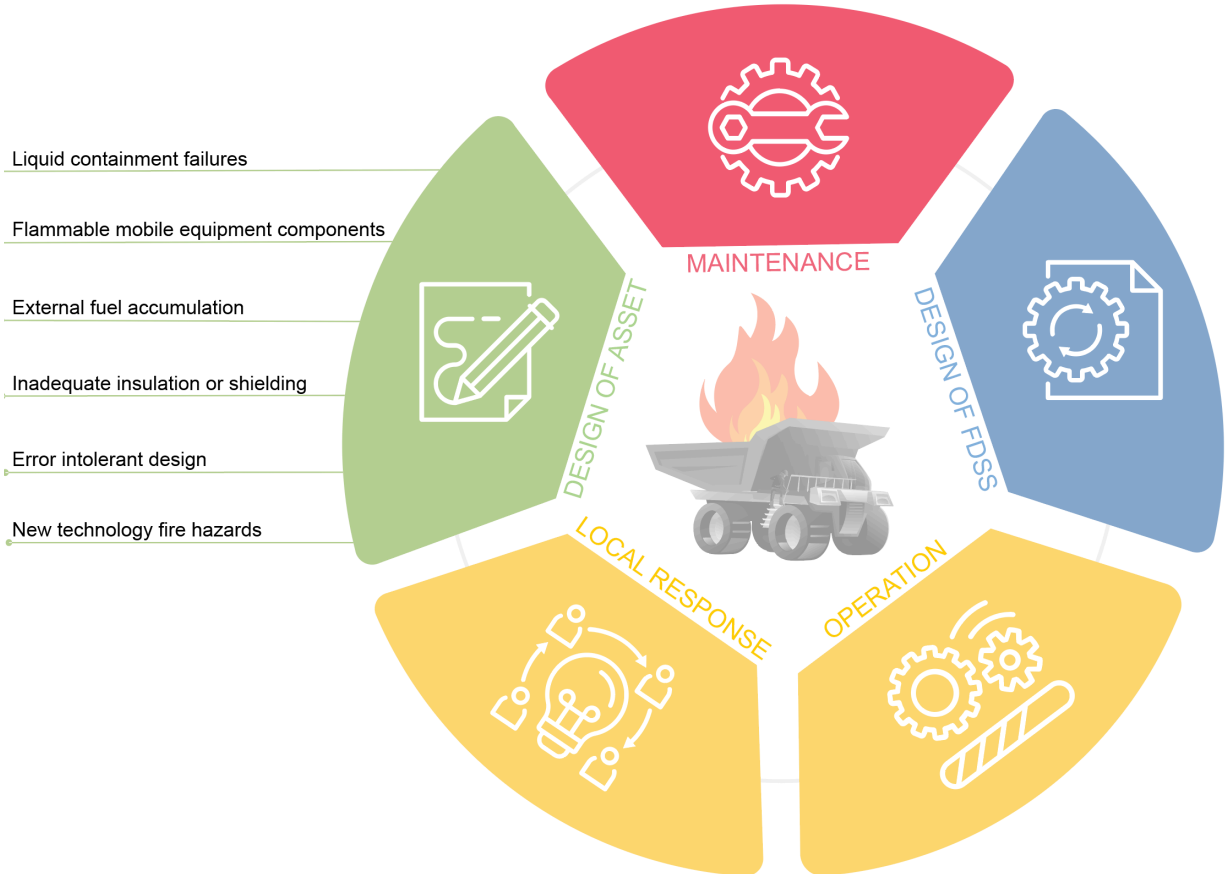


Table 2: All navigation aid focus areas and sub-topics.

FOCUS AREA	SUB-TOPIC
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 FDSS	• Detection and suppression systems fail • Interface logic between equipment and fire systems • Fire detection and suppression systems design are inadequate • Inadequate installation of fire detection and suppression systems
Operation	• Operating environment • Tramming distances • Over loading • Excessive heat
Local Response	• Not able to shut down equipment • Fire suppression not activated • Fire suppression not sequenced with equipment operation • Site emergency response

17.4 INTERNATIONAL STANDARD ISO 13649

International Standard ISO 13649 Earth-moving machinery – Fire prevention provides guidelines for consideration in reducing the risk of fires generated on earth-moving machinery.

The document provides fire prevention principles for the design, operation and maintenance of earth-moving machinery during their intended use. ISO 13649 was cancelled in 2019 due to resourcing constraints.

The project was reinstated in early 2022, partially as a result of discussion had throughout this project regarding the need for a set of fire prevention best practices and guidelines during the design of machinery phase.

There is an intention to capture some of the identified pathways in PR-4 that led to and propagated a fire and resulted in an adverse outcome and add that as guidance in an ISO 13649 appendix.

Standards are useful in locking in change, but they do not lead change. EMESRT engages and works with the industry through project such as this to advance the design of equipment to improve safe operability and maintainability beyond standards.

Engine fire caused by rag placed on hot surface. *Image sourced from Resources Safety and Health Queensland.*

Battery fire. *Image sourced from Resources Safety and Health Queensland.*

Truck engulfed by fire. *Image sourced from Resources Safety and Health Queensland.*

18. CONCLUSION AND FUTURE WORK

Publishing PR-4 was achieved through regular meetings, information and knowhow sharing and industry collaboration. This is a major milestone for EMESRT, the Technical Working Group and other contributors, but there is more to be done. Continued engagement with industry in 2023 is key to sustain the work towards a project cut-off date.

The causation data indicates that the highest percentage of fire initiations is caused by human errors mainly in maintenance activities. It is clear that more work is need in developing error tolerant design that mitigate the human error potential.

This project has identified the functional design requirements from factory, and is timely, in that as industry addresses decarbonisation opportunity exists as major equipment providers transition design from existing energy platforms to new energy platforms.

As a result, an opportunity exists to frame the functional design requirements that should be considered as the industry migrates to new platforms to error proof and eliminate the fire propagation potential.

Fire propagation implies the transfer of heat from the fire to the fuel bed which heats it up to the point of ignition.

In 2023, further industry engagement will occur to close out the project:

- Focussed OEM fire mitigation design improvement opportunities from the project
- Engage with OEM designers to provide an understanding of the potential unwanted events
- Finalise the Fire Management Control Effectiveness (FMCE) process
- Finalise and publish Design Philosophy 4 – Mobile Equipment Fire Management
- Develop and publish project management templates on Knowledge Hub

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.

Broken wire to brake solenoid causes fire to loader being operated under tele-remote conditions. *New South Wales Resources Regulator Fires on Mobile Plant, April to June 2020.*

19. ACKNOWLEDGEMENTS

The technical working group has put a lot of time and effort into understanding the fire problem and this resulted in the development of PR-4.

The EMESRT Advisory Group expresses their appreciation to the technical working group members for their time and effort and thanked the Project Lead, Mark Geerssen, for his leadership and contribution during this project.

The Advisory Group also thanks:

- Risk Mentor for preparing and maintaining the Mobile Equipment Fire Management Control Framework, facilitating industry workshops, supporting the development of the EMESRT Fire Management Knowledge Hub and developing key concepts that inform this document and PR-4
- Organisations who made their individual technical working group contributors available
- Published papers from Dr Rickard Hansen and from The University of Queensland researchers
- The New South Wales Resources Regulator and Resources Safety and Health Queensland for the fire related images used in this report
- All EMESRT members, past and present, for their continued support

Thank you all for your interest and continued support.

Compressor failure causes fire. *Image sourced from Resources Safety and Health Queensland.*

ABOUT EMESRT

Established in 2006, the Earth Moving Equipment Safety Round Table (EMESRT) is a global 'safety by design' initiative by mining companies to fill the gap between earth moving equipment users and designers.

EMESRT connects an international community of end users, equipment manufacturers, researchers and third-party suppliers.

EMESRT works with key mining industry equipment manufacturers to improve equipment design and safety. It focuses on ways to reduce health and safety risks from operating and maintaining mining equipment, sets industry-level goals and coordinates their delivery.

EMESRT presents a common industry voice, focused on reducing risks from operating and maintaining mobile earth moving equipment. It focuses on specific projects to foster candid dialogue, encourage transparent collaboration, share non-commercial information and encourage stakeholder engagement.

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 design to minimise the risk to health and safety through a process of engagement with original equipment manufacturers, contractors and users.

EMESRT TIER 1 MEMBERS

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AngloGoldAshanti

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