

VEHICLE INTERACTION CONTROL IMPROVEMENT GUIDE

1 INTRODUCTION

1.1 Scope

The EMESRT Vision is a mining industry free of fatalities, injuries and occupational illnesses associated with operating and maintaining earth moving equipment.

Since 2013, EMESRT has facilitated an industry-level vehicle interaction project with the goal of improving the reliability of vehicle interaction controls in mining.

This guide has been developed to assist operating sites in the resources industry deliver successful projects that improve vehicle interaction controls.

1.2 Conditions of Use

This publication is written by practitioners for practitioners. While it acknowledges the extensive input of researchers, academics and other industry thought leaders, including referencing and applying their research and theory, it remains firmly based on approaches that have been successfully applied in mining operations.

This resource was prepared by EMESRT with the agreement of all content contributors. It is freely offered as part of an evolving good practice industry reference resource through EMESRT, and reflects the industry intent to collaborate and share information. As such it cannot be, nor is it intended to be, a prescriptive document. Instead it is expected that users will appropriately adapt the information, based on their specific circumstances and role.

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1.3 Objective

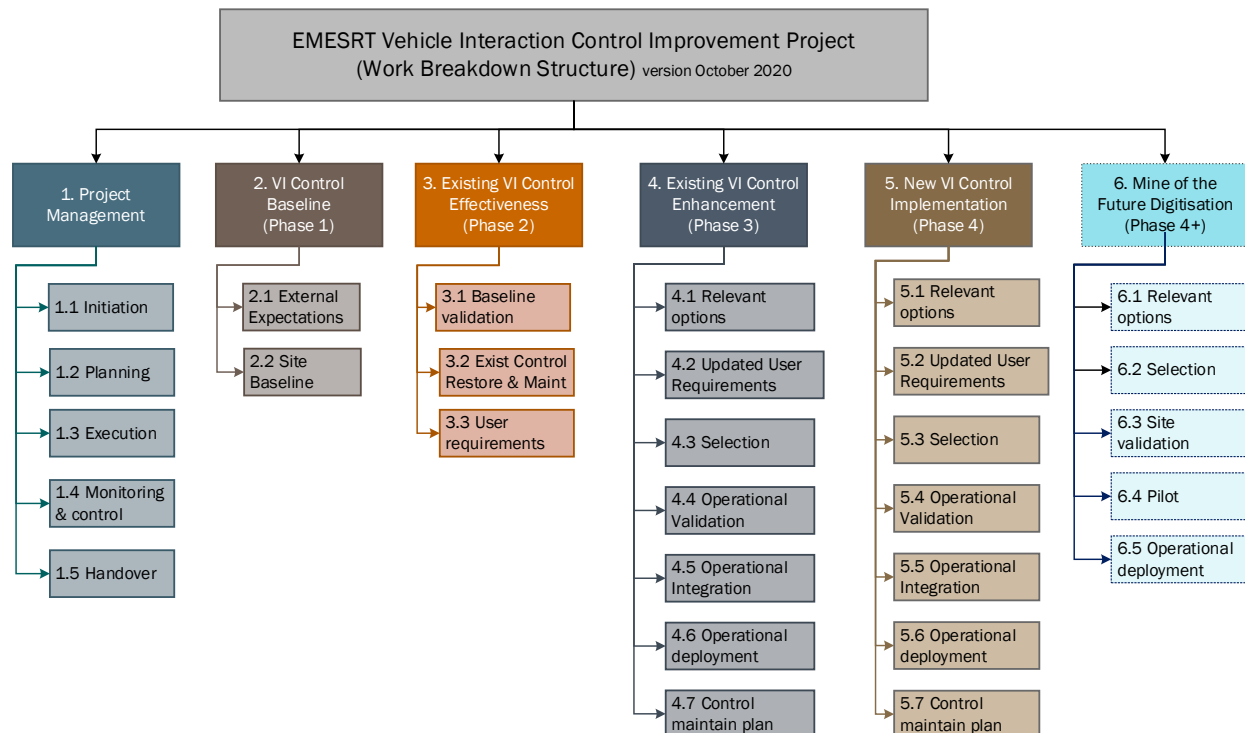
The overall objective of this guide is to provide consistent structured guidance for resource industry operating sites, so that they can deliver projects that improve Vehicle Interaction (VI) controls.

The guide has six further objectives (see Figure 1):

1. Manage as a Project
2. **Phase 1** – Understand your vehicle interaction control baseline i.e. know where are you starting from
3. **Phase 2** – Identify and correct any gaps between the baseline design and current operations
4. **Phase 3** – Enhance existing approaches, by selecting and implementing design and technology innovations that iteratively improve operations (doing what we do now – but better)
5. **Phase 4** – Identify and implement step change design and technology innovations that improve operations (replace, or add to, what we do now)
6. **Phase 4+** – Fit your VI Control Improvement approach into the operating site and company digital strategy.

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Figure 1: EMESRT VI Control Improvement Project - Work Breakdown Structure with Objectives and Results



2 USING THIS RESOURCE

This resource is based on processes and approaches that have been applied at EMESRT member company operations to systematically improve vehicle interaction controls. This includes the operational integration of new technology VI controls.

Expected users are site and divisional leaders with the business knowledge and experience to plan and deliver complex business improvement projects.

Note: the terms *Vehicle Interaction (VI)* and *Mobile Equipment Interaction (MEI)* have the same meaning in this guide. Both terms have been used in a range EMESRT documents and forums, and are interchangeable.

2.1 Resource Structure

To assist users with project scoping, planning and delivery, this resource is organised around a hierarchical Work Breakdown Structure (WBS), with six objectives that are developed in the procedure below.

For each objective, the results required for success are listed. These are in turn linked to work packages that summarise the inputs necessary to deliver the results.

When combined, the results and work packages provide users with starting point information that can be adapted for site use.

Each WBS level provides different project management information:

- The **Objectives** level answers – *What outcomes are required for a successful site VI Control Improvement Project?*

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- The **Results** level answers – *What are the building blocks needed to deliver each objective?*
- The **Work Package** level answers – *How can sites complete the activities necessary to deliver each result?*

Work packages combine company experience, knowledge and processes into a standard summary format, which detail:

- A WBS hierarchical reference
- Required outcome
- Completion state, i.e. when the activity has been completed
- Suggestions for work package owner and participants
- Important references
- Case study information, where relevant, based on EMESRT member company and industry experience
- Notes and advice
- Links to tools, templates and processes that can be adapted for site use.

2.2 Process Overview of VI Control Improvement Approach

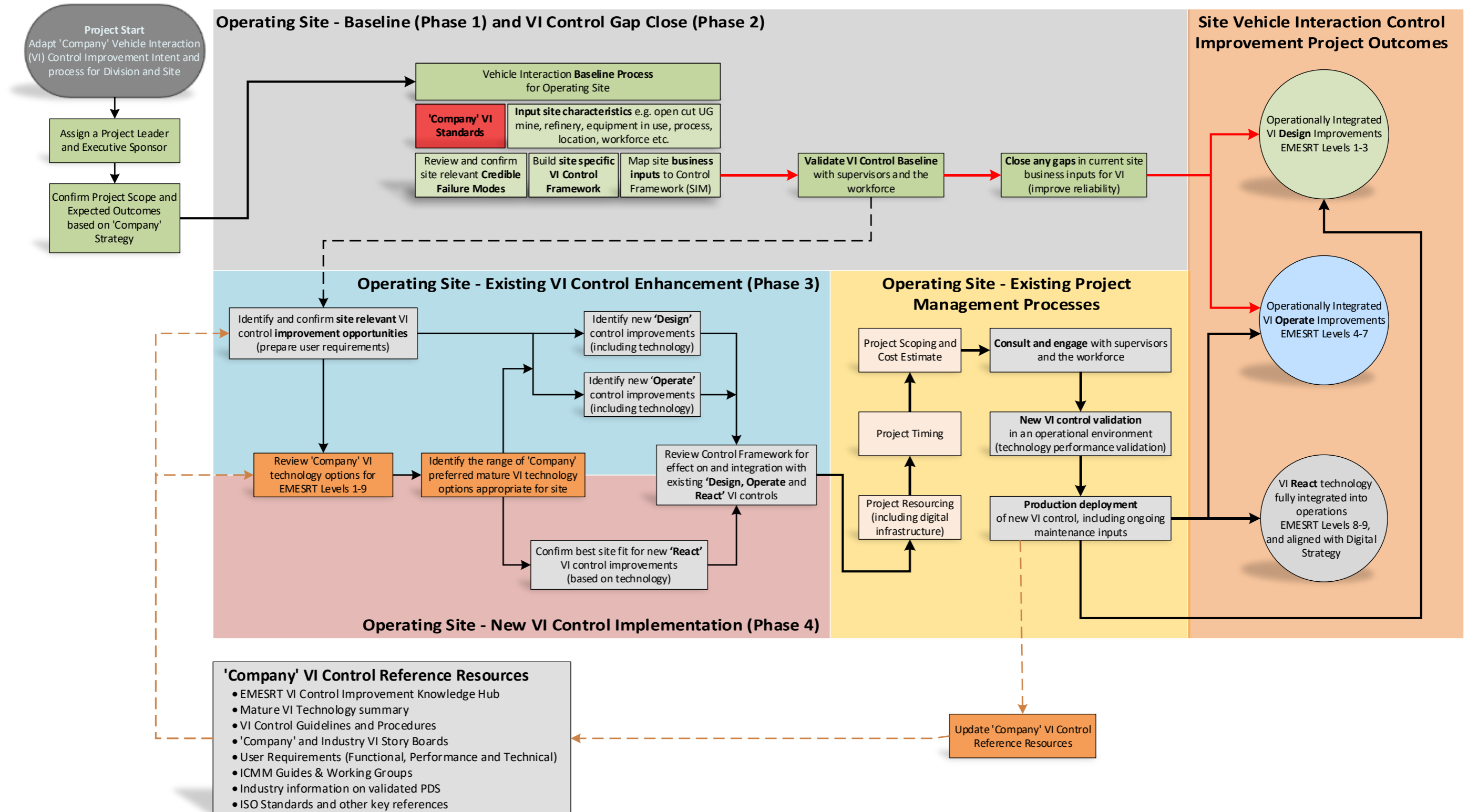
For people not directly involved in VI Control Improvement project planning and delivery, the approach can also be communicated as a four phase business improvement process.

Importantly, communicating this way confirms the site inputs necessary for project success and how each project phase must integrate with existing site processes for consultation, project management, operational planning, maintenance etc.

Figure 2 provides a VI Control Improvement Process Overview that is complementary to the Work Breakdown Structure used to organise this resource.

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Figure 2: Overview of the EMESRT Vehicle Interaction (VI) Control Improvement approach as a four phase Business Improvement Process



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PROCEDURE	INFORMATION
Step 1: Set up as a Project	Responsible: Project Manager supported by Project Sponsor
<p>1. Conduct project planning – improving mobile equipment controls at operating sites is best conducted as a PROJECT. This requires coordinating multiple related activities such as:</p> <ul style="list-style-type: none"> • Reviews and assessments of current VI control performance • Supporting experienced personnel to reassess and modify how they carry out their work • Change management • Stakeholder management • Operational validation and integration • New technology assessment and sourcing • Approvals and finance • Data collection and analysis <p>Also consider other related projects (e.g. future mine digitisation) in the project planning phase.</p> <p>2. Apply existing “Company” project management approaches to deliver required outcomes, including:</p> <ul style="list-style-type: none"> • confirming a senior manager sponsor • appointing an appropriately experienced project manager. <p>3. Conduct a review of operating site vehicle interaction control status, using the the ICMM Maturity Framework Assessment tool. The site results from this broad review will assist both the senior manager sponsor and the project manager to make the business case, develop the project charter and manage stakeholders.</p>	<p><i>Project Management Book of Knowledge (PMBOK) Version 6</i></p> <p><i>‘Company’ Project Management resources and requirements</i></p>
<p>See Results and Work Packages:</p> <p>1. Project Management</p> <p>1.1 Initiation</p> <p>1.1.1 Maturity Framework Assessment</p> <p>1.1.2 Project Charter</p> <p>1.1.3 Project Initiation</p> <p>1.1.4 Stakeholder Management Plan</p> <p>1.2 Planning</p> <p>1.2.1 Scope and budget</p> <p>1.2.2 WSB and schedule</p> <p>1.3 Execution</p>	<p><i>WBS Objective 1. Project Management – Results and Work packages</i></p> <p><i>For Project Charter:</i></p> <p><i>Company Standards relevant to Vehicle Interaction e.g. Fatal Hazard Protocols for Mobile Equipment</i></p> <p><i>EMESRT Vehicle Interaction Control Improvement Strategy 2020</i></p>

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PROCEDURE	INFORMATION
1.3.1 Status and tracking 1.3.2 Quality, reliability and integration 1.4 Monitoring and control 1.5 Project Handover	
Step 2: Establish a VI Control Framework Baseline (Phase 1)	
1. Following the EMESRT Control Framework (CFw) approach, establish a site VI control baseline to ensure: <ul style="list-style-type: none"> • External expectations of operating site – legal and company are captured and reviewed • The EMESRT nine-level layer control effectiveness model is applied • A project risk and control management process is established that can be reviewed and updated through each project step and passed on at project handover • A reference and consultation process is established for operational input and validation of key project steps • Effective change management reviews are completed and updated at each step, such as capturing the interactions between new and existing VI controls. 	Responsible: Project Manager <i>A CFw is a study process aligned with both Failure Modes and Effects Analysis and the ICMM Critical Control Methodology.</i> <i>It is useful for identifying VI controls that are dependent or partly dependent on people.</i> <i>WBS Objective 2. VI Control Baseline</i> <i>EMESRT Vehicle Interactions Self Assessment Review Guideline (SARG)</i> <i>EMESRT Control Framework Facilitator Guide Version 1.1</i>
See Results and Work Packages: 2. Vehicle Interaction Control Baseline (Phase 1) <ul style="list-style-type: none"> 2.1 External Expectations <ul style="list-style-type: none"> 2.1.1 Legislative requirements 2.1.2 Company Standards 2.1.3 Sector Resources 2.1.4 Site specific requirements 2.2 Site Baseline <ul style="list-style-type: none"> 2.2.1 Required Operating States 2.2.2 Incident analysis 2.2.3 Site conditions 2.2.4 Credible Failure Modes 2.2.5 Site Control Framework (CFw) Baseline Preparation <ul style="list-style-type: none"> 2.2.5.1 Specify 2.2.5.2 Implement 2.2.5.3 Monitor 	<i>Control Framework Facilitator Guide Version 1.1</i>

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PROCEDURE	INFORMATION
Step 3: Confirm Existing VI Control Effectiveness (Phase 2)	Responsible: Project Manager
<p>This phase ensures that existing VI controls are robust, reliable and practical BEFORE investing in enhanced and/or new VI controls.</p> <ol style="list-style-type: none"> Conduct validation workshops with experienced and knowledgeable site personnel and other useful contributors: <ul style="list-style-type: none"> Introduce participants to the new control thinking Harness their experience to review the site VI CFw (Version 1), with the aim of identifying gaps in existing VI Controls, and confirming causes for gaps (e.g. it is difficult to monitor and verify that ME operators always give way). Update the site VI CFw map (Version 2) and use it to: <ul style="list-style-type: none"> Prepare and implement a plan that will improve the reliability of existing VI controls Confirm inputs required to maintain adequate performance of VI controls Prepare site functional and performance requirements for enhancing <u>existing</u> VI controls (EMESRT Levels 1–7) Prepare site functional, performance and technical requirements for <u>new</u> VI controls (EMESRT Levels 8–9) 	<p><i>VI risk analysis resources e.g. bow ties</i></p> <p><i>CFw – Validation Workshop Control Sheets</i></p> <p><i>EMESRT Control Framework Facilitator Guide Version 1.1 (under development)</i></p> <p><i>VI Control Restore Plan Template</i></p>
<p>See Results and Work Packages:</p> <p>3. Existing VI Control Effectiveness (Phase 2)</p> <p>3.1 Baseline validation</p> <p>3.1.1 Baseline tool user training</p> <p>3.1.2 Validation of Baseline by site</p> <p>3.2 Existing control restore and maintain plan</p> <p>3.3 User requirements</p> <p>3.3.1 Functional Requirements</p> <p>3.3.2 Performance Requirements</p> <p>3.3.2 Technical Requirements</p>	<p><i>WBS Objective 3. Existing VI Control Effectiveness – Work Packages and associated tools</i></p>
Step 4: Enhance Existing VI Controls (Phase 3)	Responsible: Project Manager
<p>When existing VI controls (EMESRT Levels 1-7) are operating as expected, then options for enhancement can be considered.</p> <ol style="list-style-type: none"> List opportunities for enhancement using the site functional, performance and technical requirements from Step 3. Examples include: using cameras to improve mobile equipment operator awareness; separating pedestrians from 	<p><i>ICMM – Case studies</i></p> <p><i>EMESRT Vehicle Interaction Functional Requirements – February 2018</i></p>

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PROCEDURE	INFORMATION
<p>mobile equipment underground; monitoring and analysing work practices.</p> <p>2. Select options based on:</p> <ul style="list-style-type: none"> • Cost • Ease of implementation • Relevance to future new control implementation • Inputs required to maintain adequate performance of enhanced VI controls. <p>3. Validate and update enhancements to existing controls, in consultation with experienced site personnel and other useful contributors, using the VI CFw.</p> <p>4. Where practical, conduct a pilot of the VI control enhancement, and engage the broader workforce before operation deployment.</p>	
<p>See Results and Work Packages:</p> <p>4. Existing VI Control Enhancement (Phase 3)</p> <p>4.1 Relevant options - Enhancement</p> <p>4.1.1 Design control options</p> <p>4.1.2 Operate control options</p> <p>4.2 Updated User requirements</p> <p>4.2.1 Functional Requirements</p> <p>4.2.2 Performance Requirements</p> <p>4.2.2 Technical Requirements</p> <p>4.3 Selection</p> <p>4.3.1 Enhance VI Control Selection</p> <p>4.4 Operational Validation</p> <p>4.3.1 Enhance VI Control Pilot</p> <p>4.3.1 Site Baseline update</p> <p>4.5 Operational Integration</p> <p>4.4.1 Logistics and Infrastructure</p> <p>4.4.2 Training and awareness</p> <p>4.6 Operational deployment</p> <p>4.7 Control maintenance plan</p>	<p><i>WBS Objective 4. Existing VI Control Enhancement– Work Packages</i></p>

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PROCEDURE	INFORMATION
Step 5: Implement New Intervention Controls (Phase 4)	Responsible: Project Manager
<p>The successful implementation and use of new VI intervention controls (EMESRT Levels 8–9) requires the integration of all levels and support processes of VI control for a ‘whole of system’ improvement.</p> <ol style="list-style-type: none"> Confirm site-relevant options as follows: <ul style="list-style-type: none"> Update and confirm site functional, performance and technical requirements for new technology controls (Steps 3 and 4 above) Identify relevant ‘Company’ VI requirements for new technology controls (EMESRT Level 8 and 9) based on operation type (e.g. underground coal mining, underground hard rock mining, open cut mining, refinery) Compare site and “Company’ VI requirements and identify any differences, e.g. additional site-specific requirements such as machine swing interlocks, and/or restrictions such as an orebody precluding the use of magnetic field PDS Prepare a site functional and performance specification, and review it against technology performance summaries of preferred PDS suppliers Select the best fit from PDS technology suppliers, and request they complete a summary of their product performance against site functional and performance requirements Ensure that technology options meet minimum set requirements based on ACARP PDS validation framework (draft ISO standard) Confirm site infrastructure requirements for each technology option Summarise capability, installation and maintenance costs, upgrade potential, data management and fit with future mine digitisation plans and other relevant information for each option. Validate the shortlisted options with knowledgeable site personnel – include some who have been involved with Steps 2–4 and all others required for successful implementation of new technology controls (e.g. IT, finance, training, technical, mine planning, senior managers, site infrastructure). Based on site validation, select the best-fit new VI Control option and confirm the commercial and logistics of technology delivery and installation. Conduct a pilot implementation: <ul style="list-style-type: none"> Brief broader workforce and train all involved in pilot 	<p><i>Note: VI intervention controls do not replace all existing Design, Operate and Awareness VI controls (EMESRT Levels 1–7).</i></p> <p><i>Industry VI Intervention Technology Case Studies see ICMM and EMESRT Knowledge Hubs</i></p> <p><i>EMESRT Vehicle Interaction Functional Requirements – February 2018</i></p> <p><i>ACARP PDS Validation Framework</i></p> <p><i>Mining3 PDS Toolkit (pdstoolkit.com)</i></p> <p><i>Mining3 PDS Sensing Capability Assessment document</i></p>

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PROCEDURE	INFORMATION
<ul style="list-style-type: none"> • Complete field trials to confirm functional performance requirements are met • Phase 1 – deploy for data gathering with an operational PDS with intervention controls bypassed • Phase 2 – full pilot deployment in a controlled area to assess actual operational performance <p>5. Review pilot outcomes, capturing:</p> <ul style="list-style-type: none"> • Acceptance within the workforce • Technology performance • Changes in mobile equipment reliability, e.g. excessive brake wear • Changes in VI operator and co-worker behaviour • ‘Point of truth reference’ – based on data measures of the effectiveness of current control performance (EMESRT Level 1–7), e.g. pedestrian clearance from underground mining equipment, speed, give-way discipline. • How performance data can be used to improve operational controls • Opportunities to extend the application of the new technology, e.g. pedestrian able to slow or stop mobile equipment, swing interlocks, seatbelt and door interlocks, general equipment performance data gathering and analysis • Opportunities to improve design and operate controls BEFORE full deployment of intervention controls • Infrastructure requirements for full deployment. <p>6. Prepare a plan as part of operational deployment, to cover:</p> <ul style="list-style-type: none"> • Routine incorporation of control effectiveness data into work planning, e.g. separating underground mining activities • Use of control effectiveness data for monitoring and verifying the effectiveness of operational controls • Analysis and performance feedback for supervisors, workgroups and individuals • Minimum equipment and maintenance requirements, e.g. PDS faults that require mobile equipment shutdown • Ongoing technology maintenance. 	
<p>See Results and Work Packages:</p> <p>5. New VI Control Implementation (phase 4)</p> <p>5.1 Relevant options</p> <p>5.1.1 React Technology Options</p>	<p><i>WBS Objective 5. New VI Control Implementation – Work Packages</i></p>

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PROCEDURE	INFORMATION
5.1.2 Site infrastructure requirements 5.2 Updated User requirements 5.2.1 Functional Requirements 5.2.2 Performance Requirements 5.2.3 Technical Requirements 5.3 Selection 5.3.1 New VI Control Selection 5.4 Operational Validation 5.4.1 New VI Control Pilot 5.4.2 Site Baseline update 5.5 Operational Integration 5.5.1 Logistics and Infrastructure 5.5.2 Training and awareness 5.5.3 Cold commissioning 5.5.4 Point of truth reference 5.5.5 Site Baseline update 5.6 Operational Deployment 5.6.1 Data incorporation 5.6.2 Design & operate review 5.6.3 Site VI CFW update 5.6 Control maintenance plan	
Step 6: Mine Digitization (Phase 4+)	Responsible: Project Manager
<p>While the delivery of future outcomes is beyond the scope of this resource, it is recommended that relevant aspects of plans in this area are considered during project scoping, development and delivery, and after handover.</p> <p>1. Consider these aspects:</p> <ul style="list-style-type: none"> • Infrastructure on mobile equipment, e.g. beyond delivering new VI controls, can the same equipment gather and transmit equipment location and performance data? • Mine infrastructure, e.g. leaky feeders for use underground, mesh networks, etc. 	<p><i>WBS Objective 6. Mine of the Future Digitisation</i></p> <p><i>(Phase 4+)</i></p>

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PROCEDURE	INFORMATION
<ul style="list-style-type: none"> Dynamic mine planning, including mobile equipment management. 	
<p>See work packages:</p> <p>6. Mine of the Future Digitisation</p> <p>6.1 Relevant options</p> <p>6.1.1 Asset / plant digitisation</p> <p>6.1.2 Personnel geo-location</p> <p>6.1.3 Dynamic mine planning</p> <p>6.1.4 Site Baseline update</p> <p>6.2 Selection</p> <p>6.3 Site validation</p> <p>6.4 Pilot</p> <p>6.5 Operational deployment</p> <p>6.5.1 Operational data incorporation</p> <p>6.5.2 Mine Operational improvement</p>	<p><i>WBS Component 6. New VI Control Implementation – Work Packages</i></p>

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3 DEFINITIONS AND GLOSSARY

Term	Description
CFw	<p>The Control Framework approach is a methodology that is aligned with Failure Modes and Effects Analysis, Human Factors and the ICMM Critical Control Methodology. It considers required business outcomes and then maps in the real-world inputs required to achieve them with a focus on answering ‘what has to be in place for work to go right?’</p> <p>Developing CFw requires a systematic review of the robustness and reliability of business inputs i.e. where the work is done.</p> <p>It follows these steps:</p> <ol style="list-style-type: none"> 1. Confirm the safe and productive outcomes relevant at an enterprise level – these required operating states (ROS) are the basis of CFw organisation, e.g. Operators Give Way 2. Identify and catalogue the credible failure modes that can compromise each required operating state 3. Based on each credible failure mode, identify the business inputs (control supports) that prevent or mitigate required operating state compromise 4. Use the Control Framework template to map site documentation and knowledge how each business input is specified, implemented, and monitored, to create CFw Version 1 5. Present Control Framework Version 1 (baseline) to knowledgeable employees for review, updating and validation to Control Framework Version 2 (validated baseline) 6. From the validation workshop, confirm the opportunities for improvement required to achieve nameplate VI Control Performance and present for senior management review 7. Use the CFw information as a reference when considering further improvements to VI controls including enhancing existing controls or step change innovation adding new controls for Phases 3 and 4 and identify: <ol style="list-style-type: none"> a) Any new credible failure modes associated with the VI Control Innovation and identify the business inputs (control supports) that prevent or mitigate required operating state compromise b) Update impacts on existing credible failure modes and/or associated business inputs 8. Over the life of the VI Control Improvement project use the CFw to manage project risk and as a ‘single point of truth’ reference for all relevant company and external obligations, procedures, risk analyses and registers, documents, work processes, external guidance etc. 9. Provide the current CFw to the operating site as part of project handover.
EMESRT	Earth Moving Equipment Safety Round Table
MEI	<p>Mobile Equipment Interaction</p> <p><i>Note: Mobile Equipment Interaction (VI) and Vehicle Interaction (VI) have the same meaning in this procedure. Both terms have been used in EMESRT documents and forums, and are interchangeable.</i></p>
PDS	Proximity Detection System

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VI	Vehicle Interaction <i>Note: Vehicle Interaction (VI) and Mobile Equipment Interaction (VI) have the same meaning in this procedure. Both terms have been used in EMESRT documents and forums, and are interchangeable.</i>
Work Breakdown Structure (WBS)	A WBS is a structured breakdown of the total project scope based on what must be delivered for a successful project. This guidance resource is based on the WBS in Figure 1. It visually defines the scope into manageable parts that a project team can understand. This WBS uses a for level hierarchy of objective, result and work packages. Note: The objective level also includes the overall project objective and the work package for 2.2.5 Site CFw Baseline Preparation includes further important advice at work package sub levels 2.2.5.1 Specify, 2.2.5.2 Implement, 2.2.5.3 Monitor
Work Package	A work package is the lowest level component of a Work Breakdown Structure (WBS). It assists work planning, assigning resources, developing estimates, and monitoring and controlling the delivery required outcomes or products.

4 REFERENCES

References are also provided in associated work packages.

- EMESRT Design Philosophies <https://emesrt.org/design-philosophies/>
- ICMM ICSV Programme Vehicle Interaction Knowledge Hub and Knowledge Base <https://icsv.miningwithprinciples.com/hub/>
- Mining3 Proximity Detection System Validation Framework <https://www.mining3.com/research/proximity-detection-systems/>
- [PMBOK Version 6, 2017 Project Management Institute](#)

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5 CONTROL AND REVISION HISTORY

5.1 Document Information

Property	Value
Approved by:	EMESRT Advisory Group
Document owner:	EMESRT
Effective date:	07/10/2020

5.2 Revision

Version	Date Reviewed	Review Team	Nature of Amendment(s)
1-0	October 2020	Developed on behalf of EMESRT by Risk Mentor Reviewed by VI Control Improvement Project Industry Group - Tony Egan, Matthew Clements.	First version developed

Figure 3 - EMESRT Vehicle Interaction Control Improvement Project Work Breakdown Structure (WBS) version October 2020

