EMESRT
Earth Moving Equipment Safety Round Table

Vehicle Interaction Control Improvement Project

Strategy and Project Overview

An EMESRT Vehicle Interaction Knowledge Hub Resource

28 September 2020

Alcoa AngloAmerican BHP GLENCORE RioTinto Teck

1. Context and Industry Business Case

Context

Industry Vehicle Interaction Experience

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

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

The EMESRT Facilitation Role 2013 - 2020

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

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

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

The EMESRT facilitative approach has created an industry level project community made up of 150 people representing Mining companies, OEM's, Third party PDS providers and other stakeholders.

Notable Milestones 2013-2020

- 2016-17 engagement with the ICMM Risk Committee and preparation of a next steps plan
- 2018 support for the ICMM Innovation for Cleaner Safer Vehicles programme
- Facilitating ACARP Project C26028 to confirm a methodology for validating proximity detection technology.
- Development of interoperability protocol between third-party PDS providers and equipment supplied by OEMs to establish a platform for the implementation of PDS controls in mixed equipment fleets - Refer ISO 21815

Industry Project Business Case

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

Since then, EMESRT has influenced, coordinated, supported and guided project activities at an industry level (as detailed in slide 3 *Industry Landscape - Vehicle Interaction Control Improvement Project*). Core to this work has been engaging with ICMM to leverage their peak industry association status and directly contribute to the *"Initiative for Cleaner Safer Vehicles."*

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

This wide range of information and experience is now being curated and will made available for industry use in a Knowledge Hub in 2020.

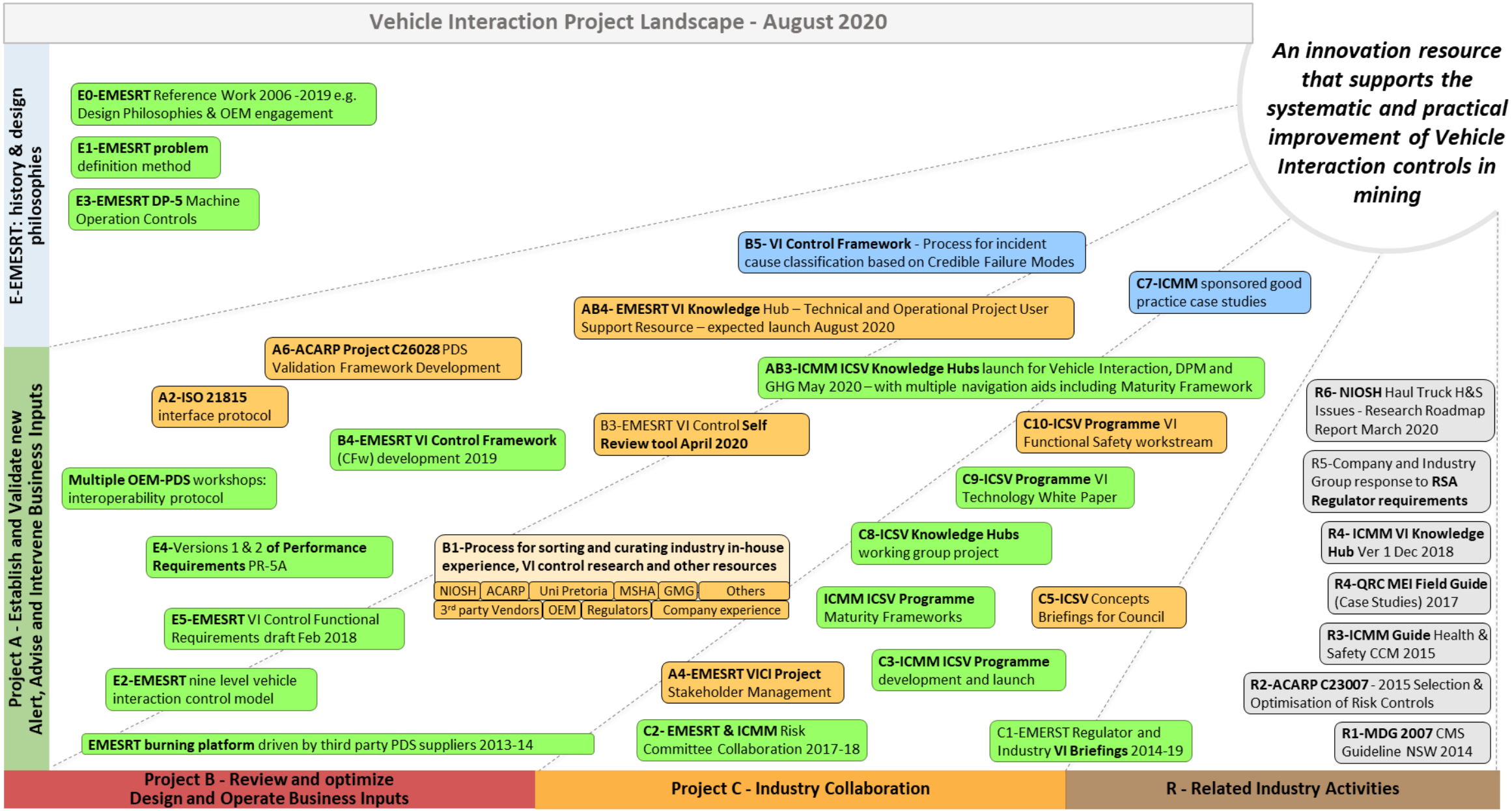
Notes on project complexity and rapid development of technology options

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

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

- During operations there is an ongoing dynamic interdependence between **design, operate** and **react controls** (reference EMESRT Level 1-9 Model)
- The successful implementation and integration of **react controls** requires a comprehensive baseline understanding of **design** and **operate** controls
- Established risk assessment and safety management approaches are inadequate for developing a baseline understanding suitable for a complex technology project
- Success requires precisely understanding what technology does and does not do, taking a project approach, and
- The potential for error due the lack of human factors considerations in design.
- There are already legislative requirements for the introduction of new technology intervention controls in some jurisdictions.

Industry Landscape - Vehicle Interaction Control Improvement Project



2. Current State (September 2020)

Failures of vehicle interaction controls cause 30-40% of industry fatalities.

Many contributors (early adopters and researchers) are working to develop and implement improved vehicle interaction controls.

Innovations include new technology controls for alerting and alarm operators and intervention controls that intervene independently of the operator.

Operational innovations are also improving the reliability of existing controls (supported by ICMM Critical Control Methodology).

Two industry associations; ICMM and EMESRT with complementary capabilities and overlapping memberships have been collaborating since 2016.

The opportunity for Industry level influence, coordination and guidance to efficiently accelerate and deliver improved performance is being delivered through the ICSV Vehicle Interaction Programme and complementary EMESRT work.

End users now have access to the ICSV Knowledge Hub. The EMESRT VI Knowledge Hub Platform has been prepared and will be launched when its usefulness has been confirmed.

5. Action Planning

Completed

1. EMESRT working group established and supported through documented monthly meetings
2. Strategy and detailed planning with regular updates since 2013 e.g. Industry Landscape and project WBS
3. Functional and performance requirements and scenario story board process developed

In progress

4. VI Knowledge hub platform V2 is now in beta mode
5. Control baseline validation support tools at pilot in an EMESRT member company

Expected Q3 2020

7. Formal launch of the VI Knowledge Hub – timing pivots on adequate content (project management) and additional navigation aids
8. Develop operating site project management resources – this will be Knowledge Hub content
9. SARG field trials and feedback on range of self-review tools required

3. Target State - increase industry knowledge and capability

This EMESRT Project develops and delivers industry level Vehicle Interaction Control Improvement curated resources that are:

- Sourced from industry good practice, experience and knowhow and promote design and technology innovations
- Designed to be relevant, useable and adaptable for a wide range of end users, including users at operating sites
- Industry validated by multiple stakeholders including mining operators, OEMs, and third-party suppliers

These resources include tools and processes that can be adapted by mining operations to:

- Review and confirm their current operating baseline(s)
- Identify and deliver improvement and innovation opportunities, relevant to their circumstances
- Effectively demonstrate vehicle interaction good practice

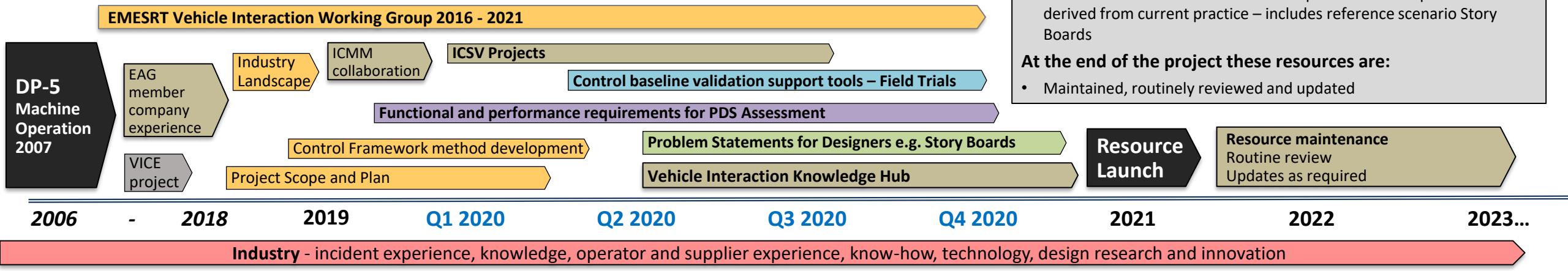
These resources accelerate equipment design and operational practice innovations by providing structured information for Operators, OEM and third-party designers that:

- Complements and builds from EMESRT DP-5 and supporting documents
- Clearly states design improvement opportunities using detailed operational scenarios that illustrate current problems
- Provides detailed user functional and performance requirements derived from current practice – includes reference scenario Story Boards

At the end of the project these resources are:

- Maintained, routinely reviewed and updated

4. Timeline (see also detailed VI Timeline Slide)



EMESRT VI Project Timeline

2006 Establishment

Fully funded industry entity
Common voice engagement process
OMAT beyond standards
Design philosophies

- Access & Working at Heights for surface mobile equipment

2009 Focus areas

1. Surface Mining
2. Exploration Drilling
3. Underground Hard Rock
4. Underground Coal & Soft Rock

Eight design philosophies
Some work on Tyres and Rims with ACARP

2011 Evaluation of OEM Design

Design evaluation linked to procurement through OMAT/EDEEP
14 members of EMESRT

- EMESRT nine level control model

2013 PDS Suppliers

Third party proximity detection suppliers (PDS)
Vehicle Interaction "burning platform" established

1. Clearly define the problem
2. Understand the scenarios
3. Build a set of performance requirements for evaluation

2015 OEM and PDS Interoperability

Control Levels 7-9 Focus

- Performance requirements PR-5 developed to supplement DP-5
- One-on-one briefings with OEMs
- One-on-one briefings with PDS
- 1st OEM- PDS workshop to initiate development of interoperability protocol
- 2nd interface workshop
- 3rd interface workshop

2017 VI Control Improvement Project

Controls at Levels 7-9

- ISO 21815 interface protocol support

Controls at Levels 1-6

- ICMM Collaboration
- Enhanced problem definition including functional requirements

Industry Project Collaboration

- ICMM Technology Acceleration Summits
- ICMM ICSV Collision Avoidance
- ICSV Maturity Framework
- ICSV Knowledge Hub
- Release of updated EMESRT PR5A (performance requirements)

Proximity Detection System Validation

- ACARP C26028 PDS Validation Framework Project

2019 Project Next steps

EMESRT Led

- EMESRT Vehicle Interaction Control Framework (CFw)
- EMESRT Knowledge Hub based on Journey Model navigation aid
- VI Self-Review Tool for review project baseline

EMESRT Influenced

- VI Functional Safety project
- ICSV Workstreams

2018

2020

6. Resource Requirements

Project coordination and facilitation

- The EMESRT Advisory Group provides strategy and planning oversight
- The Industry Project leader and steering team coordinate the delivery of planning outcomes through working with the stakeholder working group

Support Resources

- EMESRT secretariat project management support
- Consultant support for strategic and work group activities
- Other consultant and contractor resources as required, e.g. for Knowledge Hub content creation.

Financial

- EMESRT provides funding for workshop venues, meetings, development of the Knowledge Hub and consultant support.
- Working group members provide in-kind support i.e. sponsorship from the organisations that the represent covering meeting attendance, travel and individual contributions

7. Implementation Approach

In late 2013, and based on the rapid development of collision avoidance systems, EMESRT combined its Design Principle DP 5, 'Machine Operation and Control, and proven methodology to:

- Clearly define the problem
- Understand and confirm the scenarios
- Build a set of performance requirements to assist with the evaluation of Proximity Detection System (PDS) technologies on the market

Since then EMESRT has led and participated in industry-level initiatives with the common goal of improving the reliability of vehicle interaction controls in mining, including:

- The development of interoperability standards between third-party PDS suppliers and equipment supplied by OEM's – a common interface protocol allows PDS controls in mixed equipment fleets
- Collaboration with the ICMM Risk Committee, ICMM Collaborative Technology Acceleration Summits and ongoing support during 2019 for the ICMM Innovation for Cleaner Safer Vehicles (ICSV) programme
- Supporting and contributing to the industry review of the ACARP Proximity Detection System Validation Framework Project C26028

Project work continued throughout 2019-20 and has and will deliver these milestones:

- Ongoing EMESRT support for the ICMM ICSV programme including attendance at workshops
- Supporting phase 3 of the ACARP Proximity Detection System Validation Framework Project C26028 that now includes a collaboration with the University of Pretoria and alignment
- Contributions to Technical Committee TC 127 (Earth-moving machinery), Subcommittee SC 2 (Safety, ergonomics and general requirements), Working Group 22 and 28 (Collision awareness and avoidance)
- Ongoing development of an integrated package of information and support material including a resources for baselining and validating current performance, before considering the introduction of new technology and other innovations
- EMESRT financially supported the development of the ISCV Knowledge Hub for Vehicle Interaction in 2019, the same approach is now being applied on the EMESRT website VI Knowledge Hubs

The EMESRT vehicle interaction community is supported by monthly telephone meetings and as required face-to-face workshops. Currently the community extends to over 150 individuals representing multiple organisations from mining companies, researchers, OEMs, third-party equipment suppliers e.g. PDS and other interested parties.

Vehicle Interaction Control Improvement

Supporting concepts and Information

EMESRT Vehicle Interaction Industry Project – 2018 Target State

The recommended project target state is the delivery of an ***innovation resource and methodology for the systematic and practical improvement of vehicle interaction controls in mining.***

- The resource and methodology will make use of good practice case studies and use a methodology that can be easily adapted and applied by end users.
- It will be useable, scalable, transferrable, and translatable and be supported by well-designed support tools that capture and codify industry experience.
- There will be multiple ways to access the 'product' and content may exist at many locations, these will be supported by suitable navigation aids to find content and where appropriate tools to tailor content based on end user requirements.
- Process outline based on functional requirements; recommended process steps, navigation aids to find and tailor content, suggested accountabilities, hierarchal inter-connected structure, links to relevant case studies, technology validation methodology etc.
- The resource and methodology will enable operating site leaders to understand their specific vehicle interaction risks and ensure that the corresponding controls are well designed, implemented, maintained, monitored and routinely verified.

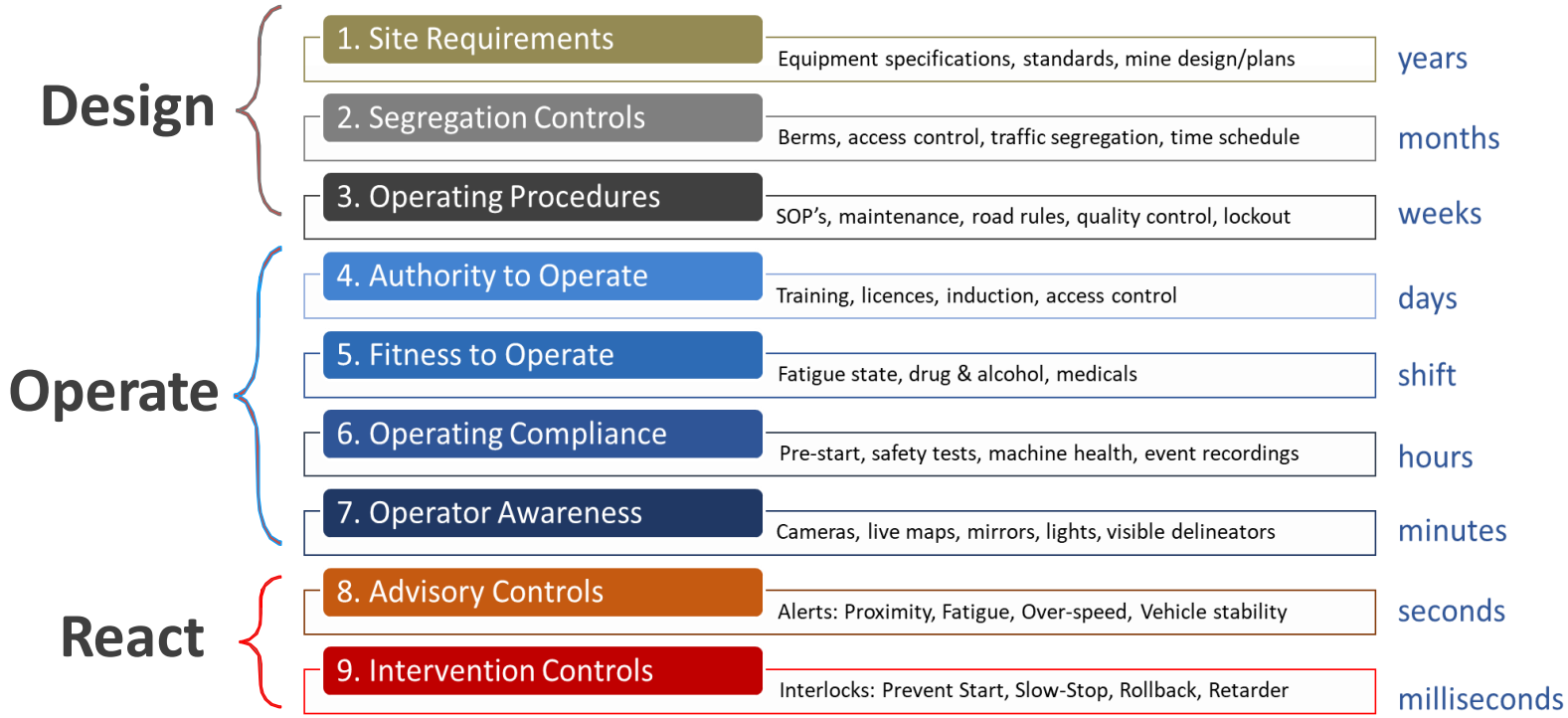
In particular, the resource and methodology will assist in reviewing and improving controls that are entirely dependent on the judgement of people and where errors have the potential for serious consequence. The intent is to build controls into operational processes so that they are applied as work is planned and executed.

Key Concepts – The EMESRT Nine Layer Control Effectiveness Model

Reframing our understanding of Vehicle Interaction Controls

Strategy Relevance

- A foundation concept
- Dynamic interdependence between control levels
- Control categories operate in different timeframes
- High dependence on real time human factor decision making
- To implement Level 8 and 9 controls well, you first need to understand your Level 1- 7 baseline



Foundation Concept

The EMESRT Nine Layer Model of Control Effectiveness

Time phased prior to a collision

Strategy Relevance

- A foundation concept
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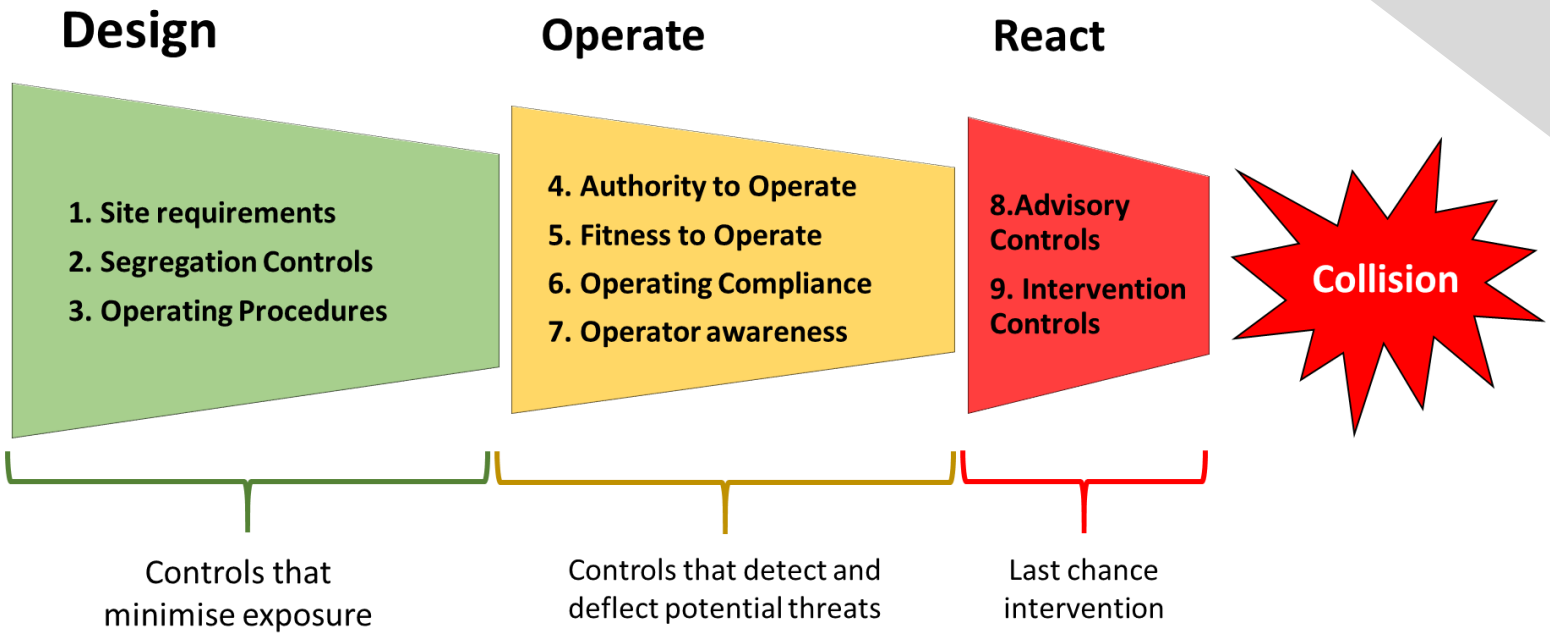
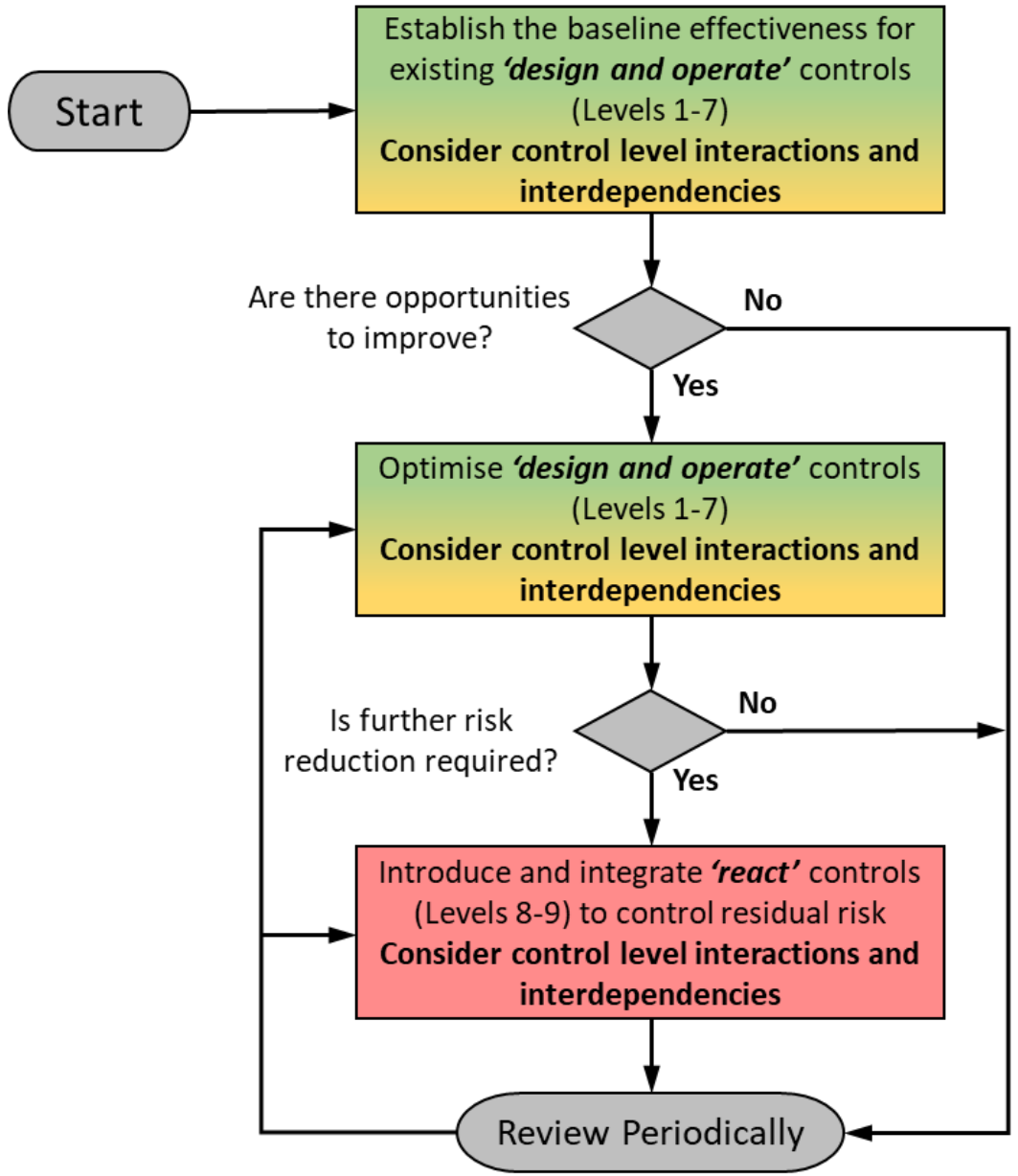


Key Concepts – Sequence for Improving Vehicle Interaction Controls

Strategy Relevance

All VIWG resources will be unambiguous about the need to:

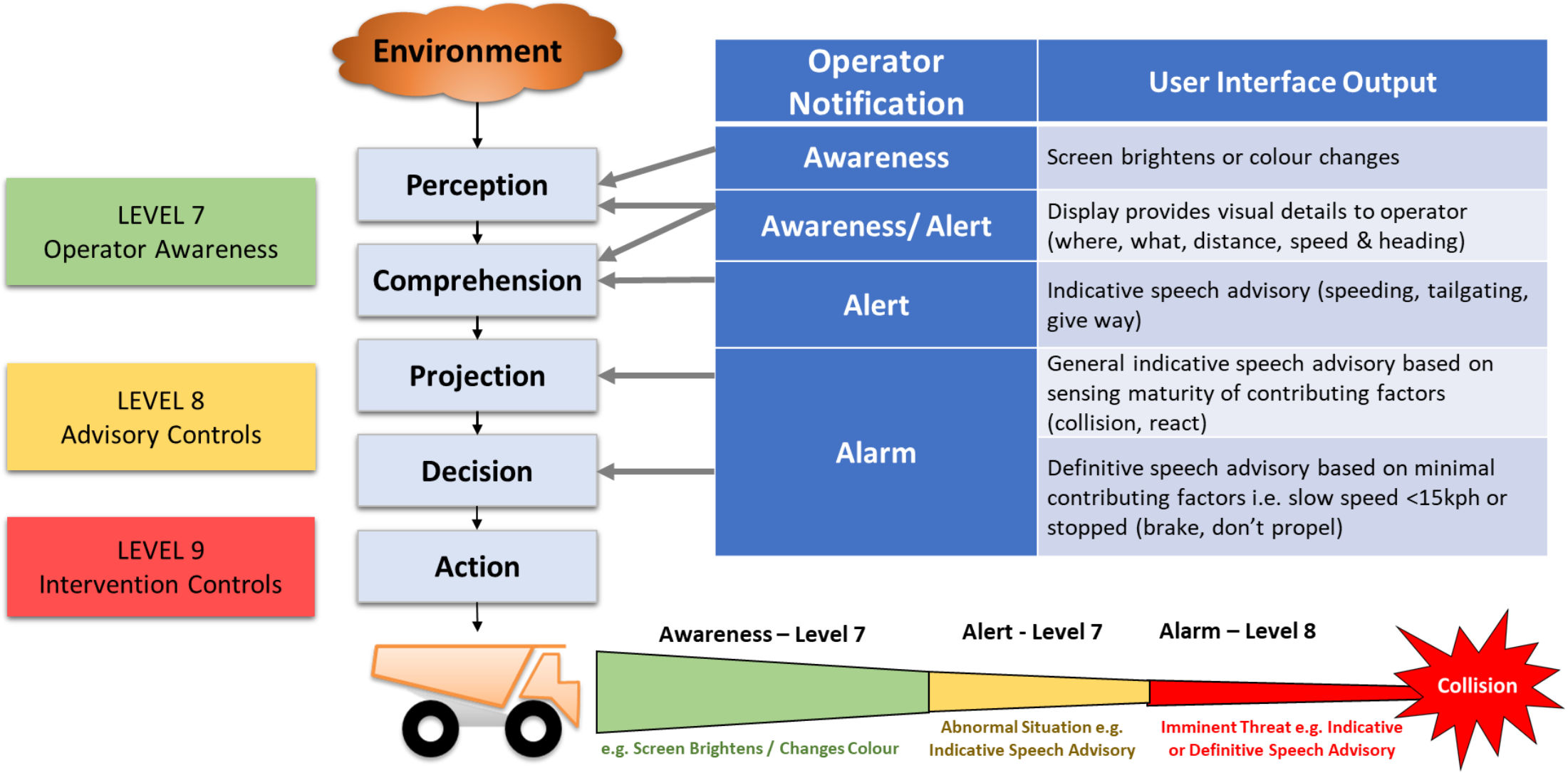
- Manage vehicle interaction control improvement as a project
- Confirm operating baseline (normal operations) before considering technology or design enhancements
- Consider control level interactions and interdependencies, considering operating site circumstances



Combining Models for a deeper understanding

Example from a Glencore Surface Mining Vehicle Interaction Technology Implementation Project

- Human Factor Interaction Model
- EMESRT Nine Layer Model of Control Effectiveness
- Mica Endsley Model of Situational Awareness



EMESRT VICI Project

Work Breakdown Structure Example

A Work Breakdown Structure (WBS) breaks complex projects into smaller components of *objectives, results* and *work packages*.

This example VI Control Improvement Project WBS has six objectives:

1. ***Manage as a Project***
2. ***Phase 1*** *- understand your baseline i.e. where are you starting from*
3. ***Phase 2*** *- identify existing operational improvements – plug the gaps, return to name plate performance*
4. ***Phase 3*** *-identify and implement - iterative design and technology innovations*
5. ***Phase 4*** *- identify and implement - step change design and technology innovations*
6. ***Phase 4+*** *Fit the approach into your broader company strategic approach e.g. digital mine of the future*