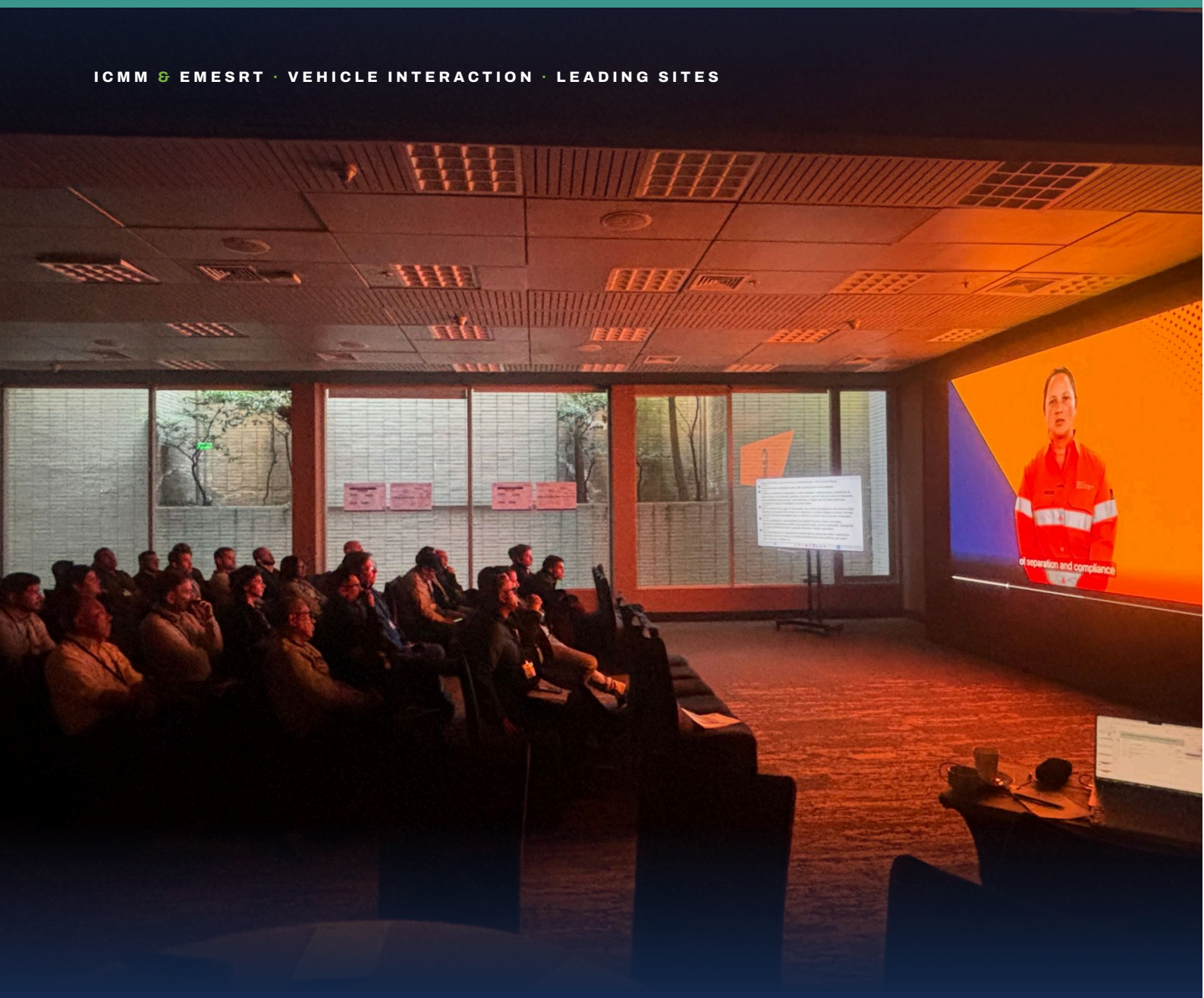

FORUM SUMMARY REPORT

ICSV Vehicle Interaction: Leading Sites Forum

Santiago, Chile | 22–24 September 2026 | 5th in-person forum

43	18	3	1st
delegates	organisations	days, three languages	forum at scale in Latin America

A summary of what practitioners learned in Santiago about building a capable vehicle interaction solution: validating the foundations first, integrating technology into the work, and collaborating as an industry.

CONVENED BY

EMESRT
Earth Moving Equipment Safety Round Table

ICMM
Innovation for Cleaner, Safer Vehicles (ICSV)

WELCOME

Santiago: a first for Latin America

In September 2026, 43 vehicle interaction (VI) practitioners from 18 organisations met in Santiago, Chile, for the fifth ICMM and EMESRT Vehicle Interaction Leading Sites Forum. It was the first forum held at scale in Latin America, and it ran in English, Spanish (notation and narration), and Portuguese (notation).



Opening the forum in Santiago on Day 1, 22 September 2026.

Mobile equipment interactions remain the leading cause of fatalities in mining. The industry has invested heavily in collision avoidance technology, yet results have often fallen short of expectations. Too often, technology deployment occurs before a site has validated how well its existing operational activities work in the field, and before human factors have been considered.

This report shares what delegates learned and committed to, so that participants can take it back to their teams and the wider industry can benefit from their open involvement.

At a glance

43 delegates from operations across Latin America, North America, Africa, and Australia

18 organisations: 16 mining companies and 2 independent experts

3 languages, with simultaneous interpretation

70% understood the 9 Layers of Defence well or could apply them after Day 1

96% rated peer discussion very or extremely useful

86% asked for a peer network, case studies, or a working group

The forum in one sentence. A cohort that arrived most interested in technology left committed to validating the effectiveness of its operational foundations first, and asked for ways to stay connected rather than for more documents.

A capable solution

The forum's purpose was to show that installing technology alone will not improve VI performance. A capable solution improves the quality of decision-making from task execution through to mine design; considers the operating environment, production requirements, and equipment design; and, where technology is part of it, integrates that technology with existing operational activities.



Setting out what a capable solution means.

THE FRAMEWORKS

What we explored

The VI 9 Layers of Defence

The EMESRT 9 Layers of Defence articulates the operational activities that prepare an operation to validate, implement, and manage work processes and technologies such as collision avoidance systems (CAS). They defend against unwanted interactions between vehicles and people, between vehicles, and between vehicles and the operating environment. The model is shown below; the forum interrogated it in three breakout groups.

DESIGN · Layers 1 – 3 Foundational and long-term	OPERATE · Layers 4 – 6 Recurring and governance-led	REACT · Layers 7 – 9 Immediate, close to the event
1 Site requirements	4 Authority to operate	7 Operator awareness
2 Vehicle separation	5 Fitness to operate	8 Operator advisory
3 Operating procedures	6 Operating compliance	9 Machine intervention

Note: Layers grouped into three equal sets as used in the forum breakouts. Conventionally, Layer 7 is part of normal daily operations.



A Day 1 breakout group works through the React layers (7 – 9), using the 9 Layers as a shared language.

Not a hierarchy or a maturity ladder. The layers interrelate: ineffectiveness in one changes what the others must try to manage. Activation of the Advisory and Intervention layers depends on the operational effectiveness the Design and Operate layers create, and data from the React layers (alarms, interventions, near misses) can provide operational effectiveness feedback into the Design and Operate layers.

The Operational Effectiveness baseline

To operate effectively, a mine must consistently satisfy its **Operational Requirements**. **Erosion Factors**, such as design constraints, misaligned decisions, or untested assumptions, lower operational effectiveness. **Operational Activities** should be designed to prevent or mitigate erosion factors from occurring. The operational activities include what is specified, implemented, and monitored on the site during normal operations. Validating the operational effectiveness baseline shows a site what is actually working in the field, before it decides what to change in its current operational activities.

Readiness levels

Readiness level	Question	In vehicle interaction terms
Technology (TRL)	*Can it work?*	Does CAS reliably support awareness and warn of hazards in real operating conditions?
Commercial (CRL)	*Can it succeed and last?*	Is there a procurement path, a support model, and a business case for the fleet?
Human (HRL)	*Will it work for people?*	Can operators understand, trust, and respond to it without overload or workarounds?

The three scales examine technology development, integration, and sustainment. The Operational Effectiveness validation process allows a site to understand the functional performance requirements for the technology, the operational activities required to implement it effectively, and how to sustain its performance over time.

KEY FINDINGS

Four measurements, one direction

Before the forum, technology design and integration was delegates' top interest (16 of 18 survey respondents). Over three days, four separate measurements pointed the same way: **validate the Operational Effectiveness baseline first.**

Day 1 poll
Most respondents chose Layer 1: Site Requirements as the layer to tackle first.

Day 2 poll
Five of eight 30-day action groups were diagnostic: baseline, gaps, verification.

Day 3 round table
The main commitment: assess Layers 1 – 7 before adding Layers 8 and 9.

Day 3 poll
"Foundations before technology" was the most-reported key insight.

Three central themes

1 Readiness, not maturity

Delegates moved away from "maturity" language, because a low maturity rating can become a reason to wait. Readiness is dynamic and lets a site implement leading practice operational activities. Organisational maturity represents insight into readiness for technology adoption: knowing that the organisation is not ready, because of conditions that can change rapidly, is a sign of maturity. Conversely, a lack of readiness does **not** mean the organisation is not 'mature'.

The VI 9 Layers of Defence model provides a good overview and can be used by sites with leaders, regulators, and peers to discuss the need for an integrated approach to understanding operational effectiveness. These discussions can help establish the commitment required to conduct an operational effectiveness baseline validation process.

The Operational Effectiveness baseline validation process is where a site's management system activities are challenged and inadequacies validated.

2 Technology builds on a foundation; it cannot replace one

Technology is not a silver bullet, though the long-term goal of zero-entry mining should still guide decisions made today. The most common problems were operational, not technical: technology systems that are not integrated into normal operational activities, so alarms trigger constantly during routine tasks and become a nuisance to the operator. The real value comes *after* the alarm, in what the operation does with the data: is the deviation created by misalignment with people, process, equipment, or the operating environment?

3 Common language and candid peer learning

Shared terminology lets sites have the same conversation with peers, regulators, and suppliers, and keeps incident discussion focused on design and systems rather than simply blaming the operator. Delegates asked for ongoing connection: a peer network, shared case studies, and involvement in working groups.



Open discussion, with simultaneous interpretation running throughout.

> ***"There's no such thing as best practice. You only ever lead to a given point in time."***
> Forum facilitator

> ***"Documentation is not implementation."***
> A recurring theme across all three days

THE PROGRAM

Three days in Santiago

1
UNDERSTAND

Understanding the 9 Layers

An introduction to the VI 9 Layers of Defence, a member company case study on its VI journey, and breakout rounds on the Design, Operate, and React layers.

What we heard: 70% said they understood the layers well or could apply them, and nobody chose "a lot more to learn". Asked what would reduce unwanted interactions today, delegates named a *combination* of road and mine design, vehicle segregation, operational discipline, awareness, operator fitness to operate, and technology, leaning most heavily towards Design.

2
APPLY

Building a VI improvement project

Where to begin, work breakdown structure, change management and executive sponsorship; Operational Effectiveness baseline validation; a member company improvement case study; and an EMESRT Technical Working Group update.

What we heard: 27 of 28 respondents rated peer discussion very or extremely useful. Delegates' 30-day actions focused on running or updating a baseline validation process to identify gaps. Diagnosis came before procurement.

3
CONSOLIDATE

Learning from an incident, and looking ahead

A live exercise with the VI Incident Contributing Erosion Factors Assessment Tool, an industry panel on future VI challenges, and a closing round table where every delegate spoke. Twelve delegates also visited the Anglo American Remote Operations Centre.

What we heard: The clearest commitment was to return to site and assess the effectiveness of Layers 1 – 7 before adding Layers 8 and 9.



A breakout group reports back, with notes captured in Spanish.



A member joins remotely from Australia to share an implementation case study on Day 2.

What delegates are taking home

- Assess Layers 1 – 7 before adding Layers 8 and 9.
- Build a checklist for every layer and find what is missing.
- Form multidisciplinary teams that take part throughout the improvement project, rather than presenting slides to them.
- Test the incident tool against existing root cause procedures.
- Review site documents, many 10 – 15 years old.
- Get information to workers in a form they can act on.

> ***"If we continue to tell ourselves it's not feasible, it will continue not to exist."***
>
> Forum delegate

DAY 3 · WORKED LIVE

Learning from an incident

Delegates worked through the VI Incident Contributing Erosion Factors Assessment Tool as an investigation team would at the start of an investigation, using a publicly investigated collision animation.



Working through the assessment tool live on Day 3.

THE CASE · MAULES CREEK, NSW, AUSTRALIA · APRIL 2018

A moved stop sign at a cross intersection

A service truck driver approached a cross intersection unaware that the stop signs had been moved the day before. Believing he had right of way, he struck the side of a haul truck and was injured. The change had been communicated at the start-of-shift toolbox talk, but the driver worked on the maintenance crew in the field and was not made aware.

3 / 9 Of nine possible operational requirements, the group identified three that had been compromised:

- Adequate clearance
- Give way
- Impairment / inattention

Tracing the erosion factors

DESIGN · OPERATE · REACT

	EROSION FACTOR	CAUSAL PATHWAYS IDENTIFIED	LAYERS
01	**Operator fails to see signage**	Sign existed but was in the wrong place after the move	1 2
02	**Operator fails to comply**	A lapse; unclear toolbox attendance requirements; worker unaware of the change	3 4 7
03	**Inconsistent supervisory enforcement**	Uneven discipline; weak performance review; production favoured over safety	4 6
04	**Planning misses chances to reduce interactions**	Site and corporate guidelines not followed in planning	1
05	**Plans not implemented to standard**	Road, intersection, and barrier design; change not communicated; poor demarcation and lighting	1 2 3 6

Every erosion factor traced back to Design or Operate layers.

None of the causal pathways would have been closed by adding React-layer technology alone.

36 : 9
FAILURE MODES

36 ways a cross intersection can fail, compared with 9 in a T-intersection, in one industry fatality post-incident analysis. A single Layer 1 design decision removes three-quarters of the failure modes before any operator or technology is relied upon.

FACILITATION TIPS FOR SITE TEAMS

- Start broad to capture all possible factors, then examine each one in depth.
- Don't separate the two vehicles too early in the analysis by hunting for the one "at fault".
- When in doubt, mark it "yes": it prompts further investigation.
- Assess what actually existed at the time, not what might have.

FINDINGS FROM THE FLOOR

- Remove cross intersections from mine designs wherever possible.
- Compare work as intended, as normal, and as done to expose drift.
- Use erosion factors as a reference point in risk assessment, rather than jumping from hazard to activity.

PRACTICE SHARED

Insights by layer of defence

Practice that delegates shared across the breakouts, case studies, and panel.



A breakout group works through Layers 7, 8 and 9.



Capturing practice on Layer 9: Machine intervention.

Layer	Key theme	Practice shared
DESIGN		
1 Site requirements	Decisions made years ago set today's limits	Equipment chosen before mine design; bigger trucks without wider roads. Multidisciplinary committees verify road standards in the field. Cross intersections removed.
2 Vehicle separation	Segregate first where possible	Tens of kilometres of segregated road; light vehicle pit entries cut by three-quarters; access gates that check CAS is working. *"Don't build a car park in the pit, because it will fill."*
3 Operating procedures	Procedure compliance drifts however often it is inspected	Review more often once technology changes the work; cultural change lags physical change.
OPERATE		
4 Authority to operate	Trained, competent, and authorised are three separate tests	Training by equipment model, not type; operator ID keys; licence refresh after time away.
5 Fitness to operate	Fatigue data challenged the roster assumption	Across 13 sites, about 20% of workers generated 80% of fatigue events, linked mainly to health and lifestyle. Self-reporting without consequences; joint review committees.
6 Operating compliance	Verification becomes box-ticking unless something physical is checked	Walk-arounds after a hot-seat change. Too much data can bury precursor events. Recognition should outnumber consequence.
REACT		
7 Operator awareness	Simple aids come before proximity systems	Mirrors and hi-vis striping; shovel perimeter lighting; LED light vehicle flag poles; radio volume limits so alarms stay audible.
8 Operator advisory	Volume does not equal value	One operation cut monthly alarms by 70% and, in doing so, found a haul road maintained well below its width specification. Spoken instructions in place of beeps from operator interfaces.
9 Machine intervention	Every site already runs Layer 9 technologies; it just isn't CAS	*"If CAS technology can't do Layer 7 awareness effectively, you can't do Layer 8 operator advisory. The only difference between 8 and 9 is where you send the signal."* Set intervention narrowly.



Recording ideas on Layer 7: Operator awareness.



A group talks through the Layer 7: Operator awareness ideas.

The loop is not linear. Signals from Layers 7 – 9 belong back in Layers 1 – 3. An alarm cluster traced to a road built too narrow is a design finding, not an operator finding.

THE BIG IDEA

Readiness starts with the baseline

Three readiness scales are used to judge new technology. The **Technology Readiness Level (TRL)** asks whether the technology can work reliably in real operating conditions. The **Commercial Readiness Level (CRL)** asks whether it can succeed and last, with a procurement path, a support model, and a business case. The **Human Readiness Level (HRL)** asks whether people can understand, trust, and respond to it without overload or workarounds. Alongside them sits the question the industry's record keeps raising: **is the operation ready to receive it?**

A technology rated highly on all three scales, deployed onto an untested Layer 1 – 7 baseline, is not a *capable solution*. Delegates suggested that much of the answer already exists: operational readiness grows out of the VI Operational Effectiveness baseline validation. A useful readiness view should:

Use readiness language
A continuing state a site holds and can lose, not a hierarchy that justifies waiting.

Build on the baseline
Draw evidence from the existing operational effectiveness baseline process, with no second assessment burden.

Point to the gap
Show where the effectiveness gap is and direct action, rather than ranking sites against each other.

A principle to test. *Do not deploy Layer 8 or 9 technologies at a scale greater than the demonstrated effectiveness of the Layer 1 – 7 baseline.*

The room broadly supported the principle, with two qualifications: zero-entry mining should still guide what the industry asks suppliers to build, and some sites will choose strategic patience on immature technology.

How it plays out

Baseline unmapped
Map and validate the Layer 1 – 7 baseline before scaling any Layer 8 – 9 technologies.

Baseline eroded
Close the erosion factor gaps first. If technology is already deployed, use React-layer data to find them, not as a substitute for fixing them.

Baseline demonstrated
Scale Layer 8 – 9 technologies to enhance the effectiveness of lower layers, site by site, with train-the-trainer.

Lessons from the industry panel



The Day 3 industry panel on what comes next: "There is no silver bullet."

- **Match scope to gap.** Know exactly what functional performance parameters technology covers, and how that matches your operation's gaps, before purchase.
- **Integration is the main risk.** *"It's not that the technology doesn't work. It just doesn't work in our environment."* Using the EMESRT functional performance scenario storyboards with suppliers before purchase exposes mismatches in functional performance early.
- **Weigh the practical questions:** local dealer support, OEM capability in country, licensing, and translation.
- **The value comes after the alarm:** using the data proactively to strengthen the lower layers.
- **A technology house built on an ineffective operational foundation will fail at some point when you least expect it.**

LOOKING AHEAD

What happens next

Delegates committed to validating operational activities at their own sites and directed the shared agenda at problems no single operation can solve alone. The program's focus areas from here are:



A delegate addresses the room. Peer exchange shaped the shared agenda for what comes next.

1 **Readiness language**

Treat operational effectiveness baseline validation as ongoing readiness assessment, not a periodic process.

2 **Staying connected**

Regional peer groups, shared case studies (including what failed), and topic working groups between forums.

3 **A focus on underground**

A dedicated underground stream, with guidance on detection, intervention, and geometry.

4 **Working with OEMs and technology providers**

Interoperability, underground detection and braking standards, and functional options built in as standard. Updated underground functional performance storyboards.

5 **Wider reach**

Consistent delegations from forum to forum, Latin American outreach through the National Safety Council of Chile, and the VI 9 Layers of Defence video series in site toolbox talks.

6 **Control centres**

Examine how remote and operations monitoring centres provide data on the effectiveness of Layers 1 – 7.

7 **Language translation underpins effectiveness**

Resources in Spanish and Portuguese, with bilingual industry reviewers checking mining-specific terms.

8 **Smarter procurement**

Use the VI functional performance scenario storyboards and PR5A technical requirements when procuring VI technology.

Can you help? EMESRT is seeking bilingual industry practitioners to review translated resources, and member companies willing to share case studies, including what did not work. Get in touch through emesrt.org.

> ***"Take the company hat off sometimes and put the industry hat on. The bigger the common voice, the more the suppliers listen and commit to act."***
>
> Closing charge, Day 3

THANK YOU

Thank you to everyone who took part



Santiago 2026 delegates and organisers at the close of the forum.

Thank you to every delegate who spoke candidly about incidents, failures, and trade-offs at their own operations; to the member companies who shared case studies; to the Day 3 panellists; to Anglo American for hosting the Remote Operations Centre visit; to our interpreters; and to Dr Sara Pazell (ViVA health at work) for facilitating the forum. ICMM and EMESRT convened and funded the forum, free of charge to participants.

Free EMESRT resources

VI Body of Knowledge

Guides, tools, and leading practice for vehicle interaction improvement. emesrt.org/vici-bok

VI 9 Layers of Defence Guide

The EMESRT guide to applying the VI 9 Layers of Defence (2025), and the accompanying video series.

VI Operational Effectiveness baseline validation

Baseline mapping and validation guides, and the Incident Contributing Erosion Factors Assessment Tool.

Functional Performance Requirements

EMESRT Performance Requirement 5A (PR5A), including the VI Functional Performance Scenario Storyboards and Performance Requirements.

Stay in touch. To join the Leading Sites network, share a case study, or help review translated resources, visit **emesrt.org**.

This summary is provided for general information only. It reflects the views of forum participants and does not constitute advice; anyone applying its content should seek independent advice from a qualified person. Delegate contributions are reported in anonymised form, with consent.