LSM TrainSense® (Int. Pat. Pend).

In-Cab Warning System (IVWS) concept for rail level crossings collision awareness avoidance (/ CAAS) system

Practical evidence, economics and rollout pathway | WSP briefing | 20 Feb 2026

Stakeholders have different pain points:

- **Rail owners / operators:** high consequence events + remote crossings.

- **Road authorities / regulators:** thousands of passive crossings, limited capex, and human behaviour challenges.

- **Rail network managers:** near hits cause emergency responses, delays, equipment damage and risk exposure.

LSM TrainSense® focuses on the dominant failure mode: the road user misses or disregards external warnings.

Problem size: scale + exposure

23,500+

Level crossings in Australia

79%

Passive crossings (Stop/Give Way only)

1,000+/yr

Near hits / near misses

Collisions are still occurring despite traditional mitigations

- ATSB recorded 283 level-crossing collisions involving vehicles (1 Jul 2014 – 30 Jun 2022).
- 44 involved heavy freight vehicles.
- Even "active" crossings rely on road user compliance- and collisions still happen.

Train braking reality

A loaded freight train can require up to ~2.0 km to stop after emergency brakes.

→ *prevention must be *proactive* (before the crossing)*.

USA (for comparison)

- 212,000+ grade crossings (active + passive)
- 2,202 collisions in 2022 (269 fatalities; 827 injuries)
- >60% of collisions occur at crossings with automatic warning systems.
- Collision with Train every 4 x hours (FRA)

Traditional mitigations: helpful, but not sufficient

What we do today

- Passive controls: static Stop / Give Way signs

- Active controls: lights / bells / booms

- Education + enforcement

- Crossing upgrades or removals (slow + expensive)

Common failure mechanisms

- Driver distraction / in-cab noise: external alarms missed

- Visibility masking: sun glare, foliage, weather

- Complacency and deliberate violations

- Fatigue / inattention

- Remote sites: active mitigation controls cost and practicality of infrastructure + maintenance

- *If 1 x RLX removed each week-will take 452 years or 1 x day= 65 years.*

Gap: we do not currently have a low- cost way to put the warning *inside the cabin*.

Human behavioural drivers

- Distraction (mobile phone set-up, radio, in-cab tasks, workload)
- Expectancy / familiarity bias ("I've never seen a train here")
- Time pressure + deadline behaviour (speed vs safety trade-offs)
- Fatigue → slower detection and decision time
- Complacency / deliberate violations (risk normalisation)
- Inattention

Environmental + crossing context

- Sun glare / poor contrast / background clutter in daylight
- Vegetation, infrastructure, weather masking (rain, dust, fog)
- Curved or skewed approaches: drivers must look "ahead + across"
- Remote / low-train- frequency crossings → low alertness, fewer cues
- Heavy vehicles: long stopping distance + trailer brake dynamics

Design implication:
Put the warning *inside the cab*, earlier than the last visual cue- then escalate only when relevant.

74%

of collisions (and **81% of near hits**) occur in daylight (ONRSR / Monash IRT train visibility research).

Monash IRT trials: focused on daylight and found visibility depends on crossing angle, vegetation and weather- not just lighting.

- Daylight glare + clutter can reduce detection ("looked-but-failed-to-see").
- Low train frequency drives expectancy and late scanning.
- Passive crossings rely on a last- moment visual cue.
- LSM TrainSense® adds an earlier, consistent *in-cab* warning- independent of lighting.
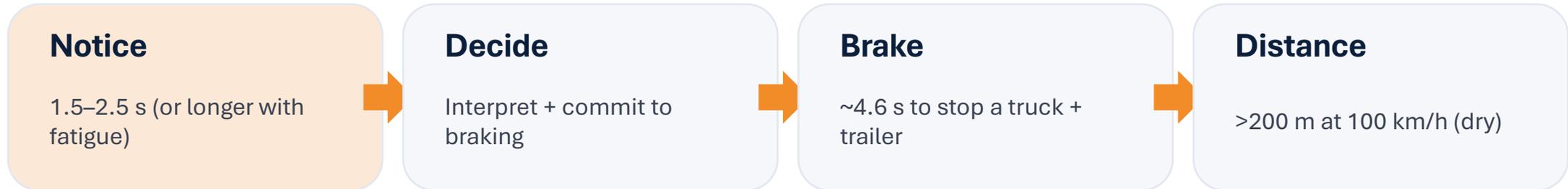

Day vs night (share)

Collisions Day 74% Night 26%
Near hits Day 8% Night 19%

Human factors: the "seconds" problem

From hazard → crash can be only seconds

Notice	Decide	Brake	Distance
1.5–2.5 s (or longer with fatigue)	Interpret + commit to braking	~4.6 s to stop a truck + trailer	>200 m at 100 km/h (dry)

So... if the driver misses the crossing until the last moment, the physics may already be against them.

Design implication- challenge:

Provide staged, in-cab warnings far enough in advance to compensate for distraction, fatigue and stopping distance- and only escalate when relevant (eg to avoid alert fatigue).

ATSB summary (RO-2021-003)

22 Feb 2021: Road-train entered an *active* flashing- light crossing (Yarri Rd, Parkeston) and collided with freight train 2C74.

- Locomotive derailed; both train crew seriously injured; truck driver uninjured.
- Crossing complied with standards and was serviceable- yet the road user still missed the warning.

Contributing human + environment factors

- Driver distraction: re-affixing phone cradle / setting up cab on approach.
- Curved road geometry → drivers must look "ahead + across" to see the flashing lights.
- Low expectancy: familiar route but had never encountered a train at this crossing.

Where TrainSense helps: in-cab alerts would persist during distraction and can trigger earlier than roadside cues; optional escalation to controlled braking at selected crossings.

Road-train truck (TK070), trailer 2
Road-train truck (TK070), trailer 3
Road-train truck (TK070), direction of travel
Train 2C74 locomotive Q4002
Train 2C74 direction of travel

Opportunity window`

- **~800 m:** Flashing lights already operating (driver distracted)
- **~160 m:** Passes 2nd advance warning sign (still setting up phone)
- **<120 m:** Notices lights + train → braking too late

LSM TrainSense® technical concept (using proven components)

Device concept

- GNSS receiver + high-gain antenna

- Stored crossing database (geofence) with "active/passive" tags

- In-cab visual + audio warnings; acknowledgement input

- Optional comms: GSM / eSIM, RF receiver, Wi-Fi

- Optional CAN / J1939 integration for deceleration / brake / AEB

Status: concept stage (no prototype available yet).

Driver experience

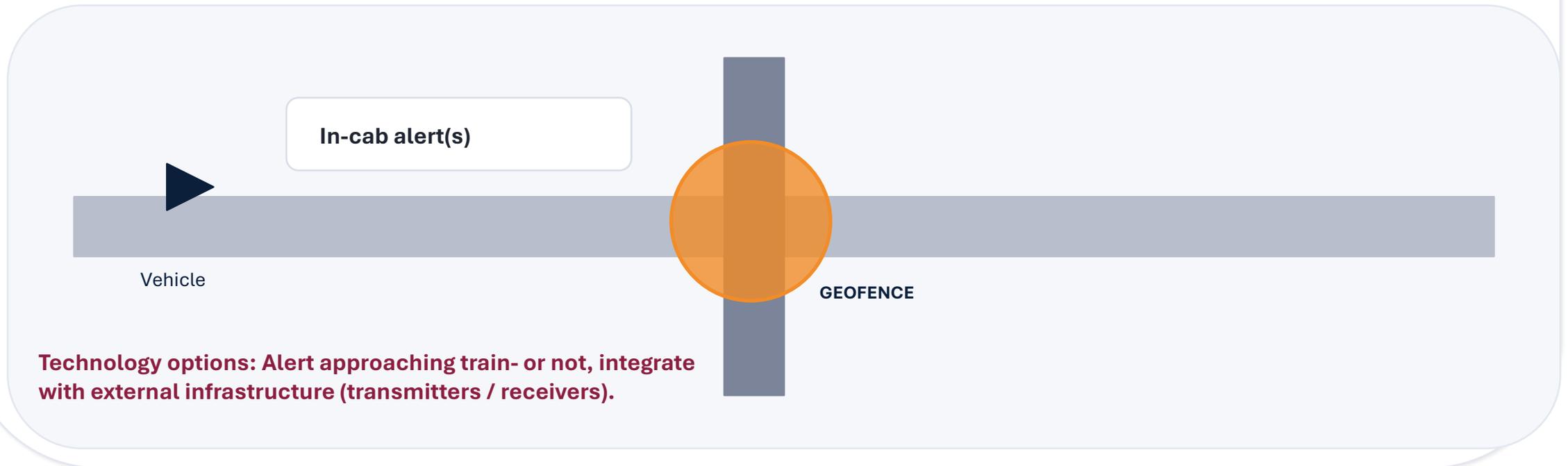"Approaching rail crossing"
+ staged alerts

If driver ignores alerts:
optional deceleration / brake / AEB

Data (optional): store non-compliance events
+ fleet reporting (telematics)

Technology integration : ADR 97/00 Radar + AEB already mandated

How it works (simple scenario)

1) Vehicle is *not* on a road that crosses a level crossing → no alerts

2) Vehicle approaches the geofenced crossing → in-cab pre-warnings (audible + visual)

3) Driver slows / stops → proceeds when safe

4) If warnings ignored → optional deceleration / braking / AEB

In-cab alert(s)

Vehicle

GEOFENCE

Technology options: Alert approaching train- or not, integrate with external infrastructure (transmitters / receivers).

Staged alerts are triggered by distance or time-to-crossing (configurable by vehicle type + crossing risk).

- Earlier than the last visual cue → supports distracted / fatigued drivers
- Consistent prompts (visual + audible) reduce reliance on roadside visibility
- Escalation logic can require acknowledgement and / or speed reduction
- Optional controlled deceleration / AEB at selected high-risk crossings (safety case-dependent)

~30s	~15s	~8s	0s
Advisory "Crossing ahead"	Caution "Prepare to stop"	Imminent "STOP"	Crossing

Integration note: TrainSense can operate as a standalone IVWS (GNSS + database). Where appropriate, outputs can also integrate via CAN/J1939 into existing radar + braking controllers- aligned with ADR 97/00 AEB systems on heavy vehicles- and be OEM-integrated for passenger vehicles over time.

Compatibility options

- Quick and easy Retrofit in existing fleets
- Can integrate via CAN / J1939 with existing radar + braking controllers (aligned with ADR 97/00 AEB technology on heavy vehicles)
- OEM integration path for passenger vehicles over time (consistent HMI) with new ADR
- Optional telematics for compliance reporting + event analytics
- Optional trackside "train approaching" input at selected high-risk sites
- Easy integration to other external infrastructure.
- Potential combined device with BridgeSense (over-height + rail crossing)
- Low costs (≈ $100 / vehicle) recoverable via vehicle registration if required- future ADR / OEM at no costs

Consistent finding across decades: timely, selective in-vehicle alerts improve driver behaviour-success depends on low false alarms + clear HMI.

NTSB: explored ITS/IVWS concepts for grade crossings

Larue: GPS IVWS improved awareness; drivers slowed earlier

Recent studies + ATSB reviews reinforce human-factors gap

La Trobe trial: alert timing + false-alarm control critical

Beanland: acceptance depends on reliability + low nuisance

FRA RCVW: in-vehicle warnings improved responses; apps have adoption limits

UniSC- DITRDCA NLCS Grant human behavioural factors for RLX Collisions

Nearly 30 years of extensive international studies determine that Human factors dominate; recommend ITS / IVWS solutions.

1998	2013	2015	2018	2020-21	2023-24	2025- 26

Why IVWS stands out: vehicle-based, scalable and can complement both passive and active crossings. RLX conventional and Infrastructure only upgrades have adoption and effectiveness constraints.

Where are we now?

Multiple Organisations Are Working to Reduce Rail Level Crossing (RLX) Collisions in Australia

Key Stakeholders Include:

- NLCSS- National level Crossing Safety Strategy Committee
- ONSR office of the National Rail Safety Regulator
- TMR- (Qld) Transport Mains Roads (Rail Safety Team)
- OTSI- (TfNSW) Office Transport Safety Investigation
- TrackSafe- Advocacy organisation
- DITRDCA- via the NLCS grant for development of RLX Collision solutions.
- NHVR- National Heavy Vehicle Regulator

What Has Been Achieved Historically?

- NLCSS has operated for more than two decades
- Significant grant funding has supported mitigation research and innovation
- Hundreds of millions of dollars invested in removing rail level crossings (primarily non-remote passive crossings), with limited overall reduction
- Development of training and education programs
- Implementation of multiple public awareness campaigns
- Introduction of enforcement measures and penalties
- Trials of alternative and innovative solutions, many proving costly or ineffective

Despite **decades** of coordinated effort, investment, and regulatory action, no comprehensive solution beyond conventional infrastructure upgrades has been implemented, particularly in addressing human factors contributing to RLX collisions.

Questions and Answers?

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Key external sources / studies / endorsements / stakeholders

LSM Technologies:
- LSM TrainSense® (int.pat.pend) product page.
- LSM TrainSense® CAAS overview.
- LSM TrainSense® IVWS vs Conventional vs RASX CAS Analysis v1.5.
- LSM TrainSense® CAAS Concept Fact Sheet v2.
  LSM BridgeSense® (int.pat.pend) product page.
- LSM BridgeSense® CAAS Concept Fact Sheet.

Endorsement references:
- 2025- Hon Scott Buchholz Support Letter.
- 2024 TrackSafe Support Letter.
- 2024- TMR Support Letter.
- 2024- HVIA Support Letter.

Other Studies / Reports / Docs:
- ATSB RO-2021-003 (Parkeston WA case study).
- NTSB Study SS-98-02 (1998)" *"Safety at Passive Grade Crossings"* National Transportation Safety Board
- NTSB Study SS-98-03 (1998) *"Highway-Rail Grade Crossing Active Warning Device Issues"*
- La Trobe University Trial (2013) *Trial of DSRC-based In-Vehicle Warning System in Victoria* (No public direct URL found; contact La Trobe Centre for Technology Infusion or VicRoads)- see video
- Beanland, V. et al. (2018) *"Evaluation of In-Vehicle Warning Systems for Railway Level Crossings"* Australasian College of Road Safety Journal
- Larue, G. et al. (2015) *"The Potential for In-Vehicle Warnings to Improve Safety at Passive Rail Crossings"* Centre for Accident Research & Road Safety – Queensland (CARRS-Q), QUT
- Nadri, M. et al. (2023) *"Improving Safety at Highway-Rail Grade Crossings Using In-Vehicle Auditory Alerts"* published in: Accident Analysis & Prevention.
- ATSB Report RS-2021-001 (2024) *"Level crossing collisions involving trains and heavy road vehicles"* Australian Transport Safety Bureau

- FRA Rail Crossing Violation Warning (RCVW) Program (2016–2021) U.S. Federal Railroad Administration.
- U.S. DOT ITS Evaluation: Illinois On-Board Advisory Warning Pilot (1997–2002) Referenced in: *ITS Benefits and Costs Report, U.S. DOT Volpe Center*.
- Callaghans Lane RASX Trial (NSW) NSW Government & ARTC (part of Regional Australia Level Crossing Safety Program)
- Queensland RASX Trials – Oakey & Thallon Queensland Rail / TMR
- Australian Design Rules (ADR) – Heavy Vehicle Safety Standards Department of Infrastructure, Transport, Regional Development, Communications and the Arts- see this link and this link.
- Bureau of Infrastructure and Transport Research Economics (BITRE) *Vehicle Registration Statistics – Australia (2023–2024)*
- LSM Technologies- LSM TrainSense® / BridgeSense® Product Info + Case Studies
- ARTC- Australian Rail Track Corporation: *Safety Around Level Crossings*
- ADR 97/00: Advanced Emergency Braking for Omnibuses and Medium/Heavy Goods Vehicles: Mandates AEB systems on new model buses from 1 November 2023, all buses from 1 November 2024, and all heavy goods vehicles > 3.5 t GVM from 1 February 2025.
- ADR 108/00 – Reversing Safety: Mandates reversing safety systems addressing human factor limitations of visual/audible-only alerts; implemented via Australian Design Rule standards.
- U.S. Mandate – AEB standard on all new passenger vehicles by September 2029: NHTSA finalized FMVSS-127 requiring AEB- including pedestrian detection—on all cars and light trucks by September 2029. Estimated to save ~360 lives and prevent 24,000 injuries annually.

Key Stakeholders:
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