Safe Systems Technology for Dynamic and Routine Road Maintenance Worksites

2025 RA Fellowship Program

Team 5 QLD / NSW

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QLD NSW FELLOWSHIP 2025

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Acronyms and Abbreviations

ADAS	Advanced Driver Assistance Systems
AGTTM	Austroads Guide to Temporary Traffic Management
AI	Artificial Intelligence
BIM	Building Information Modelling
CCTV	Closed Circuit Television
CRC	Cooperative Research Centre
DVR	Digital Video Recorder
DE	Digital Engineering
DRAC	Deceleration Rate to Avoid Crash
EBRWs	Electronic Boards for Roadworks
EOQ	End of Queue
EU	European Union
FWC	Fair Work Commission
GPS	Global Positioning System
GSR	General Safety Regulation
ISA	Intelligent Speed Assistance
ITS	Intelligent Transportation Systems
LED	Light Emitting Diode
MCA	Multi-Criteria Analysis
NFDH	National Freight Data Hub
NTC	National Transport Commission
OSHA	Occupational Safety and Health Administration
PPE	Personal Protective Equipment
PTCD	Portable Traffic Control Devices
QGTTM	Queensland Guide to Temporary Traffic Management
RA	Roads Australia
SWMS	Safe Work Method Statements
TfNSW	Transport for NSW
TCAWS	Traffic Controls at Worksites
TMR	Transport and Main Roads
TTC	Time to Collision
VMS	Variable Message Signs

Executive Summary

This report summarises the findings and recommendations of Group 5 NSW / QLD 2025 research Project to consider road safety. The project emphasised safety at mobile and temporary worksites through comprehensive research and active stakeholder engagement.

The group undertook extensive research of data across Australia and globally to identify drivers impacting safety at temporary worksites.

Challenge and Framework

Our initial assessment determined that a significant systemic barrier exists in improving safety: a critical **lack of real-time data** regarding incident precursors, near-miss events, and worker and driver behaviour. This data deficit makes it difficult to accurately diagnose and target core safety issues. To address this, we adopted the **Safe Systems Approach** as the guiding framework, focusing on designing systems and environments that inherently reduce the risk of serious harm, to introduce a shared responsibility for safety at worksites.

Proposed Solution: Digital Data Capture and Behaviour Change

The key recommendation arising from this project is the rapid deployment of a **digital solution** designed to serve two functions:

1. Immediate Safety Improvement: To influence driver and worker behaviour by reinforcing shared responsibility for safety.
2. Continuous Data Collection: To systematically gather objective data on critical safety metrics previously unavailable.

This digital solution enables cost-effective, efficient deployment. It can be mounted on existing maintenance and operational vehicles with little extra cost, setup time, or staff effort. The collected data will provide the evidence base needed to influence safer driving and working behaviours immediately, while simultaneously building the foundation for future data-driven policy changes.

The Safe Systems Technology – Roadwork Truck Kit

The Safe Systems Technology – Roadwork Truck Kit's purpose is to create a digitally enabled, safety-first road maintenance vehicle that enhances protection for workers and road users at temporary and mobile worksites.

The 7 key capabilities of the Safe Systems Technology – Roadwork Truck Kits are:

1. Satellite Communications

Satellite connectivity ensures reliable communication and real-time location tracking, especially in remote areas with poor mobile coverage. It supports rapid incident reporting and enhances situational awareness, forming the backbone of all other safety technologies in the kit.

2. Post-Incident Communications

In the event of an emergency, satellite-enabled systems provide direct and dependable communication with emergency services. This capability improves post-crash care and ensures timely escalation of incidents, even in isolated locations.

3. Real-Time Location Tracking & Reporting

GPS and satellite integration allow roadwork trucks to broadcast their location to public navigation systems and traffic platforms. This alerts drivers early, encouraging safer speeds and attentiveness. Cooperative Intelligent Transport System roadside devices further enhance warnings for vehicles with compatible technology.

4. Speed Compliance, Warning & Enhanced Lighting

Radar-linked Variable Message Signs (VMS) provide real-time speed feedback to approaching drivers. Automated flashing lights, CCTV, and approved speed cameras enforce compliance, while audio alerts warn workers of speeding vehicles. Enhanced LED lighting improves visibility and safety during night works.

5. LiDAR Technology

LiDAR maps the worksite in 3D and monitors interactions between vehicles, equipment, and workers. It acts as an intelligent safety agent, issuing audio alerts when threats are detected. This technology helps protect vulnerable road

users and supports data collection for future improvements.

6. Digitalisation of Work Zones

All data from the truck's systems is streamed to a central data lake, standardised across transport departments nationwide. This enables cross-jurisdictional analysis, supports crash investigations, and informs future road design and policy development.

7. Flexibility and Simplicity

The kit is modular and adaptable, allowing technologies to be deployed across one or multiple vehicles based on site conditions. Designed for ease of use, it ensures road crews can operate efficiently without added complexity, while maintaining high safety standards.

Conclusion and Next Steps

The proposed digital solution offers a pragmatic, data-centric pathway to overcoming the current information void and realising immediate safety benefits. We recommend the following steps for successful implementation:

- Pilot Trials: Conduct focused field trials to validate the technology's effectiveness and measure safety improvements.
- Standardisation: Update organisational standards and industry codes of practice based on the new data and the Safe Systems framework.
- Implementation Support: Secure industry and government support to ensure rapid, widespread adoption across the sector.

This approach provides a scalable and cost-effective mechanism to move beyond reactive safety management toward a proactive, evidence-based safety culture.

1. Introduction

1.1 Roads Australia Fellowship Program

The Roads Australia Fellowship Program is a prestigious national mentoring initiative aimed at cultivating future leaders in the Australian transport and infrastructure sector. It targets professionals with 8 to 15 years of experience who demonstrate strong leadership potential. Fellows are paired with senior industry mentors and engage in structured activities including one-on-one mentoring, workshops, site visits, and networking events. The program also involves a research project, undertaken in groups.

The 2025 Roads Australia Fellowship Research Task focused on empowering future industry leaders to tackle pressing challenges in transport infrastructure, particularly around **Road Worker and Road User Safety**. The project is designed to enhance stakeholder engagement, policy development, and presentation skills through collaborative group projects. The Fellowship Program also encouraged participants to look internationally for best practices that could be adapted to the Australian context. By fostering cross-jurisdictional collaboration and forward-thinking solutions, Roads Australia continues to play a pivotal role in shaping a more sustainable and resilient transport future.

1.2 Project Team

Group 5 consists of fellows from Northern NSW, Brisbane and the Sunshine Coast.

Bruce Bernhardt – Transmax

Bruce is the Consulting Services Team Leader at Transmax, where his extensive experience in transportation help clients define their requirements and ensure that the ITS solutions meet their needs. Bruce previously worked for Transport and Main Roads Queensland as a Principal Technical Officer of ITS networks and a Senior Advisor of Traffic Systems.

Jacqui Berry -WSP

Jacqui is a civil engineer and project manager in road and highway design across Queensland. Based on the Sunshine Coast, she leads WSP's local Bridges, Aviation and Roads team. She is passionate about road safety, mentoring and delivering practical outcomes for communities.

Dearbhla Brennan – Arcadis

Dearbhla Brennan is a **chartered civil engineer** with over 20 years of experience in engineering design consulting. At Arcadis, she serves as the **National Pursuit and Bid Leader**, a role where she oversees the company's work-winning efforts. She has a background in flooding and drainage, as well as design and project management across roads and other major infrastructure projects.

Kirryn Crossman - SMEC

Kirryn Crossman is an Associate Civil Engineer and the Manager of Roads & Highways for the Gold Coast at SMEC. With over 15 years of experience in transport infrastructure, she specialises in road design and project management. Kirryn is committed to team development and is a strong advocate for women in engineering, striving to create an inclusive and supportive environment.

Shaun Gillespie – Transport for NSW

Shaun Gillespie is a District Works Manager for Transport for NSW, with over 14 years of experience primarily in maintenance and delivery. His work focuses on road maintenance, road safety improvements, and rebuilding projects. He is accomplished in delivering road construction projects throughout the entire project lifecycle and currently leads a team of 100 frontline staff who perform essential maintenance work on the NSW Far North Coast Road network.

1.3 Project Issue

Following a review of the project brief, Group 5 decided to focus on **improving worker safety at short-term and mobile worksites**. This issue was particularly relevant to team member **Shaun Gillespie**, a District Works Manager who has first-hand knowledge and a passion for protecting his team. The group agreed that the vulnerability of workers at these sites outweighs any data-driven arguments against the need for better safety measures. These mobile worksites present unique challenges, including **proximity to live traffic**, **limited space**, and **time and budget constraints**. The team was enthusiastic about finding a solution that would increase worker safety while not exposing workers to additional risks during the mobilisation and demobilisation of safety measures.

1.4 Project Objectives

The central project issue is the high safety risk workers face at **short-term and highly mobile worksites**, such as utility maintenance or roadside repairs. Unlike stable, permanent locations, these transient environments lack established safety infrastructure and fixed controls. This systemic instability, combined with operational pressure to minimise setup and demobilisation, elevates the probability of serious incident or fatality, rendering traditional safety management protocols insufficient for effective worker protection.

A primary challenge arises from:

- Transience and lack of routine. Workers have minimal time to familiarise themselves with unique hazards like unexpected terrain or public interface conflicts. This constant shift prevents the development of stable safety habits. Safety depends on quickly recognising hazards, but fast-paced work can lead to cognitive overload and errors in judgment.
- Lack of supervision and formalised training can be insufficient in these mobile settings. In practice, managerial attention to operational matters can lead to safety oversight being delegated to self-supervision. Since workers must pivot quickly between diverse tasks and navigate complex, evolving risks, generic training is often inadequate. The requirement for sophisticated, immediate hazard-specific instruction is difficult to deliver effectively, particularly when operational deadlines are tight.
- The administrative requirement for documentation and compliance is often minimised or rushed. Critical safety documents like Safe Work Method Statements (SWMS) become generalised templates rather than detailed, site-specific assessments. The cultural pressure to "get the job done" can prevent workers from halting work to re-assess when conditions change. This results in a critical gap where formal risk documentation fails to reflect the actual, dynamic hazards in the field, undermining the entire safety system.

In summary, the project must address the convergence of environmental **variability**, inconsistent **supervision and training**, and inadequate **risk documentation** under time pressure. Together, these factors create a high-risk operational environment in which safety management can quickly break down. The project aims to develop agile, **technology-driven solutions** that simplify real-time hazard identification and embed critical safety verification directly into daily workflows, strengthening protection for roadworkers operating in short-term and mobile work sites.

2. Historical Context

Roadwork site safety has undergone a series of significant revolutions over the last century, each driven by a fundamental shift in how we view the relationship between vehicles, infrastructure, and people. The history of safety is a progression from simple physical barriers to a sophisticated, technology-driven system.

2.1 The Early Years: Physical Revolution (1920s - 1950s)

This era marked the shift from relying on luck to implementing basic physical tools and regulations. The first revolution standardised signs and signals in the 1920s, creating a shared "language" for road users. Key innovation was the rubber traffic cone (1940s) - highly visible and resilient, replacing heavy wooden barriers. Rudimentary PPE also saw early adoption in major construction projects.

2.2 The Enforcement and Awareness Revolution (1960s - 1990s)

This period used a top-down, legislative approach. Mandatory high-visibility clothing became standard for crews to increase visibility. This era saw landmark legislation like the creation of OSHA in the US and compulsory seatbelts in Australia, mandating worker protection. Crash-attenuating barriers and improved vehicle designs helped reduce accident severity.

2.3 The Data and Automation Revolution (2000s - Present)

This ongoing revolution leverages technology to mitigate risk. Intelligent Transportation Systems (ITS) and Variable Message Signs (VMS) enabled dynamic traffic management. Advanced Driver Assistance Systems (ADAS) prevent collisions. Crucially, automated cone trucks and remote-controlled equipment now remove workers from live traffic danger, supported by digital tools like BIM for integrated safety planning.

3. Methodology

3.1 Definition of Project Scope

This project focuses on roadworker and road user safety in the context of routine road maintenance activities, specifically those carried out at temporary, short-term, and mobile worksites where live traffic is present. The investigation explored contributing risk factors including the effectiveness of existing safety measures, and identifying practical, low-cost improvements. Through a review of literature, policy frameworks, operational practices, and engagement with stakeholders including road authorities and research bodies such as ARRB, the project identified targeted recommendations to enhance the safety and wellbeing of roadworkers and road users.

The scope includes:

- A review of national and international literature on roadworker safety at mobile and temporary roadwork sites
- Stakeholder engagement surveys
- Analysis of existing safety protocols and their practical effectiveness
- Examination of incident trends and contributing risk factors
- Engage stakeholders such as road authorities, contractors, and research institutions
- Identification of low-cost, implementable safety improvements

3.2 Context

Australia's vast geography and low population density outside major cities result in a disproportionately large regional road network to maintain. The significant majority of the Australian Road Network are roads in regional, rural, and remote areas. With around 70% of fatalities recorded across Australia occurring on regional roads, we need to keep road crews safe that play a vital role in maintaining and delivering critical safety infrastructure upgrades to the road network.

Despite existing safety protocols, incidents at roadwork sites continue to occur, with driver

inattention, speeding, and complacency being major contributing factors. Our research, including a key stakeholder survey, confirmed that these dynamic, short-term sites are particularly high-risk. Current safety measures, often designed for longer-term projects, fall short in these fast-paced environments where it's not always possible to separate live traffic from workers.

3.3 Project Methodology

The project largely followed the plan outlined in the team's Project Scoping paper, but evolved following the initial phases, as the research did not present an obvious path for progression. The following paragraphs outline the process undertaken to reach the preferred solution to address safety of workers at short term and mobile worksites.

3.3.1 Phase 1 - Foundational Research and Data Collection

The initial stage of the project was a literature review, detailed below in Section 4. This phase included research through literature review, standards review, and a targeted stakeholder engagement survey.

This data gathering phase, formed the basis for Phase 2 and the solution development.

3.3.2 Phase 2 - Analysis and Solution Identification

Following the research phases and the identification of the framework, the team concluded that:

- There was inadequate data from short-term roadwork sites to confirm the safety issues present.
- Lack of data prevented the identification of a solution that would resolve the issue.
- Time and budget constraints were key drivers in the selection and implementation of safety measures at short-term worksites, often limiting opportunities for innovation or proactive risk management.
- Safety is a shared responsibility, but current measures place an unfair burden on workers to manage safety.
- Solutions need to distribute the responsibility for safety across all road users to ensure shared accountability and behavioural change.

The lack of data challenge was central to identifying the preferred solution, with the team focusing on an approach that would both collect meaningful data and enhance road worker safety.

A comparative assessment was then undertaken to evaluate potential solutions against the Safe System Approach. This process considered factors such as cost, practicality, alignment with safety principles, and potential for rapid implementation. The assessment informed the selection of a suite of complementary tools designed to address the key challenges identified in Phase 2 and form the basis for the next stage of development.

3.3.3 Phase 2 – Solution Identification

Following the research phases, and identification of the framework the team concluded that:

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- Lack of data prevented the identification of a solution that would resolve the issue.
- Time and budget constraints were key drivers in the selection and implementation of safety measures at short-term worksites, often limiting opportunities for innovation or proactive risk management.
- Safety is a shared responsibility, but current measures place an unfair burden on workers to manage safety.
- Solutions need to distribute the responsibility for safety to all road users to ensure shared accountability and behavioural change.

The lack of data challenge was central to identifying the preferred solution, with the team focusing on an approach that would both collect

meaningful data and enhance road worker safety. The team then applied a Multi-Criteria Analysis (MCA) tool to assess potential options against the Safe System Approach. This process resulted in the identification of a suite of complementary tools designed to address the key challenges identified in Phase 2.

3.3.4 Phase 3 - Validation and Paper Development

Following the MCA the team reengaged with the survey participants to pressure-test the proposed solution and identify barriers to implementation and suggestions for a whole of Australia wide approach to implementation.

This coincided with preparing the final paper and documenting the findings of the research paper.

3.3.5 Phase 4 - Dissemination and Advocacy

After finishing the paper and presentation, the team plans to work with stakeholders to implement the proposal, including updating standards and adopting a nationwide approach to safety and data analysis for ongoing improvements.

3.3.6 Phase 5 - Implementation and Monitoring

Following adoption, the next phase is data gathering, and continued improvement in safety based on real time information from across Australia's vast network of roads.

4. Research and Literature Review: Key Insights and Gaps

Understanding the regulatory landscape for roadwork safety requires a clear view of the current national and state guidelines, particularly as they apply to temporary, short-term, and mobile worksites. The following overview highlights the most relevant standards and identifies where opportunities for improvement remain.

This section reviews the technical standards, digitalisation practices, data systems, and published research that shape road worker safety in Australia and internationally. Reviewing current methods helps pinpoint where innovation and coordination are most needed to enhance road safety for workers and users.

The Austroads Guide to Temporary Traffic Management (AGTTM) serves as the harmonised national standard for temporary traffic management across Australia. It provides a comprehensive framework for planning, designing, and implementing safe traffic management at roadworks, including requirements for signage, barriers, and worker safety. Queensland and New South Wales have each used the AGTTM as a foundation for their respective guidelines, which are discussed in the following sections.

- national-level analysis of worksite conditions, near-misses, or safety measure effectiveness.

4.1 Overview of Existing Research

In addition to reviewing technical standards and data systems, it is essential to consider the body of research and literature that informs current approaches to road worker safety. This section examines key studies, guidelines, and initiatives from Australia, Roads Australia, and international sources to identify both achievements and ongoing barriers to effective implementation. To supplement published research and address gaps in available data, the team also conducted a survey of industry stakeholders (see Section 4.2 for findings).

4.1.1 Roads Australia Research and Initiatives

Roads Australia has made significant progress in advancing road worker safety through initiatives such as the *Safer Work Zone Initiative* and the *'Safer Work Zone – Raising the Bar'* action plan. These have established valuable industry guidance and momentum. However, opportunities remain to strengthen safety outcomes for short-term, temporary, and mobile worksites contexts where existing systems often rely on manual processes and inconsistent data.

This project builds on Roads Australia's strong foundation, proposing the digitalisation of all roadwork sites to improve data collection, enable real-time monitoring, and support proactive safety management.

4.1.2 Australian Research and Guidelines

Australian research and guidance developed by organisations such as Austroads, Safe Work Australia, and state-based regulators have established frameworks aimed at improving safety at temporary and mobile roadworks. A recurring challenge identified in these frameworks is driver non-compliance with temporary traffic controls, particularly excessive speed and inattention around active worksites.

Key themes common across national and state guidance include:

- Absence of a consistent national framework for collecting and analysing roadwork incident data, limiting the ability to conduct root-cause assessments and evaluate interventions.
- Need for traffic-management plans to more explicitly incorporate driver behaviour and human-factor considerations.
- Importance of clear advance warning, adequate lighting, and use of physical

speed-reduction measures to moderate driver approach speeds.

- Evidence suggesting that minimising unnecessary speed-limit changes can improve driver compliance and reduce confusion.

Recent initiatives within both the public and private sectors have sought to address these persistent gaps through the application of digital technologies and data-driven approaches.

ALTUS Workzone Digitalisation

An example of industry-led innovation in this area is the Altus Workzone Digitalisation platform, developed by Altus Traffic to improve the real-time monitoring and management of temporary traffic arrangements. The system connects cones, barriers, and signage using sensors and communication tags, converting traditionally passive devices into active safety assets. Through the MyWorkzone digital dashboard, field staff can view live site conditions, receive automated alerts for asset displacement or site incursions, and access detailed event logs for audit and reporting purposes.

Trials conducted on Australian corridors such as the M5 East Motorway and M1 Tugun Tunnel have reported reductions in manual inspection requirements, earlier detection of hazards, and lower average vehicle speeds through worksites. These findings demonstrate the potential for automated data capture to enhance both worker safety and driver awareness. While not a government or Austroads initiative, the Altus program illustrates how digitalisation and automation can begin to close long-recognised data and visibility gaps in temporary traffic management. Its focus on machine-readable, standardised data aligns with emerging national priorities for interoperable roadwork information systems.

iMOVE CRC – National Research and Innovation

Complementing private-sector initiatives, the iMOVE Cooperative Research Centre (CRC) serves as Australia's national centre for transport and mobility research and development. Operating through partnerships between government, academia, and industry, iMOVE delivers high-impact collaborative projects across the intelligent-transport-systems and road-safety domains.

The iMOVE project "Roadworks Zones – Increasing Safety for Roadworkers and Drivers" investigated strategies to reduce *end-of-queue* (EOQ) collisions and improve driver compliance at temporary worksites. Conducted with Transport for NSW and Deakin University's Safe Future Mobility Lab, the study evaluated 33 combinations of 25 countermeasures across 13 roadwork sites in New South Wales. Treatments included radar-activated speed signs, portable rumble strips, dynamic signage, and increased enforcement presence.

Over a 116-day evaluation period, the research team used radar, video monitoring, and driver surveys to assess behavioural and safety outcomes. Results indicated that combinations incorporating radar-activated speed signs and visible police presence achieved measurable reductions in speeding behaviour and rear-end crash risk. Survey responses showed high driver awareness and acceptance of these measures, with more than 80 percent of drivers reporting that they noticed the digital speed signs. The study recommended further longitudinal trials to confirm the persistence of safety benefits over time.

These projects demonstrate Australia's growing capacity for data-driven safety research and digital innovation within roadwork environments.

4.1.3 International Best Practice

Globally, roadwork safety is advancing through engineering, enforcement, education, and digital innovation. No single intervention is universally effective; the best outcomes come from tailored, multi-faceted approaches. An evident global trend is the shift towards digitalisation and the adoption of integrated safety systems. Many countries now require or recommend real-time data, advanced vehicle tech, and connected infrastructure to improve road and work site safety.

Key Developments in Europe and the EU include:

- Vision Zero: The EU's "Vision Zero" initiative aims for zero fatalities and serious injuries on roads by 2050.
- General Safety Regulation (GSR): Mandates Intelligent Speed Assistance (ISA) on all new vehicles sold since July 2024.
- Mandatory Data Sharing: Proposed legislation for comprehensive speed limit and road safety event data.
- Digital Product Passports (DPPs): Lifecycle-based digital records for assets, including those used in construction.

Country Specific examples further illustrate this trend:

- Germany: "Road Map for Digital Design and Construction" established BIM as a standard for transport infrastructure projects by 2020.
- Sweden: Swedish Transport Administration's roadmap for a connected and automated road transport system, including machine-readable data and IT infrastructure.
- United Kingdom: National Highways "Digital Roads" vision, including resources for Electronic Boards for Roadworks (EBRWs).

Other regions are also advancing digitalisation:

China:

- LiDAR as a National Standard: China's draft national standard incorporates LiDAR into mandatory standards for intelligent vehicles, with detailed requirements for roadwork scenarios.

United States:

- Integration with Drones and Mobile Systems: LiDAR-equipped drones and vehicle-mounted mapping systems for rapid, safe data collection.
- Roadside and Intersection Monitoring: Roadside LiDAR sensors for traffic efficiency and safety.
- Enhanced Data for Design and Maintenance: LiDAR for roadway design, asset management, and maintenance.
- Federal Funding and Initiatives: Grants for LiDAR, V2X technology, and national data collection.
- Integration with AI and Machine Learning: AI transforms LiDAR data into actionable safety intelligence.

These international developments demonstrate a clear movement towards harmonised, technology-driven approaches to roadwork safety. They highlight the potential benefits of adopting real-time compliance data, standardised digital reporting, and advanced analytics - opportunities that Australia can leverage to address its own gaps in roadwork safety management.

4.2 Key insights and Opportunities for Improvement

The review of national and state guidelines shows that while frameworks such as the *AGTTM*, *QGTTM*, and *TCAWS* provide a solid basis for temporary traffic management, there is still no requirement for full digitalisation across all worksites. Digital technologies are permitted and increasingly trialled through initiatives such as Austroads' ALTUS and the iMOVE connected-vehicle safety research but remain optional rather than mandated. The absence of a harmonised national approach and proactive digital compliance continues to limit improvements in road worker safety, especially at short-term and mobile sites. Building on these existing initiatives offers an opportunity to move from state-specific practices to a nationally consistent, digitally enabled system.

Internationally, leading jurisdictions are moving towards integrated, real-time digital safety systems for roadworks. Initiatives such as the EU's Vision Zero, mandatory Intelligent Speed Assistance, and the adoption of digital product passports and LiDAR standards demonstrate the benefits of harmonised, technology-driven approaches. These outcomes highlight the potential for Australia to improve road worker

safety by adopting similar measures - particularly in mandating real-time compliance data, standardising digital reporting, and leveraging AI for proactive risk management.

Reflecting both the Australian context and international best practice, several key gaps and opportunities for improvement emerge:

Lack of Harmonised Data Collection: There is no national, harmonised standard for collecting and reporting worksite compliance and incident data across all jurisdictions.

Reactive vs. Proactive Systems: Current guidelines often focus on reactive safety measures rather than proactive, integrated digital systems.

Need for Mandated Digitalisation: There is an opportunity to enhance existing guidelines by mandating digital tools (e.g., GPS beacons, LiDAR, real-time data feeds) and harmonised data collection for all worksites, regardless of size or duration.

4.3 Stakeholder Engagement

4.3.1 Research Survey

The team conducted a survey to engage key stakeholders and identify strategies for improving safety for both road workers and road users at temporary, short-term, and mobile routine road maintenance worksites. The purpose was to gather information and insights from across the roads industry, aligning with the project's goal of applying the Safe System approach to enhance safety for drivers and workers alike.

The survey explored key factors affecting safety, potential improvements across the Safe System pillars (safer roads, vehicles, speeds, road users, and post-crash care), and the strategies and barriers organisations have encountered in enhancing road worker and road user safety. Feedback and ideas informed the Roads Australia Fellowship Group's safety recommendations for temporary and mobile road maintenance sites, aligning with the May 2024 industry guideline.

A total of 69 respondents participated, representing a broad cross-section of the industry, including Transport for NSW, Department of Main Roads, local councils, traffic control providers, and NSW Highway Patrol. 45% of all respondents (31 out of 69) indicated interest in discussing potential innovations and trialling worksite improvements, suggesting strong industry support for driving improvements. A summary of the survey data is provided below, with the full data available in Appendix A.

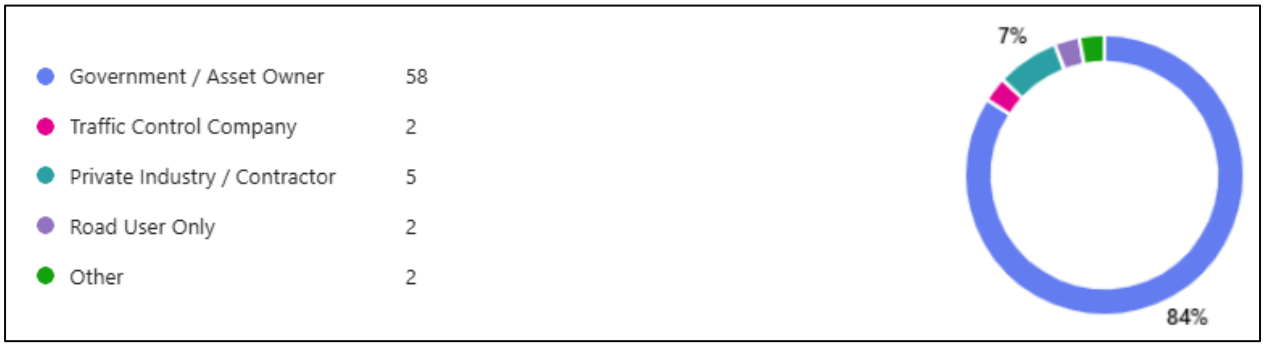

Figure 4-1 Survey Respondents

4.4 Survey Findings – Key Points

Responses from a broad range of stakeholders in the roads industry, primarily government agencies and asset owners, on safety at short-term road maintenance worksites identified the following:

Separation of Roadworkers and the Public:

The problem of keeping roadworkers and motorists separate is more complex than a simple solution, as short-term maintenance work requires interaction between the travelling public and workers. Keeping roadworkers and the travelling public separated is an inherent challenge, and the problem is more complex than it may initially seem.

Key factors affecting safety include:

- Driver behaviour, speed, and distraction
- Inadequate traffic management and signage
- Restricted work areas and lack of separation
- Worker experience and complacency

Adopted Safety Strategies:

Strategies adopted to improve safety include using traffic control setups as per guidelines, deploying technology like variable message signs and speed cameras, increasing police presence, and scheduling works during off-peak hours. However, barriers like cost, public acceptance, and culture change can hinder the implementation of effective treatments.

Safety Systems Approach:

The Safe Systems approach, with its focus on safer roads, vehicles, speeds, post-crash care, and shared responsibility, is seen as a framework to guide safety improvements. Suggestions included a broad range of safety improvements are possible against all five Safe System Pillars of safer roads, vehicles, speeds, post-crash care.

Need for a Multi-Faceted Approach and a Shared Responsibility:

Overall, there is recognition that a multi-faceted approach is required to enhance the safety of both roadworkers and road users at short-term maintenance sites. Road maintenance work requires interaction between the travelling public and workers. Respondents highlighted that roads are a shared public space, so the problem is not just about keeping workers and the public apart, but managing the interactions between them safely is a shared responsibility.

Short Term vs Long Term Sites:

Key factors at short-term sites include driver speed, distraction, complacency, and environmental constraints (e.g., narrow shoulders, limited sight distances). These are often more pronounced than at long-term projects, with frequent setup and pack-down introducing additional risks at short term and dynamic sites.

Barriers to Implementation

Common barriers identified include:

- Cost and budget constraints
- Time and logistical challenges of implementing new treatments
- Resistance to change and hesitance to trial unproven solutions
- Competing priorities and a lack of senior management commitment
- Difficulties in changing driver behaviour and public perceptions

A more detailed summary of the survey data analysis is attached in Appendix B.

4.5 Survey Recommendations

The following recommendations were proposed by the survey respondents:

Safer Roads

Emphasises the importance of designing roads and work zones to improve safety for road workers. Key elements include separating workers from live traffic through permanent infrastructure, enhancing road geometry and visibility to aid driver awareness, integrating safety features like barriers and attenuators, implementing effective speed management measures, and prioritising worker-focused design elements like safe access paths and staging areas.

Safer Speeds

Ensuring speed compliance in roadwork zones is critical and there is an available range of digital, physical, enforcement, and policy/education measures that can be implemented to improve driver speeds around work sites. This includes leveraging technology like variable message signs and speed feedback, as well as physical interventions such as speed humps and increased enforcement

Safer People

Emphasises the importance of enhancing the safety of road workers themselves through a range of digital and technological solutions. These include integrating work zone information into navigation apps, using variable message signs and speed feedback to influence driver behaviour, automating equipment to remove workers from live traffic, implementing passive behavioural nudges, and designing work zones for predictability and clarity. By leveraging these digital and design-based interventions, the Safe Systems approach aims to improve safety for road workers without relying solely on enforcement or worker compliance.

Safer Vehicles

Key elements include incorporating advanced safety technologies like proximity sensors and collision detection systems, enhancing vehicle visibility and communication capabilities, and optimizing vehicle selection and operations to minimise worker exposure to live traffic. By prioritising safer vehicle design, connectivity, and operational practices further protection of road workers and surrounding motorists during roadwork activities is possible.

Post-Crash Care and Support

Strengthening emergency response capabilities through pre-planned access, on-site first aid, and real-time worker tracking. Enhancing incident reporting, communication, and telecommunications infrastructure is also crucial to ensure prompt and effective response. The approach also highlights the need to integrate learnings from incidents into future planning, coordinate closely with external agencies like emergency services, and provide psychological support and follow-up for affected workers and their families.

4.6 Options Analysis and Selection Process

The options analysis, informed by research findings and stakeholder engagement, enabled the team to systematically evaluate a wide range of potential interventions and identify those most applicable to short-term and mobile worksites.

The team reviewed a broad spectrum of innovations, from driver compliance technologies to enhanced worker visibility measures, including some that had previously been considered less viable. For example, transverse rumble strips used as tactile warnings at the start and end of roadwork sites were trialled in Australia with limited success and initially appeared unsuitable. However, the team recognised the importance of understanding why such approaches had not succeeded in the past and identifying what changes could improve their effectiveness. Factors such as limited stakeholder buy-in, high implementation costs, inadequate training, and poor alignment with site conditions were found to have contributed to earlier shortcomings.

To ensure a fair and transparent evaluation, the team applied a structured assessment process that considered key factors including cost, effectiveness, ease of implementation, adaptability, and alignment with safety objectives. The analysis began with a long list of potential safety interventions, which was refined to a shortlist of measures most relevant to short-term and mobile worksites. This process provided a clear, evidence-based foundation for identifying the recommended suite of solutions, as outlined in the following section.

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5. The Proposal: The Future Direction of Road Maintenance Truck Modernisation

Our proposal merges the Safe Systems Approach with digital innovations to deliver a cost-effective "Safe Systems Technology - Roadwork Truck Kit," a vehicle-based solution for current road maintenance truck fleets.

The core proposal is to set the future direction road maintenance truck fleet requirements through combining Safe Systems Approach and Technology innovations (Safe Systems Technology) within roadwork zones. The application of digital enhancements to traffic control and road maintenance truck fleet vehicles aligned with the Safe Systems Approach will provide consistent strategic alignment of road maintenance fleet development across the Roads Industry.

The following sections detail the proposal and how it aligns with the Safe Systems Approach, providing a multifaceted solution to improve safety.

5.1 The Safe Systems Technology - Roadwork Truck Kit

A combined direction of a coordinated Safe Systems Technology approach to fleet renewal, technology integration, and operational efficiency will deliver safer, more efficient road maintenance outcomes across our road network.

The "Safe Systems Technology – Roadwork Truck Kit" is a suite of digital technologies designed for road maintenance and roadwork vehicles.

It directly addresses the unique safety challenges of temporary and mobile worksites, enhancing protection for workers and road users alike.

The Safe Systems Technology Truck Kit concept stems from our vision of the “perfect world” road maintenance vehicle, a digitally enabled, safety-first truck designed for the future of mobile worksites.

This initiative demonstrates our commitment to innovation, safety, and operational excellence, combining advanced technologies and the Safe Systems Approach to meet the evolving demands of temporary and high-risk roadwork environments.

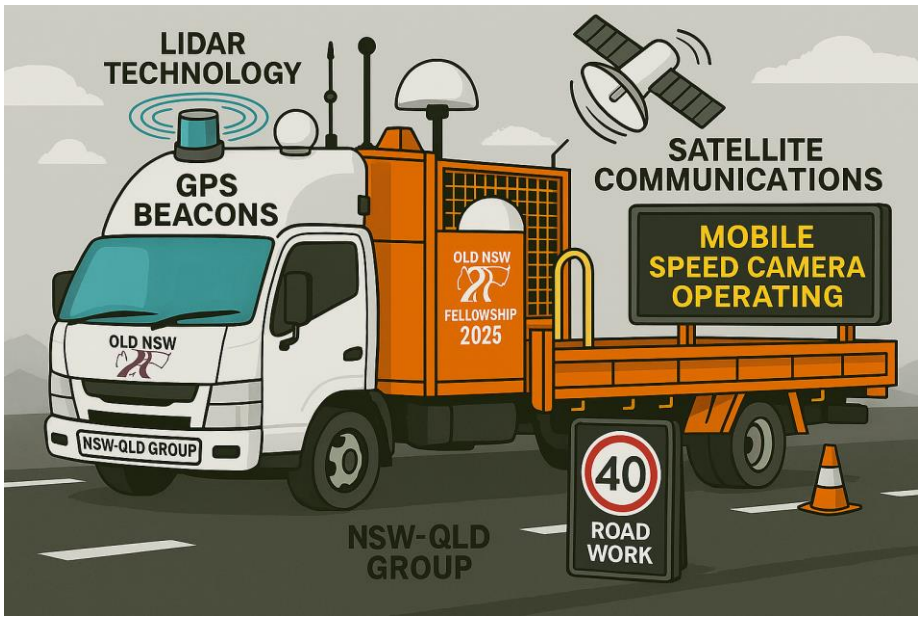

Figure 5-1 Safe Systems Technology Truck

5.1.1 Capability 1: Satellite Communications

Satellite communications play a critical role in enhancing safety and operational efficiency for road maintenance fleets, particularly in remote areas with limited mobile coverage. By enabling real-time location tracking of vehicles and workers, this technology ensures reliable communication and rapid incident reporting. Integrated digital tools allow for immediate logging and escalation of incidents, supporting faster emergency response and improved post-crash care. As part of the Safe Systems Technology Truck Kit, satellite connectivity strengthens data collection and situational awareness, helping deliver safer, smarter outcomes across temporary and mobile worksites. This technology is central to the Safe Systems Technology Truck Kit, maintaining safety and responsiveness at any worksite.

5.1.2 Capability 2: Post Incident Communications

Post-incident communications will leverage satellite technology to enable rapid and coordinated responses to on-site emergencies - from medical incidents to catastrophic vehicle impacts. This system ensures direct, reliable communication with emergency services, even in areas with poor mobile coverage, enhancing post-crash care and aligning with the Safe System Approach. By providing real-time connectivity, satellite communications become a critical pillar in supporting worker safety, incident escalation, and effective emergency management.

5.1.3 Capability 3: Real Time Location Tracking and Reporting

By integrating real-time GPS tracking and satellite communications, road maintenance trucks will provide advanced warnings to drivers via public navigation systems and government traffic platforms. This proactive alert system encourages drivers to slow down and increase attentiveness before reaching a worksite, supporting safer driving behaviour and contributing to the Safe System Approach. It not only improves awareness for those unfamiliar with the site but also helps inattentive or complacent drivers respond appropriately, fostering safer interactions and creating “safe people” entering roadwork zones.

A Cooperative Intelligent Transport System (C-ITS) roadside device would also be installed to give instant warnings to vehicles with compatible technology.

5.1.4 Capability 4: Speed Compliance, Warning and Enhanced Lighting

The truck will also be equipped with a Variable Message Sign (VMS) integrated with radar technology to deliver real-time feedback to motorists as they approach the designated roadwork area.

To further improve compliance and act as a decelerator that would intuitively elicit a lower speed from drivers, red and blue flashing lights would be triggered automatically if a vehicle enters this part of the work site above the required speed limit. The speeding vehicle will also be captured on Closed Circuit Television (CCTV) and a speed camera approved under the state’s camera detection program. Any speed violation within a road works site will attract double fines and demerit points. This capability shifts the focus from sporadic police enforcement to a consistent, system-based approach to speed management.

An audio alert is triggered when a speeding vehicle enters the site, delivering an essential early warning to road workers so they can respond appropriately.

The truck will also provide enhanced LED lighting for night works, the purpose of which is to not only illuminate the work zone, but also to make the site stand out at greater distance for the travelling public as they approach the site.

Speed compliance is a critical component of the Safe System Approach, directly contributing to safer speeds and reduced risk within roadwork zones.

5.1.5 Capability 5: LiDAR

LiDAR technology will also be utilised, this system will map out each work site and capture a 3D representation of the site and all interactions between objects and road workers. The data from this system will automatically be streamed back to the departments data storage lakes.

This system will also act as a real time “intelligent” safety agent that provide real time warning to road workers via audio alerts when a threat is detected such as a speeding vehicle or potential conflicts between a road worker and plant equipment. The LiDAR system acts as an additional layer of protection, alerting workers to dangers they may not see. It works to protect vulnerable road users by accommodating human error.

By accommodating human error and enhancing situational awareness, LiDAR supports the Safe System Approach and helps safeguard vulnerable road users in dynamic work environments.

5.1.6 Capability 6: Digitalisation of Works Zones

All data captured by the systems fitted to the truck would be streamed back to the Transport Departments data storage lake. The data would be categorised and standardised across all transport departments in Australia. The data can then be used to evaluate current and any future refinements to the systems fitted to the truck and any policy or procedures for traffic control of these sites. Each State’s Transport Department can view and review each other’s data as the data has been captured and categorised in same way allowing for direct comparisons.

Digital reporting tools allow for immediate logging of incidents, ensuring accurate data is available for investigations and to enhance the learning from the crash. This aligns with the Safe Systems principle of continuously improving the system based on data and experience.

The data collected by the LiDAR can also be used to improve future road design guidelines, such as by identifying locations with poor geometry or limited sight distances.

The initiative seeks to make worksites a "forgiving road system" by using technology to enhance their design and operation. Instead of relying on static signage, the proposal uses digital solutions to make the temporary road environment safer.

5.1.7 Capability 7: Flexibility and Simplicity

The Safe Systems Technology Truck Kit is designed with flexibility and simplicity at its core. Its capabilities can be fitted to a single vehicle or distributed across multiple vehicles, depending on the nature of the roadworks, site risk, time of day, and traffic volume. While not all features need to be deployed at once, the satellite communication system serves as the foundational enabler for all other technologies.

Importantly, the system is designed to be intuitive and easy to use, ensuring that road crews can set up and pack down without additional time or complexity, supporting efficient operations while maintaining high safety standards.

Table 5.1 Safe Systems Tech Truck Kit Capabilities & Alignment with the Safe System Approach

Capability	Safer Roads	Safer Vehicles	Safer People	Safer Speeds	Post Crash Care
1. Satellite Communications	☑	☑	☑		☑
2. Post Incident Communications	☑	☑	☑		☑
3. Real Time Location Tracking and Reporting	☑	☑	☑	☑	
4. Speed Compliance, Warning & Enhanced Lighting	☑	☑	☑	☑	
5. LiDAR	☑	☑	☑	☑	
6. Digitalisation of Work Zones	☑	☑	☑		☑
7. Flexibility and Simplicity		☑	☑		

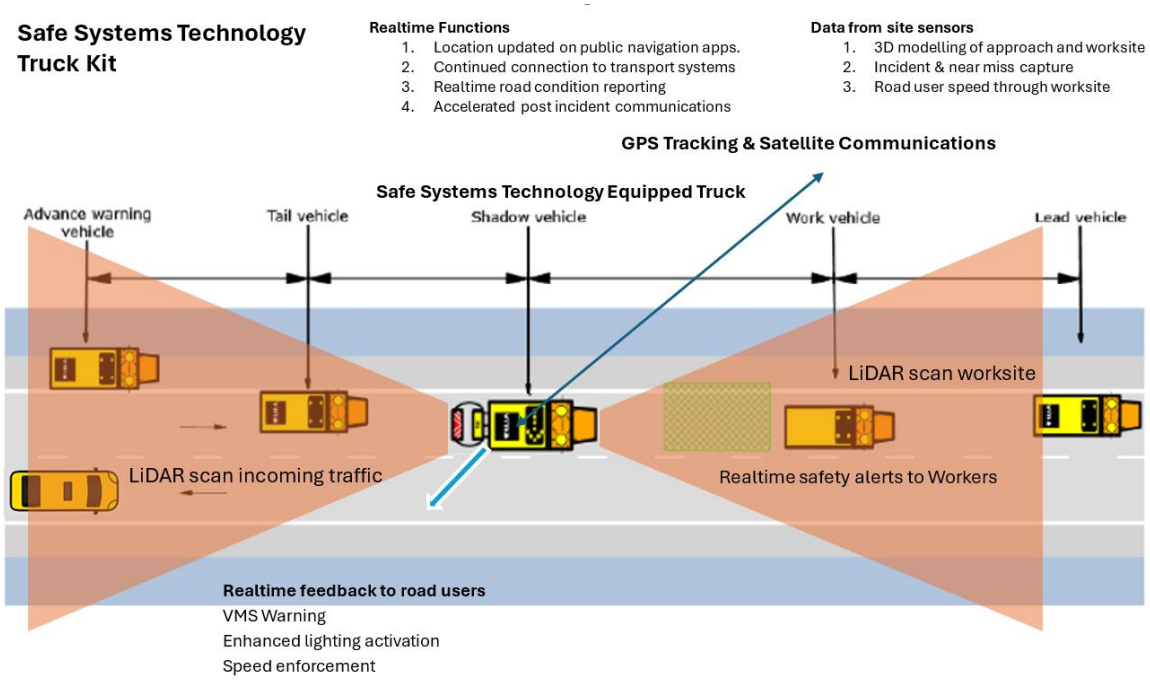

Figure 5-2 Safe Systems Technology Schematic

6. Implementation and Recommendations

As discussed in Section 4.1.2, recent Australian research, such as the Altus Workzone digitalisation trials and iMOVE CRC's *Roadworks Zones – Increasing Safety for Roadworkers and Drivers* project has demonstrated the growing use of data-driven, real-time technologies to improve roadwork safety. However, these initiatives remain fragmented across jurisdictions. The proposed initiative builds on these findings by developing a nationally consistent and scalable approach that integrates multiple technologies into one unified platform.

The initiative represents a digital shift in road maintenance safety, transitioning from a reactive, static model to a proactive, dynamic, and intelligent system. By integrating technologies such as satellite communications, LiDAR, and real-time data integration, this approach fundamentally transforms every roadwork site - enhancing safety not only for large-scale projects but also for smaller, temporary, and mobile worksites. It creates a smarter, more responsive environment that protects all road users and workers, aligning with the Safe System principles of safer roads, safer people, and continuous improvement.

6.1 Phased Rollout Strategy

6.1.1 Pilot Program:

A call has been made to respondents of the Safe Systems for Road Worker Safety Survey to gauge interest in participating in a pilot trial of the Safe Systems Tech Truck Kit. This outreach aims to identify suitable partners and locations across NSW and QLD that meet the pilot criteria, including high traffic volume, remote access, and a history of road incidents. The feedback from survey participants will help shape the scope, deployment strategy, and evaluation framework for the pilot program.

6.2 Evaluation Metrics:

The Deakin University Work Zone End-of-Queue Study, competed under the iMOVE CRC, established a robust set of surrogate safety metrics and data collection methods to evaluate the effectiveness of traffic control treatments at roadwork sites. These metrics are highly applicable to the Safe Systems Tech Truck Trial and can be adapted to assess the impact of integrated digital technologies on roadworker safety.

Key Evaluation Metrics from the Deakin Study the Safe Systems Technology Truck can adopt include:

- Excess Speed: Measures how much vehicles exceed posted speed limits using radar and traffic counters and helps quantify how well treatments reduce speeding behaviour.
- Probability of Speeding: Statistical likelihood of speeding at specific locations which indicates driver compliance and effectiveness of speed management tools.
- Rear-End Crash Risk: Identifies high-risk interactions and potential crash scenarios.
- Time to Collision (TTC): Time remaining before a potential crash.
- Deceleration Rate to Avoid Crash (DRAC): Required deceleration to prevent collision.
- Near-Miss Events: Captured via video analytics to identify unsafe interactions. Provides a proactive measure of safety before actual crashes occur.
- Driver Perception and Behaviour: Assessed through roadside surveys and feedback to assess user acceptance and behavioural change.

6.3 Cost-Benefit Analysis

Table 6.1 below provides a Strategic cost estimate overview for the Safe Systems Technology Truck – Kit, based on current industry data and research:

Table 6.1 Safe Systems Tech Truck Kit Cost Summary (AUD)

Capability	Component(s)	Est. Cost Range	Notes
1. Satellite Communications	GPS & Satellite Communications	$2,500 – $6,000	Includes hardware and subscription; enables real-time tracking and remote connectivity.
2. Real-Time Location Tracking & Reporting	GPS & Satellite Communications Digital Reporting Software	$1,000 – $3,000 $500 – $2,000/year	Supports proactive driver alerts and incident logging.
3. Speed Compliance, Warning & Enhanced Lighting	Variable Message Sign (VMS) Radar Speed Detection CCTV & DVR System LED Lighting System	$10,000 - 20,000	Real-time speed feedback, visual deterrents, and worker alerts.
4. LiDAR	LiDAR System	$10,000	Provides 3D mapping and real-time threat detection.
5. Digitalisation of Work Zones	Digital Reporting Software LiDAR System	$500,000	Enables data streaming, crash analysis, and system improvement.
6. Flexibility & Simplicity	Installation & Integration Annual Maintenance	$12,000	Modular setup; supports scalable deployment and upkeep.

Total Estimated Setup Cost per Vehicle is $26,000 – $53,000 (excluding ongoing software and maintenance).

Table 6.2 summarises the key benefits associated with implementing the Safe Systems Technology Truck – Kit, highlighting both direct and indirect impacts across several critical areas.

Table 6.2 Benefit Summary

Benefit Area	Estimated Impact
Accident Reduction	20–50% fewer incidents per fleet
Cost Savings per Major Accident	$50,000 – $200,000
Insurance Premium Reduction	10–20% annually
Reduced Congestion	Faster incident clearance
Improved Emergency Response	Quicker escalation and dispatch
Operational Efficiency	Better routing, reduced downtime

6.3.1 Return On Investment Snapshot

- Break-even: Avoiding just one major crash can offset full system cost.
- Payback Period: Typically, 2–3 years, depending on fleet size and incident history.
- Scalability: Modular design allows deployment across single or multiple vehicles.

6.4 A Roadmap for the Next Revolution

Our team's proposed roadmap outlines a strategic, phased approach to avoid change fatigue and allow for the gradual adoption of the technology to transforming roadwork safety through the national adoption of Safe Systems Technology.

By integrating AI, LiDAR, and digital twin capabilities into road maintenance operations, this initiative aims to shift the industry from reactive safety practices to a proactive, data-driven model. The roadmap spans from initial pilot testing to full-scale deployment, culminating in intelligent, autonomous, and immersive worksites that protect every road worker and user through advanced, real-time systems.

6.4.1 2025–2026: Test and Validate in Real-World Conditions

Pilot programs are launched across varied road environments in partnership with Roads Australia and key stakeholders. These trials will collect data on safety performance, operational efficiency, and user experience. Insights from the pilots will be used to refine the technology and build a strong evidence base to support national policy advocacy.

6.4.2 2026–2029: Increase Rollout and Policy Development

Generation 2 of the Safe Systems Technology is developed based on pilot outcomes and deployed more broadly across roadwork and maintenance fleets. Guidelines for technology certification, data governance, and compliance monitoring are established to support adoption, aligning with existing road safety strategies and infrastructure investment plans.

6.4.3 2027–2029: Transition Phase

Government endorsement is sought for the Safe Systems Technology digital toolkit. Efforts focus on integrating the technology into key technical manuals, including the Austroads Guide to Temporary Traffic Management (AGTTM), Traffic Control at Work Sites (TCAWS), and Queensland's Temporary Traffic Management Technical Manual. This ensures consistency and standardisation across jurisdictions.

6.4.4 2030: Nationwide Adoption

Formal endorsement of the Safe Systems Technology is achieved, with inclusion in national traffic management manuals. For the first time, every worksite regardless of size or location can be monitored in real time, providing enhanced situational awareness and immediate hazard detection for workers and supervisors.

6.4.5 2030–2035: Digital Twin & Predictive Analytics

Harmonised data from the national fleet is used to build real-time Digital Twins of worksites. AI and machine learning analyse these models to forecast incidents, delays, and assign danger scores, enabling proactive safety interventions and smarter traffic management planning.

6.4.6 2036 onwards: Autonomous & Immersive Worksites

The Full Safe Systems Technology kit becomes a national standard. A centralised data hub supports AI-driven insights that inform future road design and safety strategies. Advanced Digital Twins enable control of autonomous machinery, while wearable and AR technologies provide real-time alerts and hazard overlays creating intelligent, responsive environments that significantly reduce human exposure to risk.

6.5 Future Opportunities for Safe Systems Technology

The integration of artificial intelligence (AI) and LiDAR technology into roadwork safety systems represents a transformative shift from reactive to proactive safety management through the following advantages:

- Proactive Safety & Hazard Prediction Artificial intelligence, when integrated with LiDAR enables the identification of hazardous patterns such as speeding vehicles, near-miss incidents, and unsafe proximity between workers and traffic. This capability allows for the generation of real-time alerts and predictive assessments, fundamentally shifting the safety paradigm from reactive responses to proactive risk mitigation.
- Incident Reconstruction & Digital Twin, the fusion of LiDAR data with other digital inputs facilitates the creation of highly detailed digital twins of roadwork sites. These virtual replicas serve as essential tools for post-incident analysis, allowing investigators to reconstruct events with precision and clarity. This capability not only supports accountability and learning but also informs future safety strategies by providing a comprehensive understanding of incident dynamics.
- Danger Scoring & Layout Optimisation, AI systems can evaluate worksite conditions and assign a "danger score" based on variables such as traffic volume, speed compliance, and suboptimal worksite configuration. This score provides a quantifiable measure of risk, which can be used to optimise site layouts for both safety and operational efficiency. By leveraging data-driven insights, roadwork planners can proactively design environments that minimise exposure to hazards.
- Predictive Maintenance and Defect Data collection, LiDAR-equipped maintenance vehicles offer the ability to assess pavement conditions in real time, identifying defects and structural weaknesses before they escalate. This transforms road maintenance from a reactive model responding to visible damage to a predictive one that anticipates and addresses issues early. Such an approach improves asset longevity, reduces costs, and enhances road safety for all users.
- Improved Design Guidelines and Post-Crash Care, the insights from a digitalised road network can inform future road design and policy, identifying "hotspots" and high-risk procedures that require systemic change. Data on vehicle speeds, traffic flow, and near-misses provides valuable information to improve road geometry and strategically place embedded safety features. Around 70% of fatalities in Australia occur on regional roads, and improved data could inform upgrades like safety barriers and wider shoulders in these areas. The real-time tracking and digital reporting tools would provide immediate and accurate data following an incident, which is crucial for fast escalation to emergency services and supports a robust Post-Crash Care model.
- Raising the National Safety Standard, the initiative aims to ensure that all road workers whether employed on major infrastructure projects or small-scale local works receive the same level of protection. The mobile, vehicle-based nature of the technology allows for rapid deployment at short-term and dynamic worksites extending into remote sites, overcoming traditional barriers related to scale and budget. This new baseline of safety ensures that protection is not a privilege of large projects but makes advanced safety measures scalable and accessible across the industry.

6.5.1 Barriers to Effective Safety Treatments

Common barriers identified include:

- Cost and Funding – Limited budgets restrict investment in high-order safety controls.

- Driver Behaviour – Public resistance to enforcement and compliance challenges.
- Resistance to Innovation – Hesitation to adopt new methods and technologies.
- Network and Productivity Pressures – Safety compromised to maintain traffic flow and meet deadlines.
- Site Constraints – Physical limitations and changing conditions at roadwork sites.
- Workforce Gaps – Shortages in skilled staff, training, and equipment.
- Organisational Culture – Safety deprioritised in favour of cost or productivity.
- Technical Limitations – Lack of suitable technology, integration issues, or data reliability concerns.
- Regulatory and Legislative Constraints – current legislation limits the use of certain high-impact safety measures, such as blue and red warning lights or temporary speed camera installations at roadworks.

6.5.2 Ways to Overcome These Barriers

- Secure Funding – Justify safety investments through data and cost-benefit analysis.
- Engage the Public – Build support through education and transparent communication.
- Foster Innovation – Pilot new solutions and streamline approval processes.
- Plan for Safety Early – Integrate safety into project design to balance access and protection.
- Tailor to Site Conditions – Use flexible, context-sensitive safety treatments.
- Build Capability – Invest in training, retain skilled staff, and improve equipment access.
- Strengthen Safety Culture – Prioritise safety consistently and engage frontline workers.
- Address Technical Gaps – Invest in reliable technologies, improve data systems, and ensure interoperability.
- Modernise Regulation – Collaborate with government and enforcement agencies to review legislation that restricts proven safety measures, such as temporary speed cameras and coloured warning lights, and enable controlled trials to support evidence-based reform.

The next step in overcoming these barriers is to embed digital and data-driven practices into the technical standards that guide roadwork design and management. Consistent standards across jurisdictions will ensure that technology adoption, data collection, and safety practices are implemented uniformly, enabling effective evaluation and national learning.

6.6 Embedding Digital Standards and National Alignment

To achieve long-term consistency, the staged rollout should be supported by updates to existing technical standards and guides, including the QGTTM, AGTTM, and TfNSW Digital Engineering Framework. Aligning these frameworks will ensure that digital systems, data collection, and emergency-response capability are embedded into everyday practice rather than remaining limited to pilot programs.

Key areas for national alignment include:

- Baseline digital requirements for all maintenance and traffic-management vehicles (e.g. GPS beacons and digital speed-limit broadcasting).
- Standardised data formats for incident and near-miss reporting to support national analysis and benchmarking.
- Integration with Smart Motorways and Digital Engineering platforms to create a connected network, including short-term and mobile sites.
- Reliable communications systems, including satellite capability in remote areas, to support Post-Crash Care and rapid emergency response.

Collaboration between Austroads, TMR, TfNSW, and industry partners will be essential to developing a unified national specification. This alignment will enable genuine data sharing, improve interoperability, and deliver a consistent standard of safety for all roadworkers across Australia.

7. Roads Australia - Next Steps

RA and its partners are uniquely positioned to lead the national shift toward mandatory digitalisation of roadwork zones. By leveraging their policy influence, convening power, and the strong business case for safety and efficiency, RA can drive meaningful change through a coordinated, multi-pronged strategy.

7.1 Advocate for Policy and Regulatory Reform

To support the integration of digital safety tools into national frameworks, RA could consider the following actions:

- Propose procurement reform: Advocate for digital technologies to become a minimum standard in the procurement process for all road maintenance contracts.
- Leverage existing policy streams: Build upon RA's current initiatives such as Stay Safe and Boost Productivity and align new policies with national strategies for smart mobility.
- Use established frameworks: Promote the Austroads Guide to Digital Engineering as a foundation for transport agencies to implement digital engineering.
- Engage strategic bodies: Collaborate with Austroads, the National Transport Commission (NTC), and the Fair Work Commission (FWC) to embed digital safety requirements into emerging standards.
- Influence decision-makers directly: Use RA-hosted events like the Transforming Transport Summit to present the business case for digitalisation to senior ministers and transport agency heads.

7.2 Drive Industry-Wide Adoption and Collaboration

Mandating digitalisation requires broad industry buy-in. RA can foster this by demonstrating real-world benefits and facilitating collaboration across stakeholders.

- Facilitate pilot programs for digital roadwork kits across regional and urban environments, in partnership with road owners, contractors, and technology providers.
- Convene industry and government stakeholders to harmonise roadwork incident data and develop a national data standard that enables seamless sharing and AI-driven safety analysis.
- Promote training programs and forums focused on digital safety, helping the workforce transition to digital engineering, such as those featured at the Roads, Tolling and Tech 2025 conference.

7.3 Emphasise Strategic and Long-Term Benefits

To build sustained support for digitalisation, RA and its partners can highlight the broader advantages beyond immediate safety improvements:

- Demonstrate how digital tools streamline workflows from procurement to maintenance, boosting productivity across the transport sector.
- Position the industry as innovative and appealing to younger, tech-savvy professionals to attract and retain talent.
- Create a framework that enables new solutions throughout the project lifecycle, encouraging innovation at every stage.
- Advocate for leveraging federal investments in mobile and broadband connectivity to support digital roadwork technologies, especially in rural areas where road fatalities are disproportionately high.

8. Conclusion

In conclusion, the proposed "Safe Systems Technology - Roadwork Truck Kit" represents a transformative approach to improving safety at temporary, short-term and mobile road worksites. By integrating a suite of advanced digital technologies aligned with the Safe Systems framework, this initiative addresses the unique challenges of these dynamic work environments on the road network.

The "Safe Systems Technology - Roadwork Truck Kit" addresses all five pillars of the Safe Systems Approach:

1. Safer Roads: The kit uses LiDAR technology to map out work sites and detect potential hazards, enabling real-time warnings to workers and informing future road design improvements.
2. Safer Vehicles: The kit includes features like speed compliance, warning systems, and enhanced lighting to improve the safety of maintenance vehicles themselves.
3. Safer Speeds: The speed compliance and warning systems aim to influence driver behaviour and ensure adherence to speed limits within work zones.
4. Safer Road Users: The real-time location tracking and reporting, as well as the communication with navigation apps, help increase awareness and attention of road users approaching work sites.
5. Post-Crash Care: The satellite communications and incident reporting capabilities enable rapid emergency response and data collection for post-incident analysis and improvement.

Deployed across maintenance vehicle fleets, this technology provides a consistent, standardised safety baseline for all worksites, overcoming the limitations of existing reactive and manual approaches. The modular, flexible design ensures the solution can be tailored to various operational needs and site conditions.

The phased rollout strategy, starting with pilot trials and progressing to nationwide adoption, enables a measured and evidence-based transition. This approach builds stakeholder support, refines the technology and secures the policy changes needed to mandate the use of these safety-enhancing digital tools.

Importantly, the initiative aligns with the principles of the Safe Systems approach, distributing responsibility for safety across all road users. By empowering workers, influencing driver behaviour and providing reliable, real-time data, the proposed solution creates a forgiving environment that accommodates human error and minimises the risk of serious harm.

Beyond immediate safety benefits, the digitalisation of road maintenance operations unlocks broader opportunities. These include predictive analytics, digital twins, autonomous equipment and integrated network management - transforming how we plan, deliver and maintain Australia's vital road infrastructure.

Through strategic industry collaboration and policy advocacy led by Roads Australia, this visionary proposal can catalyse a nationwide revolution in road worker and road user safety. By embracing innovation and systemically embedding the Safe Systems principles, the transport sector can move beyond reactive risk management toward a future of proactive, data-driven protection for all who rely on our roads.

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Appendix A

Survey Request - Safety Systems to Improve Road Worker Safety

Request for Survey Response

Hi,
I am currently working on a project to improve Road Worker Safety. Your input into and on sharing the online survey below would be greatly appreciated!!

PURPOSE OF SURVEY

My name is Shaun Gillespie, and I am currently conducting an online survey to engage with key stakeholders as part of the 2025 Roads Australia Fellowship Group Project on the topic of recommending safety improvements for road workers and/or road users.
My Group is aiming to ***Improve Road User and Road Worker Safety at temporary/short-term and mobile routine road maintenance worksites***.
The purpose of this survey is to identify strategies to improve safety for road workers and road users at routine road maintenance worksites.

I would appreciate your time to fill out the survey attached and forward onto your colleagues.

This survey should take approximately 10 minutes. Please answer as honestly and openly as possible.

BACKGROUND

The Safe System approach to road user safety acknowledges that human error is inevitable in road crashes but aims to design systems that minimize the severity of injuries, even when crashes occur.
To improve safety for drivers **and road workers** the risk of errors occurring at road maintenance worksite should not result in fatalities or serious injuries when utilising the safe systems approach.
My Group aims to apply the principles of the Safe System approach to road maintenance worksites situations to find improvement.
The application of the Safe System approach will apply all the elements of the road transport system that can work together to prevent crashes or limit crash forces at worksites, making them survivable and reducing the severity of injury to both drivers and road workers.

Roads Australia - Road Worker Safety Industry Guideline – May 2024

Follow this link to the Survey:

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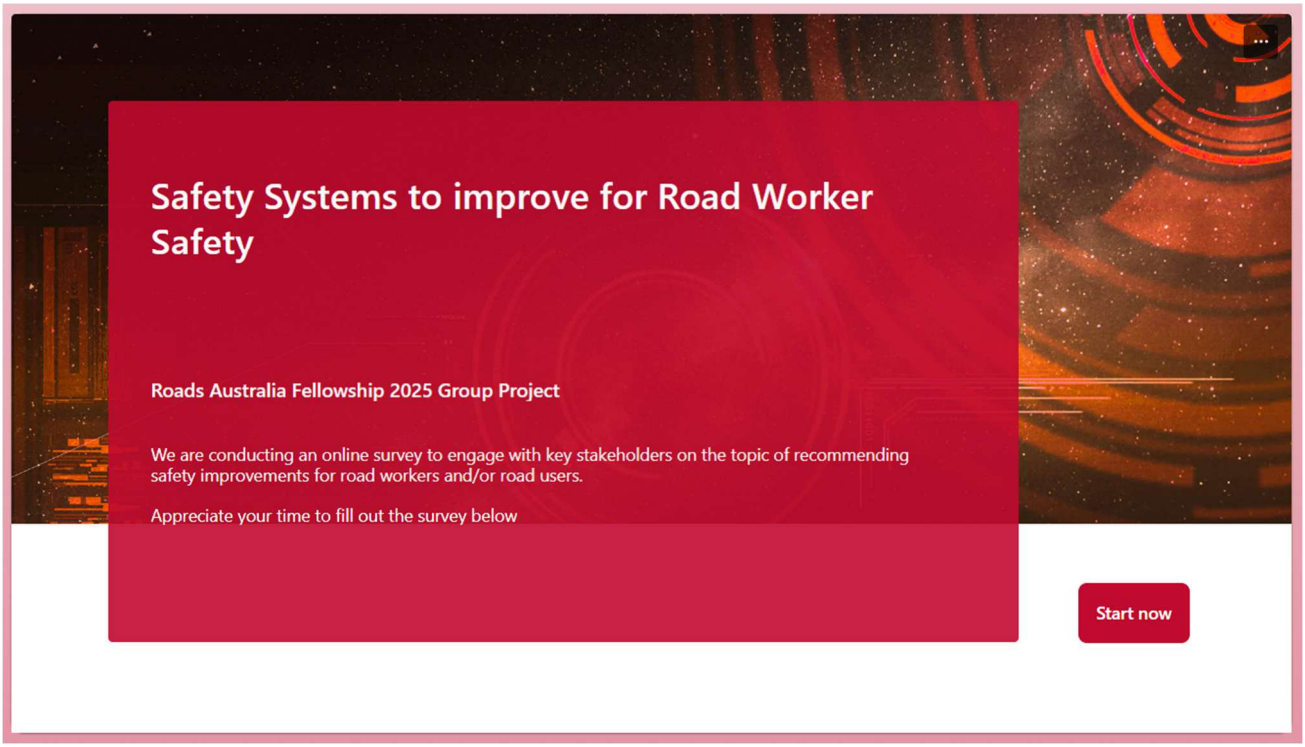

Safety Systems to improve for Road Worker Safety

August 2025

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* Required

1. It's often said that the problem is to keep roadworkers where they should be and the traveling public where they belong. Do you agree or do you think it's a bit more complex? *

Enter your answer

2. What top 5 key factors do you believe affect the safety of Road Users & Road Workers at short-term road maintenance worksites? *

Enter your answer

3. What strategies have you or your organisation adopted to improve safety for drivers & Road Workers through short term road maintenance worksites traffic? *

Enter your answer

4. The Safe Systems approach emphasizes a shared responsibility for safety, focusing on four key pillars: **safer roads,** safer vehicles, safer speeds, post-crash care and safer road users**.** Safe roads are designed and built to be more forgiving and account for human error. If a driver or rider makes a mistake, safer road design can significantly reduce the chance that it will result in a death or serious injury. What improvements could be me made to roads to so they can be more forgiving to Road Workers at short-term road maintenance worksites? *

Enter your answer

5. The Safe Systems approach emphasizes a shared responsibility for safety, focusing on five key pillars: safer roads, safer vehicles, **safer speeds**, post-crash care and safer road users. A small increase in speed can make a big difference to the severity of a crash. Driving too fast is the single biggest contributor to death and injury on our roads. That's why setting safe speed limits, and ensuring drivers comply, is critical. **What improvements could be me made to ensure safer worksite speeds compliance at short-term road maintenance worksites?** *

   Enter your answer

6. The Safe Systems approach emphasizes a shared responsibility for safety, focusing on five key pillars: safer roads, safer vehicles, safer speeds, post-crash care and **safer road users**. People are at the heart of the Safe System approach to road safety. All road users need to be motivated to follow the rules and make safety a priority on and around the road. **What improvements could be me made to motivate safe decision making at short-term road maintenance worksites?** *

   Enter your answer

7. The Safe Systems approach emphasizes a shared responsibility for safety, focusing on five key pillars: safer roads, **safer vehicles**, safer speeds, post-crash care and safer road users. Safe vehicle choices can greatly affect your ability to survive a crash. **What improvements could be me made to selection road maintenance vehicles to create safer environments at short-term road maintenance worksites?** *

   Enter your answer

8. The Safe Systems approach emphasizes a shared responsibility for safety, focusing on five key pillars: safer roads**,** safer vehicles, safer speeds, **post-crash care** and safer road users**. What improvements could be me made to post-incident care procedures to improve Road Workers safety at short-term road maintenance worksites?** *

   Enter your answer

9. What measures if any have you or your organisation tried to implement or are currently working on to improve road worker safety. What were the outcomes? *

   Enter your answer

10. What barriers to implementing effective safety treatments have you encountered and/or do you see possible? *

Enter your answer

11. Would you be interested to discuss any potential innovations further, provide any further information and/or be willing to trial any worksite improvements? If so please provide your contract details in the Questions 11 & 12. *

Enter your answer

12. Please provide your Name

Enter your answer

13. Please provide your email address

Enter your answer

14. What area of the Roads Industry do you currently work in? *

- ◯ Government / Asset Owner
- ◯ Traffic Control Company
- ◯ Private Industry / Contractor
- ◯ Road User Only
- ◯ Other

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Appendix B

Survey Data Analysis - Safety Systems to Improve Road Worker Safety

Safe Systems for Road Worker Safety - Summary of Survey Questions Responses:

Question 1

It's often said that the problem is to keep roadworkers where they should be and the traveling public where they belong. Do you agree or do you think it's a bit more complex?

Based on the provided responses, it appears that the majority of respondents believe the problem of keeping roadworkers and the travelling public separated is more complex than the simple statement suggests.

The key points raised include:

- It is not always feasible to completely separate roadworkers and the travelling public, especially in constrained or short-term work zones. There needs to be a balance and accommodation for both.
- Human factors and behaviour play a significant role, such as driver compliance, risk-taking, and perceptions of safety around roadworkers.
- Site-specific constraints like traffic volumes, work type/duration, environmental impacts, and community considerations add complexity.
- The ideal of eliminating live traffic from the work zone altogether is not always practical or supported by authorities, further complicating the issue.
- There is a need for a greater understanding and awareness from both roadworkers and the travelling public to improve compliance and safe interactions.

In summary, the respondents largely agree that the problem is more nuanced and complex than the simple statement implies. Complete separation is an ideal, but achieving the right balance of safety, mobility, and productivity requires consideration of multiple factors in each unique work site scenario.

Question 2

What top 5 key factors do you believe affect the safety of Road Users & Road Workers at short-term road maintenance worksites?

Based on the responses provided, the top 5 key factors that affect the safety of Road Users and Road Workers at short-term road maintenance worksites are:

1. Vehicle Speed:

- Excessive speed and poor speed compliance by drivers is a major contributing factor to safety risks. Drivers failing to slow down appropriately through work zones increases the likelihood and severity of incidents.

2. Traffic Management and Signage:
    - Effective traffic management plans, consistent signage, and clear communication of changed conditions are crucial. Poor traffic control setup, confusing signage, and lack of advance warning can disorient and distract drivers.
3. Separation and Physical Barriers:
    - Adequate separation and physical protection between workers and live traffic lanes is key. Lack of suitable barriers or buffer zones increases the exposure and risk to workers on foot.
4. Driver Behaviour and Distraction:
    - Inattentive, distracted, or complacent driving behaviour by members of the public, including use of mobile phones, can significantly compromise safety.
5. Planning, Preparation and Site Conditions:
    - Factors such as work scope, site location, access, traffic volumes, weather conditions, and overall work planning and preparation can all impact the safety of short-term maintenance sites.

Other frequently mentioned factors include worker complacency, lack of worker training and experience, ineffective communication, traffic composition (presence of heavy vehicles, vulnerable road users), and the duration/complexity of the works.

The responses highlight the multifaceted nature of safety challenges at short-term road maintenance worksites, with a need to address both driver and worker behaviour, as well as the design and management of the work environment.

Question 3:

What strategies have you or your organisation adopted to improve safety for drivers & Road Workers through short term road maintenance worksites traffic?

Based on the information provided in the documents, organisations have adopted a range of strategies to improve safety for drivers and road workers through short-term road maintenance worksites. The key strategies include:

1. Traffic Control Measures:
    - Implementing Traffic Control at Worksites (TCAWS) manual practices
    - Using advanced warning signage, flashing signs, rumble strips, and other visual cues to alert drivers

- Deploying traffic control devices like lane closures, chicanes, and speed reduction measures
- Utilising technology like variable message signs, radar speed boards, and automated cone trucks

2. Worker Safety Practices:
    - Providing workers with appropriate training, such as in traffic control and work near traffic
    - Employing spotters and sole spotters to monitor oncoming traffic
    - Minimising the number of workers on foot by using machinery and equipment where possible
    - Establishing buffer zones and physical barriers to separate workers from live traffic
    - Conducting risk assessments, toolbox talks, and safety inspections
3. Operational Strategies:
    - Scheduling work during off-peak or low-traffic periods
    - Utilising road possessions, detours, and contraflows to divert traffic
    - Employing truck-mounted attenuators (TMAs) and other impact protection devices
    - Collaborating with police and highway patrol for enforcement and presence at worksites
4. Organisational Approaches:
    - Forming dedicated committees to drive consistent, innovative, and data-driven safety improvements
    - Conducting audits, reviews, and trials of new safety strategies and technologies
    - Promoting a culture of safety awareness, accountability, and continuous improvement
    - Engaging workers and road users through education, communication, and feedback mechanisms

The overarching themes emphasise a multifaceted approach that combines engineering controls, administrative controls, and a strong safety culture to enhance the protection of both road users and road workers. The strategies aim to address the various risk factors present at short-term road maintenance worksites, with a focus on reducing exposure, improving visibility, and fostering collaboration and compliance.

Question 4:

The Safe Systems approach emphasizes a shared responsibility for safety, focusing on four key pillars: **safer roads,** safer vehicles, safer speeds, post-crash care and safer road users**.**

Safe roads are designed and built to be more forgiving and account for human error. If a driver or rider makes a mistake, safer road design can significantly reduce the chance that it will result in a death or serious injury.

What improvements could be me made to roads to so they can be more forgiving to Road Workers at short-term road maintenance worksites?

Based on the provided information, the key recommendations for making "safe roads" to improve the safety of road workers include:

1. **Increased Separation and Space**:
    - Wider shoulders and lane widths to provide more distance between workers and live traffic
    - Dedicated maintenance shoulders or widened verges to reduce the need for lane closures
    - Permanent hardstands or service bays for maintenance vehicles to allow work off the live carriageway
    - Median crossovers or bypass lanes to enable safer traffic diversions during works
2. **Improved Road Geometry and Visibility**:
    - Enhanced sight distances around curves and crests to give drivers more reaction time
    - Consistent lane widths and shoulder treatments to reduce erratic driver behaviour
    - Vegetation management and lighting upgrades to improve visibility for workers and drivers
3. **Embedded Safety Features**:
    - Permanent barrier systems (e.g. wire rope, concrete) to protect workers in high-risk zones
    - Crashworthy attenuators and impact-absorbing devices integrated into the road design
    - Smart infrastructure like in-road sensors or connected signage to alert drivers to upcoming works
4. **Speed Management Infrastructure**:
    - Permanent variable speed limit signs for dynamic control during short-term works
    - Road narrowing treatments and rumble strips to slow traffic approaching work areas
    - Speed enforcement zones with camera infrastructure in high-risk corridors
5. **Worker-Focused Design Considerations**:
    - Safe access paths for workers to enter and exit sites without crossing live traffic
    - Staging areas for equipment and materials that are physically separated from traffic
    - More stockpile and layby areas built within the road environment

Overall, the recommendations focus on physical infrastructure improvements to the road environment that can create safer conditions for both road workers and the travelling public. These include increasing separation, improving visibility and geometry, implementing embedded safety features, managing traffic speeds, and designing for the specific needs of road workers.

Question 5:

The Safe Systems approach emphasizes a shared responsibility for safety, focusing on five key pillars: safer roads, safer vehicles, **safer speeds**, post-crash care and safer road users.

A small increase in speed can make a big difference to the severity of a crash. Driving too fast is the single biggest contributor to death and injury on our roads. That's why setting safe speed limits, and ensuring drivers comply, is critical.

What improvements could be me made to ensure safer worksite speeds compliance at short-term road maintenance worksites?

Based on the context provided in the documents, there are several key strategies that can be employed to improve speed compliance and safety in roadwork zones:

1. Enhanced Signage and Visual Cues:
    - Use of Variable Message Signs (VMS) and Multi-Message Signs (MMS) to reinforce speed limits and alert drivers to upcoming works
    - High-visibility signage, including LED-enhanced signs and reflective materials, to improve driver awareness
    - Radar-based speed feedback signs ("Your Speed Is...") to provide real-time feedback and encourage lower speeds
2. Enforcement and Monitoring:
    - Deploy mobile speed cameras or average speed detection systems temporarily to enforce compliance
    - Increase police presence and enforcement, including regular drive-throughs of work sites
    - Explore alternative enforcement options beyond just police, such as camera-based systems that can record and issue fines
3. Technology Trials and Innovation:
    - Trial connected vehicle alerts or geofenced speed zones that communicate directly with in-vehicle systems
    - Explore technologies like temporary speed humps, rumble strips, or lane narrowing to physically slow vehicles
4. Education and Awareness:

- Conduct public education campaigns to raise awareness about the risks and importance of slowing down in work zones
- Ensure temporary speed zone changes are well-communicated and justified to drivers

5. Holistic Approach:
    - Adopt a Safe Systems approach that considers the shared responsibility for safety across roads, vehicles, speeds, post-crash care, and road users
    - Ensure temporary speed limits are realistic and appropriate for the site conditions
    - Coordinate the removal and installation of traffic management devices to maintain driver trust and compliance

The key is to employ a multifaceted strategy that combines engineering, enforcement, education, and innovative technologies to address the complex issue of speed compliance in roadwork zones. A collaborative, data-driven approach that engages all stakeholders is crucial for improving safety outcomes.

Question 6:

The Safe Systems approach emphasizes a shared responsibility for safety, focusing on five key pillars: safer roads, safer vehicles, safer speeds, post-crash care and **safer road users**.

People are at the heart of the Safe System approach to road safety. All road users need to be motivated to follow the rules and make safety a priority on and around the road.

What improvements could be me made to motivate safe decision making at short-term road maintenance worksites?

The documents provided suggest a range of potential approaches to improve road safety around work sites and enhance the shared responsibility for safety, as emphasized by the Safe Systems approach. Some key themes and recommendations that emerge from the responses include:

1. Regulatory and Enforcement Measures:
    - More regulation of requirements and stronger law enforcement with greater penalties for non-compliance
    - Mandatory driver education and testing on hazards and risks faced by road construction workers
    - Increased police presence, speed cameras, and fines for speeding or non-compliance
2. Technology and Infrastructure Improvements:
    - Use of variable message signs, speed feedback displays, and other technologies to guide and influence driver behaviour
    - Improved traffic management and work zone design for predictability and clarity
    - Automation of high-risk tasks to reduce worker exposure to live traffic
3. Behavioural Interventions and Campaigns:

- Public awareness campaigns to promote shared responsibility, empathy, and courtesy towards road workers
- Incorporation of the "human factor" in messaging to elicit emotional connection and understanding
- Behavioural nudges such as rumble strips and visual narrowing to encourage safer speeds

4. Planning and Coordination Improvements:
    - Better planning, coordination, and communication to minimise disruption and driver frustration
    - Consideration of work timing, site setup, and workforce management to optimise safety
    - Increased collaboration between stakeholders, including police, regulators, and road users
5. Training and Culture Change:
    - Improved training and mentoring for road workers to enhance competence and decision-making
    - Fostering a culture of safety, shared responsibility, and care for fellow workers

The responses highlight the need for a multifaceted approach that combines regulatory, technological, behavioural, and organisational interventions to address the safety of road workers and road users alike, in line with the Safe Systems philosophy.

Question 7:

The Safe Systems approach emphasizes a shared responsibility for safety, focusing on five key pillars: safer roads, **safer vehicles**, safer speeds, post-crash care and safer road users.

Safe vehicle choices can greatly affect your ability to survive a crash.

What improvements could be me made to selection road maintenance vehicles to create safer environments at short-term road maintenance worksites?

Based on the provided documents, here is a summary of the responses regarding safer vehicles for roadworks:

1. Vehicles that eliminate worker exposure:
    - Automated cone trucks and line marking vehicles to reduce the need for workers to manually operate near live traffic
    - Remote-controlled or robotic equipment to allow tasks to be performed from a safe distance
2. Vehicles with integrated safety features:

- Crash attenuators (e.g. TMAs) on mobile operations
- High-visibility lighting, arrow boards, and reflective markings to improve visibility
- Proximity sensors and cameras to enhance situational awareness and reduce blind spots

3. Vehicles that support efficient site setup and removal:
    - Vehicles designed for rapid deployment and pack-down to reduce time spent in high-risk environments
    - Multi-purpose vehicles that combine signage, barriers, and traffic control equipment to streamline operations
4. Other suggestions:
    - Larger, high-visibility vehicles with plenty of safety technology
    - Retractable crash barriers that extend out to the side of live traffic to protect the vehicle and workers
    - Satellite communications, video capture, and speed cameras on site to monitor traffic
    - Sweeper trucks with detergent dispensers to quickly remove oils and fluids from the roadway
    - Tow bars fitted to vehicles to prevent submarining from errant vehicles
    - Mandatory all-round cameras on all roadworks vehicles
    - Automated warning lights/sounds/notifications for workers within a clearance zone
    - Use of VMS boards or light bar boxes at the back of vehicles to provide early warning to approaching traffic

The overall theme is to prioritise vehicles and technologies that can reduce worker exposure to live traffic, enhance visibility and situational awareness, and streamline site setup and removal to minimise time spent in high-risk environments.

Question 8:

The Safe Systems approach emphasizes a shared responsibility for safety, focusing on five key pillars: safer roads**,** safer vehicles, safer speeds, **post-crash care** and safer road users**.**

What improvements could be me made to post-incident care procedures to improve Road Workers safety at short-term road maintenance worksites?

Based on the responses provided, here is a summary of potential improvements to post-crash care and support for road workers in the context of the Safe Systems approach:

1. Psychological and Trauma Support:

- Provide access to counselling, Employee Assistance Programs (EAPs), and other mental health support services for workers affected by incidents.
- Conduct wellbeing check-ins and follow-up with workers post-incident to monitor recovery and readiness to return to work.
- Promote a culture where seeking support is encouraged and destigmatized.
- Offer opportunities for victims (if willing) to participate in safety campaigns and policy development.

2. Incident Reporting and Communication:
    - Implement digital reporting tools to allow immediate logging of incidents, near misses, and hazards.
    - Establish clear escalation protocols to ensure all relevant parties are informed promptly.
    - Use incident debriefs to gather insights and ensure lessons are captured and shared across the organisation.
3. Emergency Response Capabilities:
    - Ensure pre-planned emergency access and first aid resources are included in Traffic Management Plans.
    - Provide on-site first aid kits and trained personnel, especially for remote or high-risk worksites.
    - Implement real-time location tracking of workers and vehicles to help emergency services respond quickly.
4. Telecommunications Infrastructure:
    - Ensure reliable mobile and radio coverage at all worksites, including redundant communication systems.
    - Integrate telecommunications into Traffic Management Plans and ensure protocols are tested and understood by all personnel.
5. Coordination with External Agencies:
    - Build relationships with local emergency services to ensure familiarity with worksite layouts and access points.
    - Include emergency responders in pre-work briefings for high-risk or complex sites.
    - Develop joint response protocols for major incidents involving multiple stakeholders.
6. Integrating Learnings into Future Planning:
    - Use incident data to review and revise Traffic Control Plans and site procedures.
    - Share findings across zones and teams to prevent recurrence and improve collective safety knowledge.

- Encourage worker participation in incident reviews to incorporate frontline perspectives.

7. Additional Suggestions:
    - Provide mandatory psychiatric analysis and support programs for workers involved in incidents.
    - Improve availability and resourcing of emergency services to triage incident sites and improve controls.
    - Enhance advanced warning systems, such as VMS trucks with message boards, to improve incident response.
    - Ensure appropriate levels of emergency response plans are in place for road work zones.

The overall focus is on improving post-crash care, strengthening emergency response, enhancing communication and coordination, and providing comprehensive psychological and trauma support for road workers. The recommendations aim to create a more resilient and supportive system to mitigate the impacts of road incidents on workers.

Question 9:

What measures if any have you or your organisation tried to implement or are currently working on to improve road worker safety. What were the outcomes?

is summary outlines various measures that organisations have implemented or are currently working on to improve road worker safety, as well as the outcomes of these initiatives. The information is based on responses collected from multiple stakeholders.

Measures Implemented

Traffic Management and Control

- Road closure and traffic elimination to remove risk, but lack of infrastructure makes this challenging
- Rumble strips and enhanced signage for end-of-queue awareness
- Increased use of variable message signs (VMS) and mobile VMS on vehicles
- Narrowing of lane widths to encourage speed reduction
- Digitalisation of traffic control processes (e.g. Deakin University trial)
- Mobile speed enforcement cameras within worksites
- Increased use of Truck Mounted Attenuators (TMAs) and advanced warning vehicles

Scheduling and Work Practices

- Scheduling work during lower traffic volume periods, such as at night

- Deferring work close to the centreline on bridges until late at night when traffic is lower
- Reducing worker exposure through changes to work shifts and tasks

Training and Awareness

- Comprehensive training programs for workers
- Mobile works awareness campaigns to educate the public
- Increased engagement and mentoring of site leaders and workers
- Ensuring all workers understand the importance of safety

Technology and Innovations

- Trialling AI camera technology on plant and equipment for separation of people and machinery
- Investigating changes to bitumen sealing operations (e.g. forward-moving aggregate spreaders)
- Developing safety-specific tools and robotic equipment to reduce worker interactions in high-risk environments
- Piloting new devices and alternative traffic control arrangements to increase motorist awareness

Organisational Processes

- Strengthening traffic management plan approval processes and monitoring
- Removing underperforming traffic control contractors and crews
- Introducing "site communication boards" for maintenance crews
- Detailed implementation of TCAWS (Traffic Control at Worksites) requirements

Outcomes and Challenges

The responses indicate that many of the measures trialled or implemented have shown positive results, such as improved worker safety, better motorist compliance, and reduced incidents. However, some challenges remain, including:

- Difficulty in completely eliminating traffic and risk through road closures
- Ongoing issues with speed compliance and the need for more effective enforcement
- Cultural resistance to change within work crews
- Limitations of current traffic management practices and the need for simplification
- Financial constraints preventing more rigorous enforcement and safety initiatives

Conclusion

Organisations are exploring a wide range of measures to improve road worker safety, including advancements in traffic management, scheduling, training, technology, and internal processes. While many of these initiatives have demonstrated positive outcomes, there are still ongoing challenges that require continued focus and innovation to ensure the safety of road workers.

Question 10:

What barriers to implementing effective safety treatments have you encountered and/or do you see possible?

Based on the provided responses, here is a summary of the key barriers to implementing effective safety treatments that have been encountered or are seen as possible:

1. Cost and Funding Constraints:
    - The high cost of implementing safety treatments, such as automated vehicles, crash-worthy barriers, and real-time monitoring tools, is frequently cited as a major barrier.
    - Limited budgets and program/project budget constraints often restrict the ability to fund higher-order safety controls.
2. Challenges to Influencing Driver Behaviour:
    - Changing the behaviour and choices of public road users can be difficult, especially in terms of getting them to comply with reduced speed limits, enforcement measures, and other safety-related changes.
    - Gaining public and political acceptance for safety-focused legislative, policy, or enforcement changes (e.g., speed cameras in work zones) can also be a challenge.
3. Innovation Paralysis and Resistance to Change:
    - There is often a reluctance to adopt new technologies and safer work methods due to risk aversion, lack of evidence, or slow procurement and approval processes.
    - Existing orthodoxies and a lack of commitment or buy-in to try new approaches can also hinder the implementation of effective safety treatments.
4. Maintaining Network Access and Productivity:
    - The need to maintain access for freight, communities, and road users, along with the challenge of eliminating risks while maintaining network capacity, can be barriers to implementing certain safety measures.
    - The pressure to deliver projects within tight timeframes can lead to shortcuts in planning or setup, compromising safety.
5. Site-Specific Challenges:
    - Factors such as insufficient lane widths, lack of shoulder space, and unsuitable or limited alternative routes can make it difficult to implement effective safety treatments in certain road environments.
    - Varying site conditions and the transient nature of roadwork sites can also introduce challenges.
6. Resourcing and Capability Gaps:

- Lack of expertise, training, and competent traffic control services can hinder the effective implementation of safety treatments.
- Difficulties in retaining trained staff and procuring necessary equipment can also be barriers.

7. Organisational and Cultural Factors:
    - Inconsistent application of the hierarchy of controls, with a focus on lower-order measures instead of higher-order controls, can undermine safety efforts.
    - Limited frontline engagement and a lack of valuing workers' insights into site-specific risks can also be barriers.
    - Safety sometimes being seen as secondary to productivity or cost savings can undermine long-term safety culture.

Overall, the responses highlight a range of technical, financial, organisational, and cultural barriers that need to be addressed to effectively implement safety treatments in road work environments.

Question 11:

Would you be interested to discuss any potential innovations further, provide any further information and/or be willing to trial any worksite improvements? Please indicate below and provide your contact details.

Based on the provided documents, here is a summary of the responses to the question "Would you be interested to discuss any potential innovations further, provide any further information and/or be willing to trial any worksite improvements? If so please provide your contract detai...":

Response	Count
Yes	24
No	16
Maybe/Unsure	4
Not applicable/Not my role	5
Provide more information/willing to trial	6
No thanks/Not interested	6
Blank/Unknown	4

The majority of respondents (24) indicated they would be interested in discussing potential innovations and trialling worksite improvements further. A sizable number (16) declined the offer, while a smaller group (4) were unsure or indicated it was not applicable to their role. Several respondents (6) expressed a willingness to provide more information or trial improvements, while others (6) politely declined the offer. A few responses (4) were blank or unknown.

Overall, the responses suggest a mixed level of interest, with a reasonable number of stakeholders open to exploring potential innovations and improvements, but also a substantial portion who do not wish to pursue this at the current time.

Question 12: What area of the Roads Industry do you currently work in?

a) Government / Asset owner
b) Traffic Control Company
c) Private Industry / Contractor
d) Road User Only
e) Other

Based on the provided data, the summary of responses to the question "What area of the Roads Industry do you currently work in?" is as follows:

- The majority of responses (58 out of 69) indicate that the respondents work in the "Government / Asset Owner" area of the Roads Industry.
- 5 respondents work in the "Private Industry / Contractor" area.
- 2 respondents are "Road User Only" and do not work directly in the Roads Industry.
- 2 respondent is a "Other".

In summary, the data shows that the majority of respondents work in the government or asset owner side of the Roads Industry, with smaller numbers working in the private contracting sector or as road users only.

Summary

The Survey presents responses from various stakeholders in the roads industry, primarily government and asset owners, on the issue of safety at short-term road maintenance worksites. A few key points emerge:

- Keeping roadworkers and the travelling public separated is an inherent challenge, and the problem is more complex than it may initially seem. Factors like road geometry, traffic volumes, driver behaviour, and the nature of the work all contribute to the safety risks.
- Strategies adopted to improve safety include using traffic control setups as per guidelines, deploying technology like variable message signs and speed cameras, increasing police presence, and scheduling works during off-peak hours. However, barriers like cost, public acceptance, and culture change can hinder the implementation of effective treatments.
- The Safe Systems approach, with its focus on safer roads, vehicles, speeds, post-crash care, and shared responsibility, is seen as a framework to guide safety improvements. Suggestions include wider shoulders, rumble strips, in-vehicle speed warnings, and better incident response protocols.
- Overall, there is recognition that a multi-faceted approach is required to enhance the safety of both roadworkers and road users at short-term maintenance sites.

Safey Systems for Road Workers Survey Summary Table and Options

Survey Response Data Highlights | *Solution Analysis*

Safety Systems Category	Element	Description	Digital Improvements to Road Works Sites	Adoptable – Minimum Standards for Improvements	Digital Improvements toolkit	Safe System Tech - Roadwork Truck Kit
Safer Road Design	Separation and Traffic Elimination	• Permanent hardstands or service bays for maintenance vehicles • Dedicated maintenance shoulders or widened verges • Built-in traffic diversion infrastructure like bypass lanes	• Pre-installed speed enforcement camera infrastructure. i.e. average speed cameras,	• Road maintenance and safety funding made available to target maintenance works. i.e. installation of median cross overs, safer maintenance access, widened shoulders for safe maintenance truck access. • Improved road data collection for safer road design.	1st Step Additional VMS Wayfinding signs about journey management alerts 2nd Step Permanent VMS Speed signs – real time feedback 😊 ☹️ Blue Sky – Pre-installed speed enforcement camera infrastructure. i.e. average speed cameras,	**Capability 1** LiDAR technology tracking to enhance real-time feedback to drivers and Roadworkers in work zones. Monitors the worksite and collects data. **Capability 2** Digitalisation of works Zones - GPS Beacons on maintenance trucks with auto update to nav apps (Waze) of road works, roadwork speed zones, etc. **Capability 3** Satellite communications on road maintenance trucks to: • Real-time location tracking of workers and vehicles • Digital reporting tools for immediate logging of incident • Fast escalation of incidents to emergency response. **Capability 4** Red and Blue lights on RW Trucks. Speed compliance capabilities within work zones.
	Improved Road Geometry and Visibility	• Enhanced sight distances around curves and crests • Consistent lane widths and shoulder treatments • Vegetation management and lighting upgrades				
	Embedded Safety Features	• Permanent barrier systems in high-risk zones • Crashworthy attenuators and impact-absorbing devices • Folding signs, movable medians, and variable message signs				
	Speed Management	• Permanent variable speed limit signs • Road narrowing treatments and rumble strips • Pre-installed speed enforcement camera infrastructure				
	Worker-Focused Design	• Safe access paths for workers • Staging areas for equipment and materials • More stockpile and layby areas within the road environment				
Safer Speeds	Digital Improvements	• Variable message signs (VMS) and multi-message signs (MMS) • Connected vehicle alerts and geofenced speed zones • Speed radar and feedback signs	• Variable message signs (VMS) and multi-message signs (MMS) • Increased Enhanced Enforcement Program (EEP) – which enhances police visibility and road safety enforcement. • LiDAR technology to enhance temporary barrier and speed	• Adopting VMS and vehicle speed technology to Road Maintenance trucks. • Speed compliance capabilities within work zones. Mobile speed cameras with	1st Step LiDAR technology to enhance realtime feedback in work zones. 2nd Step Red and Blue lights on RW Trucks. Double fines on sites when	
	Physical and Enforcement Measures	• Increased police presence and enforcement • Temporary speed humps, chicanes or rumble strips • Stronger penalties and double fines for speeding				
	Policy and Education	• Ensuring speed limits are appropriate • Public education campaigns • Incorporating roadwork safety into driver training				

	Integrated Approach	• Combining digital, physical and enforcement measures • Engaging all stakeholders • Continuous evaluation and refinement	compliance safety in roadwork zones by creating "smart" digital environments for real-time monitoring and early warning systems	work zones or speed detection with real time feedback capabilities on maintenance trucks. • Double fines for when Roadworker present.	Roadworkers present by Police Blue Sky – Regular Speed compliance capabilities within work zones. adopted onto advance warning RW trucks.
Safer People	Integrating with Navigation Apps	• Provide real-time alerts to drivers about upcoming work zones and speed limits	• Displaying driver's current speed to encourage safer driving • Provide real-time alerts to drivers about upcoming work zones and speed limits • Increasing Integration with Navigation Apps • Intru	• Realtime data to be provided to navigation apps. • GPS Beacon on maintenance trucks to update nav apps of road works, roadwork speed zones, etc... • Data collection of driver behaviour at road work sites.	1st Step Digitalisation of works Zones - GPS Beacon on maintenance trucks to update nav apps (Waze) of road works, roadwork speed zones, etc. 2nd Step Provide real-time alerts to drivers about upcoming work zones and speed limits. Displaying driver's current speed to encourage safer driving. 3. Blue Sky – Data collection of driver behaviour at road work sites to improve future strategy. Digital barriers with roadworks sites.
	Variable Message Signs (VMS) and Speed Feedback	• Timely, relevant information to drivers about work zones and speeds • Displaying driver's current speed to encourage safer driving			
	Automated Equipment	• Utilising automated cone trucks and line markers to reduce worker exposure			
	Behavioural Nudges	• Rumble strips and lane narrowing to subtly encourage slower speeds			
	Improved Work Zone Design	• Predictable, clear layouts with consistent signage to support safe decisions			
Safer Vehicles	Safer Vehicle Design and Features	• Proximity sensors, cameras, and collision detection systems • Larger, more visible warning lights and reflective markings • Integrated crash attenuators and remote/automated capabilities	• Proximity sensors, cameras, and collision detection systems. • Speed Cameras at Worksites or on maintenance trucks.	• Satellite communications on road maintenance trucks.	
	Communication and Connectivity	• Vehicle-to-vehicle and vehicle-to-infrastructure communication • Variable message signs (VMS) mounted on vehicles • Satellite communications, speed cameras, and red-light cameras			
	Operational Improvements	• Consolidating vehicle types and numbers • Prioritising vehicles with higher safety ratings and features ensuring adequate safety equipment and signage			
Improving Post-Crash Care and Support	Strengthen Emergency Response Capabilities	• Pre-planned emergency access in Traffic Management Plans • On-site first aid kits and trained personnel • Real-time location tracking of workers and vehicles	• Real-time location tracking of workers and vehicles • Digital reporting tools for immediate logging of incident	Satellite communications on road maintenance trucks to: • Real-time location tracking of workers and vehicles	1st Step Road maintenance crews to carry 1st Aid/Defibulators 2nd Step
	Improve Incident Reporting and Communication	• Digital reporting tools for immediate logging of incident • Clear escalation protocols and incident debriefs			

Enhance Telecommunications Infrastructure	• Reliable mobile and radio coverage at worksites • Redundant communication systems like satellite phones	• Satellite communications enabled for reliable	• Digital reporting tools for immediate logging of incident • Fast escalation of incidents to emergency response. Road Work Trucks equipped with: • Defibulators • First aid response kits	Satellite communications for reliable coverage at worksites 3. Blue Sky – Enhanced Coordination with Emergency response agencies
Integrate Learnings into Future Planning	• Review and revise Traffic Control Plans and site procedure • Share findings across zones and teams to prevent recurrence			
Enhance Coordination with External Agencies	• Build relationships with local emergency services • Include emergency responders in pre-work briefings			
Provide Psychological Support and Follow-Up	• Access to counselling or Employee Assistance Programs • Wellbeing check-ins post-incident			