Executive Summary

Wayside Asset Protection (WAP) systems are widely used across Australian freight rail networks to monitor the condition of rolling stock, supporting safe, reliable and efficient railway operations. Technologies such as hot bearing detectors, wheel impact load detectors, acoustic bearing detectors, machine vision systems and dragging equipment detectors generate significant volumes of operational and condition-monitoring data.

Despite substantial investment in these technologies, WAP data remains largely fragmented across Rail Infrastructure Managers (RIMs) and Rolling Stock Operators (RSOs). Information is typically stored within organisation-specific systems using different data structures, event classifications, alarm thresholds and governance arrangements. As a result, valuable condition-monitoring information cannot be consistently exchanged, interpreted or utilised across network boundaries.

A review of Australian interoperability frameworks, industry guidance and international research found that while significant progress has been made in rail systems interoperability, limited guidance exists for operational WAP data exchange, common event structures, governance arrangements and minimum interoperable datasets.

This report proposes developing a nationally aligned Code of Practice for WAP data exchange based on a federated interoperability model. The proposed framework focuses on common terminology, standardised event classifications, minimum interoperable datasets, governance arrangements and vendor-neutral interoperability requirements. The objective is not to mandate technologies or centralised platforms, but to enable consistent and secure exchange of WAP information across the Australian rail industry.

Implementation of the proposed framework would improve asset visibility, support predictive maintenance, strengthen safety outcomes, enhance operational efficiency and provide a foundation for future digital railway initiatives, including advanced analytics, digital twins and artificial intelligence applications.

Enhancing Wayside Asset Protection Interoperability

in the Australian Freight Rail Industry

Towards a nationally aligned Code of Practice for WAP information exchange

SAFETY

Strengthening safety through timely asset condition interventions

RELIABILITY

Improving network reliability and operational performance

INTEROPERABILITY

Enabling consistent information exchange across networks and organisations

EFFICIENCY

Enhancing asset management and maintenance efficiency

INNOVATION

Creating a foundation for digital rail innovation and future technologies

Project Standard

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ARiSO Horizons 7 | 2026

ARiSO

AUSTRALIAN RAILWAY INDUSTRY STANDARDS ORGANISATION

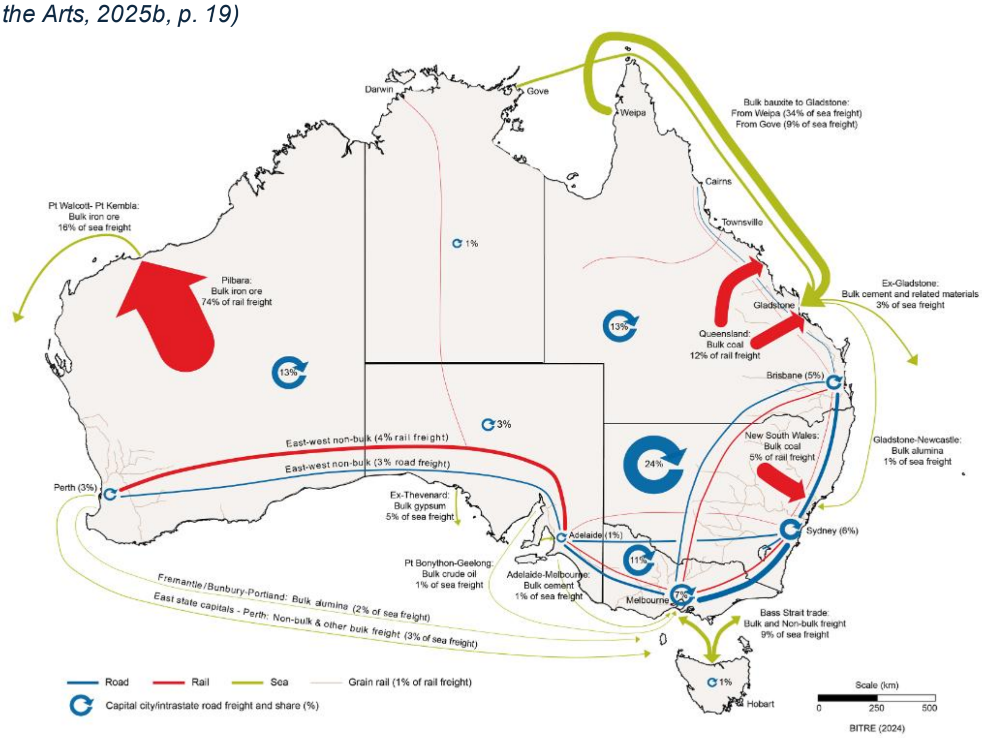
Contents

1. Introduction

The Australian freight rail network is a critical enabler of national economic productivity, supporting the efficient transport of bulk commodities and intermodal freight across vast geographic distances. As rail operations become increasingly digitised, the integration of advanced monitoring systems, communication technologies, and data-driven decision-making is transforming how infrastructure and rolling stock are managed. In this context, Wayside Asset Protection (WAP) systems, designed to detect faults, monitor asset condition, and prevent operational incidents, play a vital role in maintaining safety, reliability, and network performance (Rail Industry Safety and Standards Board, 2022).

Beyond supporting rolling stock reliability, WAP systems also help protect rail infrastructure by identifying defects before they cause track damage and disrupt the supply chain. With Australia's freight task projected to grow by 26 per cent between 2020 and 2050 (Department of Infrastructure, Transport, Regional Development, Communications, Sport and the Arts, 2025a), maintaining a safe, reliable and productive rail network will become increasingly important for supporting national economic growth and supply chain resilience. As national freight services increasingly operate across multiple rail networks, the ability to consistently exchange and interpret WAP information is an important enabler of national rail interoperability.

Figure 1
Australian Freight Flows Map (Department of Infrastructure, Transport, Regional Development, Communications, Sport and the Arts, 2025b, p. 19)



However, despite significant technological advancements in areas such as condition monitoring, digital twins, and automated train control, the Australian rail sector remains fragmented in its approach to data sharing and interoperability. WAP systems are typically deployed and managed independently by different Rail Infrastructure Managers (RIMs) and Rolling Stock Operators (RSOs), resulting in siloed data environments and limited cross-network visibility.

This report examines the current state of WAP systems in the Australian freight rail industry, identifies interoperability gaps, and proposes a nationally aligned Code of Practice to support consistent, interoperable WAP data exchange.

1.2. Purpose

The purpose of this report is to evaluate the current landscape of WAP systems within the Australian freight rail network and identify the limitations associated with fragmented data-sharing practices. Specifically, the report aims to:

- Examine the role of WAP systems in supporting safe and efficient rail operations.
- Assess current deployment and data-sharing practices across Australian rail networks.
- Identify gaps in interoperability, harmonisation, and data accessibility.
- Define a minimum interoperable dataset for WAP information exchange.
- Propose a practical implementation framework aligned with existing Australian interoperability initiatives.
- Support the objectives of the ARiSO Horizons 7 program by identifying practical opportunities to improve interoperability, industry collaboration and digital capability.

2. Alignment with Horizons 7 Objectives

The ARiSO Horizons 7 program seeks to identify practical opportunities that improve interoperability, collaboration, innovation and long-term sustainability across the Australian rail industry. This project directly supports these objectives by advancing the interoperability of WAP information across Australian freight rail networks.

Extending interoperability principles to WAP datasets presents a practical opportunity to unlock additional value from existing monitoring technologies and investments. By improving the consistent exchange of operational information between RIMs and RSOs, the industry can support more informed decision-making, strengthen network resilience and improve supply chain performance without requiring significant changes to existing systems or operational practices.

This initiative supports Horizons 7 objectives by promoting interoperability among rail organisations, improving collaboration and information sharing, leveraging existing industry investments, and laying the foundation for future digital railway initiatives. By building upon existing technologies and interoperability reforms, it provides a practical pathway towards nationally harmonised WAP information exchange. Consistent with the National Rail Action Plan's vision of a more interoperable national rail system, improved WAP information exchange would support harmonisation, strengthen operational decision-making, and contribute to safer, more productive and resilient freight rail networks (National Transport Commission, 2025b).

3. Industry Context: Australian Freight Rail System

Australia's freight rail industry operates within a highly federated environment comprising private heavy-haul railways, interstate freight corridors, regional networks and metropolitan interfaces. Multiple organisations manage these networks with differing operational requirements, technology strategies and asset management practices.

Consequently, digital maturity varies across the industry. While some operators have implemented advanced asset health platforms, predictive maintenance capabilities and integrated data environments, others continue to rely on legacy systems with limited interoperability and information-sharing capability.

Recent industry initiatives have recognised interoperability as a key enabler of future railway capability. The National Transport Commission's Digital Train Control Technology Interoperability Requirements Assessment identified interoperability as a critical requirement for increasingly digitised rail operations (National Transport Commission, 2025a). Similarly, AS 7450 Rail Systems Interoperability (Rail Industry Safety and Standards Board, 2021a) and AS 7666 Train Protection and Control Interoperability (Rail Industry Safety and Standards Board, 2021b) establish principles intended to support greater consistency across Australian rail networks.

However, existing interoperability initiatives have largely focused on infrastructure, signalling and train control systems. Operational condition-monitoring information generated by WAP systems remains largely outside the scope of current interoperability frameworks. As freight demand continues to increase, the absence of harmonised WAP information exchange may become a limiting factor in the industry's ability to maintain network resilience, optimise asset performance and support the growing demands of the national freight task.

4. Current State of Wayside Asset Protection

WAP systems are deployed throughout Australian rail networks to monitor the condition of rolling stock and infrastructure during train operations. These systems provide critical information that supports asset management, maintenance planning, operational assurance and safety management activities.

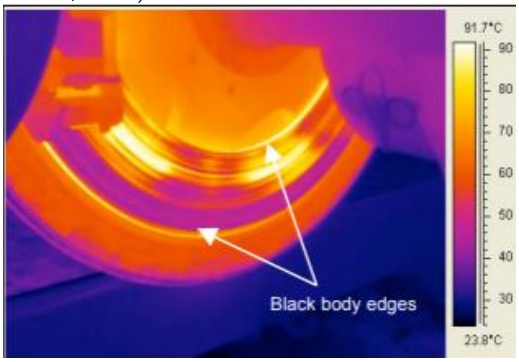
Modern WAP technologies utilise thermal sensing, acoustic monitoring, force measurement, machine vision and advanced analytics to identify developing defects before failures occur. Collectively, these systems provide rail organisations with improved visibility of asset condition and support the transition from reactive maintenance practices towards predictive maintenance approaches (Stewart et al., 2019).

4.1 Classification of Wayside Asset Protection Systems

WAP systems can generally be grouped into the following categories:

- Bearing condition monitoring systems
- Wheel and wheelset condition monitoring systems
- Dragging equipment detection systems
- Machine vision and imaging systems
- Vehicle geometry and performance monitoring systems

Figure 2
Thermal Camera Temperature Plot (Doyle & Fazah, 2012)



While individual technologies vary in capability and application, their common purpose is to identify developing defects and support timely operational intervention.

4.2 Deployment Across Australian Rail Networks

The deployment of WAP systems varies significantly across Australian rail networks. Heavy-haul mining operations, such as those in the Pilbara, typically employ highly advanced, densely deployed WAP systems, reflecting a focus on operational efficiency and risk minimisation in high-throughput environments. These networks often leverage integrated monitoring platforms and real-time data analytics to support autonomous operations.

In contrast, interstate and regional freight networks exhibit more variable levels of WAP deployment, with some corridors relying on legacy detection systems and limited integration with centralised data platforms. This disparity reflects differences in investment priorities, operational requirements, and organisational capabilities.

The lack of consistent deployment and integration across networks contributes to gaps in asset visibility, particularly for rolling stock operating across multiple jurisdictions.

4.3 Current Data Sharing Practices

Current WAP data-sharing practices remain largely organisation-centric. Information generated by monitoring systems is typically retained within proprietary platforms or internal operational systems and is seldom exchanged using standardised governance arrangements.

As a result, condition-monitoring information is often unavailable to stakeholders despite rolling stock routinely operating across multiple rail networks. This limits opportunities for coordinated maintenance planning, shared asset visibility and cross-network condition monitoring.

The issue is no longer the availability of monitoring technology. Rather, it is the absence of common information structures, governance arrangements, and interoperability mechanisms that prevents rail organisations from consistently exchanging and applying WAP information.

5. Problem Definition

Australia has successfully deployed sophisticated wayside monitoring technologies across multiple rail networks. However, the absence of nationally consistent information-sharing arrangements limits the broader value that can be derived from these investments.

While interoperability principles exist for rail systems, signalling and digital engineering, limited nationally aligned guidance currently exists for operational WAP information exchange, common telemetry structures, governance arrangements and vendor conformance requirements. As a result, WAP information remains difficult to exchange, interpret and apply consistently across organisational boundaries.

Therefore, the core problem can be defined as:

The lack of a harmonised, interoperable framework for sharing wayside asset protection data across Australian rail networks limits safety, operational efficiency, and the effective utilisation of digital technologies.

5.1 Industry Evidence

Case Study 1: Minnesota Wayside Detector System Study

An examination of wayside detector deployment found that the effectiveness of condition-monitoring programs is influenced not only by detector technology but also by data governance, information management, and operational integration practices (Minnesota Department of Transportation, 2026). The study identified governance arrangements, notification processes, ownership models and information-sharing mechanisms as critical factors in achieving effective operational outcomes.

The findings reinforce the importance of governance and information-sharing frameworks in maximising the value of wayside monitoring systems.

Case Study 2: Rio Tinto Integrated Asset Health Analytics

Rio Tinto's Pilbara heavy-haul railway implemented an integrated asset-health capability that combined information from multiple condition-monitoring systems into a common digital environment. Operational teams developed asset health analytics using multiple condition indicators, maintenance history and operational context rather than relying on individual detector alarms.

The initiative demonstrated that integrating information from multiple monitoring systems can significantly improve asset visibility and maintenance decision-making. The program improved visibility of developing wheelset and bearing defects and enabled earlier intervention before faults resulted in operational disruption. During the first year of operation, the integrated asset health analytics capability contributed to an approximately 20% reduction in unscheduled loss associated with monitored wheelset and bearing defects.

The case study also highlighted the importance of operational knowledge. While technology vendors provide expertise on individual monitoring systems, rail organisations possess a broader understanding of fleet characteristics, maintenance practices, environmental conditions, and network-specific operating constraints. Consequently, the most effective analytics are often developed by combining interoperable datasets with local operational expertise.

Case Study 3: Industry Cross-Network Defect Visibility

As a train traverses multiple rail networks, a wagon develops a bearing defect. One network records elevated bearing temperature, another identifies wheel impact events, and a third detects vibration anomalies. Without harmonised information exchange, these indicators remain isolated within individual organisations, preventing any single operator from seeing the complete picture of asset condition (Jagan & Zhu, 2016).

This scenario illustrates how fragmented information can limit the industry's ability to identify emerging defects and support coordinated operational and maintenance decision-making across network boundaries.

6. Proposed Solution: Code of Practice for WAP Data Exchange

To address the interoperability challenges identified in the Australian freight rail industry, this report proposes developing a nationally aligned Code of Practice for WAP information exchange.

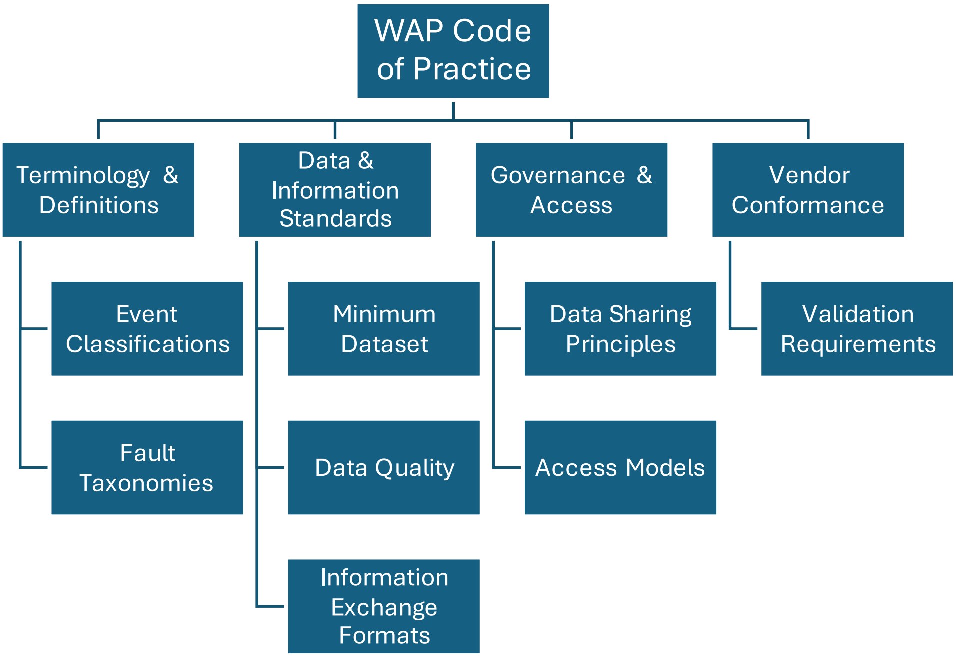
Current ARiSO interoperability guidance demonstrates increasing industry maturity in relation to harmonisation, digital engineering and condition monitoring. Existing standards, guidance and interoperability initiatives provide a strong foundation for this work by establishing principles relating to information management and digital railway capability (see Appendix B: Applicable Standards, Regulations and Guidance). However, the analysis presented in Appendix D: Analysis of Existing Standards identified several gaps relating to the operational exchange, governance and interpretation of WAP information

The objective is not to standardise detector technologies, analytics platforms or maintenance practices. Rather, the Code of Practice would establish a common framework that enables

RIMs and RSOs to exchange, interpret, and utilise WAP information consistently across organisational boundaries.

Analysis of current standards and industry guidance indicates that while interoperability principles are well established, limited guidance currently exists for the exchange, governance and interpretation of WAP information. The proposed scope of the Code of Practice is illustrated in Figure 3 Proposed scope of the WAP Code of Practice.

Figure 3
Proposed scope of the WAP Code of Practice



6.1 Purpose and Scope

The proposed Code of Practice would provide practical, vendor-neutral interoperability guidance focused specifically on operational WAP information exchange. The framework would support consistent information sharing while remaining sufficiently flexible to accommodate differing operational environments, technology strategies and organisational requirements.

The proposed framework would not include:

- Development of a centralised national platform
- Mandated software or vendor technologies
- Prescriptive maintenance practices or operational procedures
- Regulatory reform or mandatory compliance obligations

Implementation of the framework would require participating RIMs and RSOs to establish agreed information-sharing arrangements that define governance responsibilities, access rights, data ownership, confidentiality requirements, and the permitted use of shared information. An indicative governance and responsibility model supporting these arrangements is provided in Appendix C: Indicative Governance and Responsibility Model.

The framework adopts a federated interoperability approach in which participating organisations retain ownership and control of operational data while enabling the governed exchange of agreed datasets through secure interfaces. This approach aligns with international interoperability initiatives such as railML (railML.org, 2026) and the European Union RailSystemModel (RSM) (UIC, n.d.), which demonstrates how common railway data structures can support interoperability between different railway systems without requiring a single national software platform.

By focusing on common information structures rather than common technologies, the proposed framework seeks to improve safety, operational decision-making and future digital railway capability while preserving organisational autonomy and existing technology investments.

7. Minimum Dataset and Data Standardisation Requirements

Effective interoperability requires agreement on common information structures rather than standardisation of individual technologies. Participating organisations should retain flexibility regarding detector selection, analytics platforms and operational processes while adopting information structures that enable consistent interpretation of WAP events.

International research and industry experience indicate that greater value can be realised when information from multiple monitoring sources is integrated and analysed collectively (Minnesota Department of Transportation, 2026).

Accordingly, the proposed minimum interoperable dataset should include the following categories.

Table 1
Proposed minimum interoperable WAP dataset

Dataset Category	Purpose
Detector Event Data	Standardised fault, alarm and event information generated by WAP systems
Rolling Stock Reference Data	Consistent identification of vehicles, wagons and monitored components
Asset Condition Data	Condition measurements, health indicators and defect observations
Operational Context Data	Train service, route and operational environment information
Maintenance and Intervention Data	Inspection findings, maintenance actions and corrective interventions
Event Severity and Risk Data	Common prioritisation, escalation and response classifications
Detector Metadata	Detector location, capability, configuration and operational status
Trend and Analytics Data	Aggregated condition trends and performance indicators

The purpose of this dataset is not to facilitate unrestricted sharing of operational information. Rather, it establishes a minimum information baseline that enables participating organisations to exchange and interpret WAP information consistently while retaining control of operational data through agreed governance and access arrangements.

7.1 Data Quality and Integrity Requirements

The review of railway asset management research identified data quality as a critical factor influencing the effectiveness of condition-monitoring programs (McMahon, 2021).

Consequently, the proposed framework should establish minimum requirements for:

- Data completeness
- Timestamp consistency
- Asset identification standards
- Detector health and availability status
- Missing data management
- Confidence indicators
- Validation and verification requirements

These controls would improve trust in shared information and reduce the risk of inconsistent decision-making due to poor-quality or incomplete datasets.

7.2 Standardisation Requirements

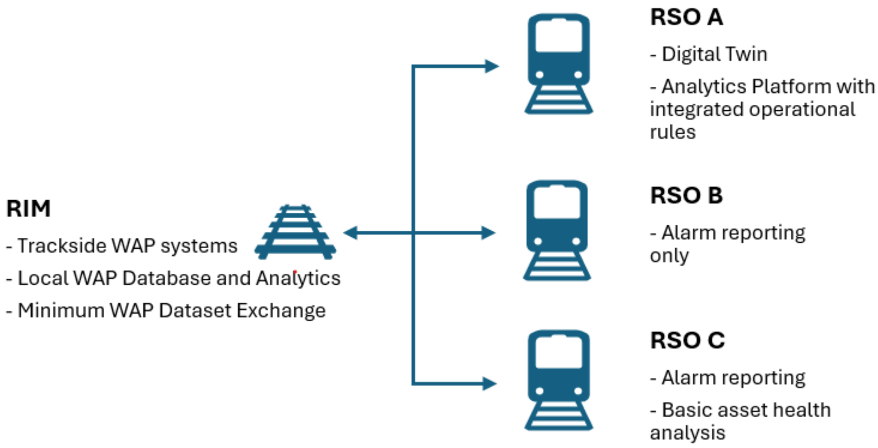
To support interoperability, the Code of Practice should establish common terminology, event classifications, fault taxonomies, severity categories, metadata requirements and information exchange formats.

These requirements would reduce ambiguity and support consistent interpretation of WAP information across participating organisations.

8. Data Sharing Architecture and Access Model

Under a federated interoperability model, operational data remains within the source organisation while agreed datasets are exchanged through governed interfaces and standardised information structures. This approach aligns with modern interoperability principles, supports organisational autonomy, and enables information sharing (Rail Industry Safety and Standards Board, 2021a).

Figure 4
Conceptual federated WAP information-sharing model



The conceptual federated WAP information-sharing model illustrates how WAP information is shared across multiple organisations. Participating RIMs retain ownership of WAP systems and operational data while exchanging a minimum interoperable WAP dataset with participating RSOs. This approach enables organisations to leverage existing technology investments while improving asset visibility and cross-network decision-making.

8.1 Governance and Access Principles

The proposed framework should be founded on principles that preserve organisational ownership of operational information while enabling the controlled exchange of agreed datasets. Access arrangements should support safety and operational objectives, protect commercially sensitive information, maintain compliance with cybersecurity obligations, and provide clear governance for the use and exchange of shared information.

8.2 Vendor Neutrality

The greatest value from WAP systems is often realised through the integration and interpretation of information from multiple monitoring technologies rather than reliance on individual vendor platforms.

While equipment vendors provide specialist expertise on detector technologies, rail organisations possess a broader understanding of fleet characteristics, maintenance practices, environmental conditions and network-specific operating constraints. Consequently, interoperability frameworks should focus on enabling organisations to exchange and interpret information consistently rather than prescribing vendor-specific solutions.

9. Benefits of a Code of Practice

Implementation of a nationally aligned WAP interoperability framework through a Code of Practice would provide significant safety, operational and strategic benefits across the Australian freight rail industry.

9.1 Safety Benefits

A coordinated and harmonised approach to WAP data sharing through a Code of Practice creates several major safety benefits. The core benefit is that all RIMs, RSOs, contractors and control centres are working from consistent, timely and interoperable information about asset status, faults, protections and risks.

It allows RSOs and RIMs to detect and respond to asset faults more consistently and faster by providing real-time asset condition and status. If multiple WAP systems use aligned formats, common terminologies, and thresholds, a deteriorating asset trend could be detected.

A Code of Practice to harmonise WAP data sharing will improve the ability to identify unsafe rolling stock conditions, infrastructure defects and emerging risks before they lead to incidents or derailments. This will aid consistent compliance and assurance, enabling the Office of the National Rail Safety Regulator (ONRSR) and RSOs to more easily verify that safety controls are functioning as intended.

9.2 Operational Benefits

Interoperable information supports a transition from reactive maintenance towards condition-based and predictive maintenance approaches.

Benefits include:

- Improved maintenance planning
- Reduced unnecessary inspections
- Earlier identification of emerging defects
- Reduced operational disruption
- Improved asset availability
- Enhanced maintenance decision-making

The Rio Tinto Integrated Asset Health Analytics case study demonstrated that integrating information from multiple condition-monitoring sources can improve defect visibility and support earlier intervention before operational impacts occur.

9.3 Strategic Value

At an industry level, interoperable WAP information supports broader digital railway objectives by enabling:

- Improved asset visibility
- Enhanced interoperability
- Greater network resilience
- Improved collaboration between RIMs and RSOs
- More effective use of condition-monitoring technologies

More broadly, WAP systems help protect rail infrastructure by identifying rolling stock defects before they cause service disruptions. Improving the exchange of WAP information, therefore, supports both rolling stock reliability and the protection of critical rail infrastructure assets.

While recent National Transport Commission (NTC) interoperability initiatives have focused on digital train control technologies and signalling systems (National Transport Commission, 2025a), the proposed Code of Practice extends similar interoperability principles to the operational exchange and interpretation of WAP information. Together, these initiatives support a more connected and digitally enabled national rail network.

9.4 Interoperability Benefits

A coordinated national approach to information structures, as set out in a Code of Practice, means that monitoring systems can communicate with each other, RSOs avoid having to invest in and mount varying and duplicated onboard and trackside systems, and data can be interpreted consistently nationwide.

Further, when wayside systems share data in common formats and through secure exchange mechanisms, alarms can be transmitted between organisations, trains can be managed consistently during incidents, disruptions can be resolved more quickly, and recovery coordination improves during emergencies.

9.5 Future Readiness and Innovation

Harmonised data and information sharing result in large, high-quality, and interoperable datasets. This supports the future rail industry, which, as mentioned previously, will increasingly rely on digital twins, remote operations, AI-driven diagnostics and autonomous decision support. Harmonised wayside data creates the foundation for machine learning at a national scale, cross-network predictive analytics, and automated risk prioritisation.

ARTC’s wayside strategy specifically identified the growing importance of condition-monitoring systems and the need for improved information sharing to support modern maintenance regimes (Jagan & Zhu, 2016).

Furthermore, the WAY4SAFERAIL project demonstrated how AI-enabled monitoring systems can improve defect identification, classification, and operational decision-making through advanced analysis of wayside monitoring data (Vale et al., 2023).

A nationally aligned interoperability framework would provide a foundation for future industry-wide innovation by enabling larger and more consistent datasets to be utilised across organisational boundaries.

10. Barriers to Adoption

Despite the potential benefits of harmonised WAP information exchange, several barriers continue to limit industry-wide adoption across the Australian rail sector.

10.1 Governance and Regulatory Barriers

A fundamental barrier to harmonised WAP information exchange is the fragmented structure of the Australian rail industry. Multiple RIMs, RSOs, state-based networks and private heavy-haul railways operate under differing governance arrangements, asset ownership models and operational requirements (Office of the National Rail Safety Regulator, 2026a).

While recent interoperability reforms and Interoperability Management Plan (IMP) requirements have strengthened national coordination, existing regulatory frameworks remain largely principles-based rather than prescriptive. Current requirements encourage consideration of the impacts of interoperability but do not mandate standardised WAP data models, information-sharing arrangements, or governance frameworks (Office of the National Rail Safety Regulator, 2026b).

Similar challenges have been identified in other areas of the Australian rail industry. Recent NTC analysis of rolling stock approval processes found significant variation in information requirements between networks, limited mutual recognition of assurance activities and inconsistent approaches to information sharing, highlighting broader barriers to national harmonisation and interoperability (National Transport Commission, 2025c).

Legal accountability under the Rail Safety National Law (RSNL) also encourages operators to rely primarily on internally generated safety evidence, limiting the willingness to utilise externally generated information for safety-critical operational decisions.

10.2 Technical Interoperability Challenges

Vendors frequently supply proprietary systems with unique algorithms, confidence metrics, and data schemas, resulting in inconsistent interoperability across networks.

These challenges are compounded by legacy infrastructure, varying levels of digital maturity and differing operational requirements across networks. Inconsistent alarm thresholds, defect classifications and local operating rules can reduce confidence in shared information, limit the effectiveness of cross-network analytics and automated decision-support systems (Stewart et al., 2019).

10.3 Cybersecurity

Rail infrastructure is classified as Critical Infrastructure under the Security of Critical Infrastructure (SOCI) Act, creating additional cybersecurity obligations for operational systems, information assets, and third-party access arrangements. Consequently, organisations often adopt conservative approaches to operational technology integration and real-time data exchange, particularly where external access to operational systems is involved (Patwardhan et al., 2022).

While cybersecurity considerations present a legitimate barrier to interoperability, they do not preclude information sharing. Rather, they reinforce the need for secure governance arrangements, controlled-access models and federated interoperability architectures that enable the exchange of agreed datasets without exposing critical operational systems.

10.4 Commercial Sensitivity and Competitive Pressures

Commercial sensitivity presents a significant barrier to interoperable WAP data sharing, particularly within the freight rail sector. Condition-monitoring information may reveal trends in rolling stock condition, maintenance effectiveness, asset degradation rates, operational performance, and infrastructure vulnerabilities. Consequently, both RIMs and RSOs may be reluctant to share operational data beyond their immediate business requirements (Office of the National Rail Safety Regulator, 2026a).

Concerns about data ownership, confidentiality, regulatory scrutiny, and competitive positioning can further reduce the willingness to participate in collaborative information-sharing initiatives. Without clearly defined governance arrangements, usage limitations and confidentiality protections, organisations may perceive broad data-sharing arrangements as commercially risky.

10.5 Organisational Capability and Cultural Barriers

Digital maturity varies significantly across the Australian rail sector. While some organisations employ advanced condition-monitoring systems, predictive analytics, and integrated digital platforms, others continue to rely on legacy systems with limited interoperability. Smaller operators may also lack the technical resources or analytics capability required to effectively utilise harmonised WAP datasets, limiting the perceived value of information-sharing initiatives (Office of the National Rail Safety Regulator, 2021).

Cultural factors remain equally significant. Historically, Australian rail has evolved as a highly decentralised industry characterised by strong local operational control and network-specific practices. This has contributed to limited trust in external information sources and a preference for localised decision-making.

The NTC have highlighted the risk of a future “digital break of rail gauge” (National Transport Commission, 2025a, p. 5) if interoperability and harmonisation challenges are not addressed. Consequently, achieving interoperability will require organisational and cultural change in addition to technical solutions.

10.6 Implementation and Transition Challenges

There is a broad industry perception that the transition toward harmonised WAP data sharing will require substantial investment in digital infrastructure, system integration, governance frameworks, staff capability development, and interoperability assurance (Rail Industry Safety and Standards Board, 2021a).

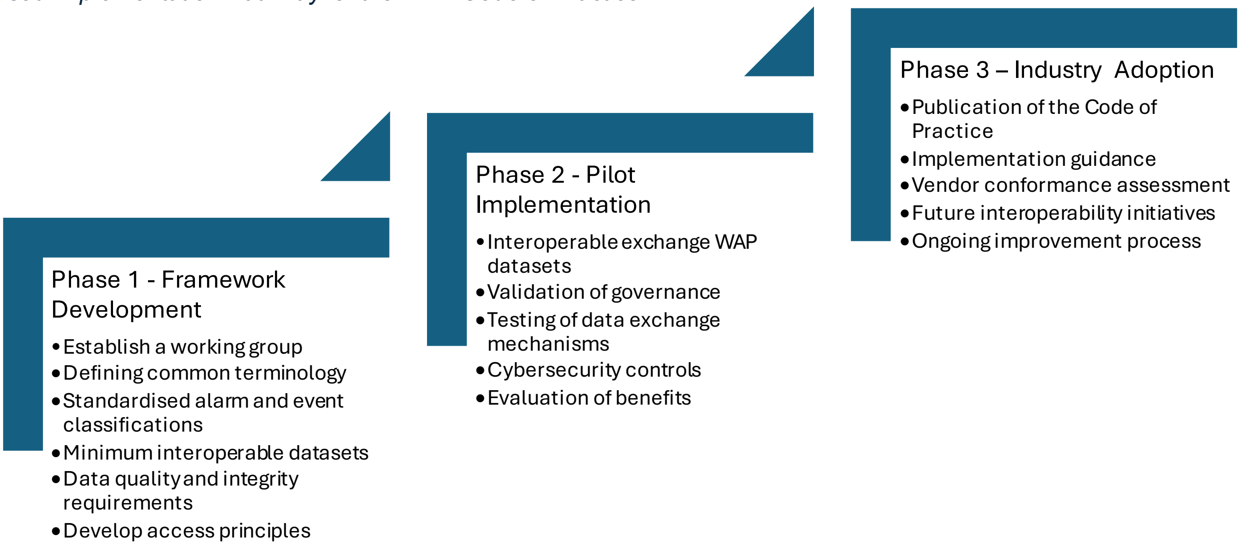
Implementation complexity is increased by the need to coordinate multiple RIMs and RSOs operating across different technical environments, operational procedures and asset management systems. While interoperability reforms are gaining momentum, harmonised WAP information exchange remains in its early stages of maturity across the Australian rail sector (Office of the National Rail Safety Regulator, 2021).

Consequently, industry-wide adoption is likely to require a phased implementation approach that balances technical, operational and governance considerations while aligning with existing business priorities and technology roadmaps.

11. Implementation Pathway

Successful implementation of a WAP interoperability framework will require a staged and collaborative approach involving RIMs, RSOs, regulators, standards bodies and technology providers. A phased implementation pathway is recommended to minimise disruption, leverage existing investments and progressively build industry capability.

Figure 5
Phased Implementation Pathway for the WAP Code of Practice



11.1 Phase 1 – Framework Development

The initial phase focuses on establishing the governance, terminology, data standards and interoperability requirements necessary to support consistent WAP information exchange.

11.2 Phase 2 – Pilot Implementation

Pilot projects between selected RIMs and RSOs should validate information-exchange mechanisms, governance arrangements, and cybersecurity controls while demonstrating operational benefits.

11.3 Phase 3 – Industry Adoption

The final phase focuses on broader industry adoption through publication of the Code of Practice, supporting implementation guidance, vendor conformance arrangements and ongoing governance processes.

This staged approach supports progressive adoption while allowing organisations to align implementation activities with existing operational and technology roadmaps.

12. Conclusion

The Australian rail industry has invested significantly in wayside monitoring technologies that support safer and more reliable railway operations. However, the review conducted as part of this study found that the industry's primary challenge is no longer the deployment of detector technologies. Rather, it is the absence of common information structures, governance arrangements, and interoperability mechanisms that prevents information generated by those systems from being consistently exchanged and utilised across organisational boundaries.

Analysis of Australian standards, interoperability frameworks, and industry guidance demonstrated that substantial foundations already exist for rail systems interoperability, digital engineering, and condition monitoring. Currently, limited guidance exists on operational WAP information-exchange arrangements between RIMs and RSOs.

International research and industry case studies further demonstrated that the greatest value from wayside monitoring systems is achieved through the integration, interpretation and application of information rather than the deployment of individual detector technologies alone. Effective governance, information quality and operational integration are critical enablers of improved safety and operational outcomes (Minnesota Department of Transportation, 2026).

Accordingly, this report proposes developing a nationally aligned Code of Practice for WAP data exchange based on a federated interoperability model. The proposed framework focuses on common terminology, standardised event classifications, minimum interoperable datasets, governance arrangements and vendor-neutral interoperability principles.

Implementation of the proposed framework would improve asset visibility, strengthen predictive maintenance capabilities, support future digital railway initiatives, and enhance safety, reliability, and operational performance across the Australian rail industry.

12.1 Recommendations

Based on the findings of this study, the following recommendations are proposed.

Recommendation 1 – Develop a National WAP Code of Practice

ARiSO should collaboratively develop a nationally aligned Code of Practice for interoperable WAP information exchange.

The Code of Practice should define:

- Common terminology and operational definitions
- Standardised alarm and event classifications
- Minimum interoperable datasets
- Governance and access principles
- Vendor conformance requirements

Recommendation 2 – Establish a Minimum Interoperable Dataset

The industry should adopt a minimum interoperable dataset that enables consistent interpretation of WAP information while allowing organisations to retain flexibility regarding internal systems and operational processes.

Recommendation 3 – Adopt a Federated Information Exchange Model

The industry should adopt a federated interoperability model that allows participating organisations to retain ownership of operational information while enabling secure, governed information exchange.

Recommendation 4 – Develop Data Quality and Integrity Requirements

Future interoperability initiatives should incorporate minimum requirements for data quality, completeness, validation, and confidence reporting to ensure that shared information can be trusted and effectively utilised.

Recommendation 5 – Establish Pilot Interoperability Program

A pilot program should be undertaken to validate technical, operational and governance arrangements before broader industry adoption.

Recommendation 6 – Support Future Analytics and AI Applications

The framework should be designed to support future digital railway initiatives, including advanced analytics, digital twins, and machine learning applications that rely on access to consistent, structured operational datasets.

13. AI Acknowledgement

We acknowledge the use of Artificial Intelligence (AI) tools, including GPT-4, during the preparation of this report. AI was used to support the consolidation of ideas, summarisation of research papers, grammar and spelling checks, and the generation of conceptual visual materials, including the report cover image. All AI-assisted outputs were critically reviewed, validated and edited by the authors.

We confirm that the final submission reflects our own analysis, interpretation and understanding of the subject matter, complies with applicable guidelines on AI use, and that we take full responsibility for the accuracy and content of this report.

14. References

Department of Infrastructure, Transport, Regional Development, Communications, Sport and the Arts. (2025a). *National freight and supply chain strategy 2025.* Retrieved from Commonwealth of Australia: https://www.freightaustralia.gov.au/sites/default/files/documents/national-freight-supply-chain-strategy-2025.pdf

Department of Infrastructure, Transport, Regional Development, Communications, Sport and the Arts. (2025b). *Freight*. Retrieved from Australian Government: https://www.bitre.gov.au/sites/default/files/documents/bitre-yearbook-2025.pdf

Doyle, S., & Fazah, I. (2012). Engineering an Advanced Bearing and Brake Temperature (BBT) Wayside System at RailCorp. *CORE 2012: Global Perspectives; Conference on railway engineering*, (pp. 31-42). Brisbane, Australia. Retrieved from https://search.informit.org/doi/abs/10.3316/informit.892974756317326

Future Systems. (n.d.). HABD & HWD. Retrieved from https://www.futuresystem.co.kr/home/solutions/hot-axle-box-hot-wheel-detector/

Jagan, D., & Zhu, Y. (2016). Long Term Strategy for Wayside Systems - ARTC. *CORE2016.* Melbourne. Retrieved from https://www.rtsa.com.au/wp-content/uploads/2025/02/LONG-TERM-STRATEGY-FOR-WAYSIDE-SYSTEMS-ARTC.pdf

McMahon, P. (2021). Development of missing data imputation models for railway asset management systems. University of Wollongong. Retrieved from https://ro.uow.edu.au/articles/thesis/Development_of_Missing_Data_Imputation_Models_for_Railway_Asset_Management_Systems/27669060

Minnesota Department of Transportation. (2026). *Minnesota wayside detector system study.* Retrieved from https://www.lrl.mn.gov/docs/2026/mandated/260603.pdf

National Transport Commission. (2025a). *Digital train control technology interoperability requirements assessment.* Retrieved from https://www.ntc.gov.au/sites/default/files/assets/files/NTC%20Discussion%20paper%20-%20Digital%20Train%20Control%20Technology%20Interoperability%20Requirements%20Assessment.pdf

National Transport Commission. (2025b). *National Rail Action Plan - Program overview.* Retrieved from https://www.ntc.gov.au/sites/default/files/assets/files/National-Rail-Action-Plan.pdf

National Transport Commission. (2025c, May). *Streamlining rolling stock approval processes.* Retrieved from https://www.ntc.gov.au/sites/default/files/assets/files/NTC%20Consultation%20Paper%20%20-%20Streamlining%20rolling%20stock%20approval%20processes.pdf

Office of the National Rail Safety Regulator. (2021). *National Rail Safety Data Strategy - Consultation Paper .* Retrieved from nraspricms01.blob.core.windows.net/assets/documents/News/Consultation-paper-National-Rail-Safety-DataStrategy.pdf

Office of the National Rail Safety Regulator. (2026a). *ONRSR Guideline - Interoperability of Railway Operations.* Retrieved from https://nraspricms01.blob.core.windows.net/assets/documents/Guideline/ONRSR-Guideline-Interoperability-of-railway-operations.pdf

Office of the National Rail Safety Regulator. (2026b). *National Network for Interoperability*. Retrieved from https://www.onrsr.com.au/publications/national-network-for-interoperability

Patwardhan, A., Thaduri, A., & Karim, R. (2022). Cybersecurity and critical infrastructure protection in railways: Challenges and opportunities for distributed ledger technologies. *Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit, 237*(4), 421-435. https://doi.org/10.1177/09544097221089389

Rail Industry Safety and Standards Board. (2021a). *AS 7450 Rail systems interoperability.* Retrieved from https://www.ariso.org.au/products/as-74502021-rail-systems-interoperability/

Rail Industry Safety and Standards Board. (2021b). *Train protection and control interoperability.* Retrieved from https://www.ariso.org.au/products/as-7666-train-protection-and-control-interoperability-2/

Rail Industry Safety and Standards Board. (2022). *Guideline - Condition Monitoring of Rolling Stock.* Retrieved from https://www.ariso.org.au/products/guideline-condition-monitoring-of-rolling-stock/

Rail Industry Safety and Standards Board. (2023). *AS 7739 Digital engineering for fixed rail infrastructure.* Retrieved from https://www.ariso.org.au/products/as_7739-1-digital-engineering/

railML.org. (2026). *About railML*. Retrieved from https://www.railml.org/en/about-railml

Stewart, M. F., Marquis, B., & Sharma & Associates. (2019). *An implementation guide for wayside detector systems.* United States Department of Transportation, Federal Railroad Administration. Retrieved from https://rosap.ntl.bts.gov/view/dot/40392

UIC. (n.d.). *RailSystemModel*. Retrieved from https://rsm.uic.org/

Vale, C., Ribeiro, D., Mosleh, A., Montenegro, P., Meixedo, A., Marreiros, G., . . . Lourenço, A. (2023). Wayside monitoring system for safe rail transportation – The WAY4SAFERAIL project. *CORE2023.* Retrieved from https://www.rtsa.com.au/wp-content/uploads/2025/02/WAYSIDE-MONITORING-SYSTEM-FOR-SAFE-RAIL.pdf

15. Appendices

Appendix A: Acronyms

Table 2
Acronyms

Acronym	Definition
ABD	Acoustic Bearing Detector
AI	Artificial Intelligence
API	Application Programming Interface
ARiSO	Australasian Railway Industry Standards Organisation
ARA	Australasian Railway Association
AS	Australian Standard
DED	Dragging Equipment Detector
FRA	Federal Railroad Administration
HBD	Hot Bearing Detector
HWD	Hot Wheel Detector
IMP	Interoperability Management Plan
NTC	National Transport Commission
ONRSR	Office of the National Rail Safety Regulator
RACI	Responsible, Accountable, Consulted, Informed
RiSSB	Rail Industry Safety and Standards Board
RSNL	Rail Safety National Law
RSO	Rolling Stock Operator
SOCI	Security of Critical Infrastructure
WAP	Wayside Asset Protection
WILD	Wheel Impact Load Detector
WAY4SAFERAIL	WAY4SAFERAIL

Appendix B: Applicable Standards, Regulations and Guidance

The following standards, guidelines and industry publications were reviewed as part of this study to assess the current state of interoperability, digital engineering and WAP practices within the Australian rail industry.

Table 3

Applicable Standards, Regulations and Guidance

Document	Year	Primary Focus	Relevance to this Study
AS 7450 Rail Systems Interoperability	2021	Establishes principles and governance for interoperability across Australian rail systems	Provides the foundational interoperability principles supporting the proposed WAP interoperability framework
AS 7666 Train Protection and Control Interoperability	2021	Framework for managing interoperability impacts associated with train protection and control systems	Demonstrates existing industry approaches to interoperability within safety-critical railway systems
Rail Systems Interoperability Guideline (RiSSB/ARiSO)	2022	High-level guidance supporting interoperability planning, governance and implementation	Supports industry harmonisation and collaborative interoperability objectives
AS 7739.1 Digital Engineering for Fixed Rail Infrastructure	2023	Establishes digital engineering concepts, structured datasets, metadata and lifecycle information management	Provides guidance relating to semantic interoperability, data structures and digital information management
RiSSB Condition Monitoring of Rolling Stock Guideline	2022	Guidance on wayside monitoring technologies, analytics, alarms, metadata and condition-monitoring practices	Provides the strongest existing alignment with WAP systems and condition-monitoring information management
ONRSR Interoperability of Railway Operations Guideline	2026	Guidance relating to interoperability obligations under the Rail Safety National Law	Supports consideration of operational interoperability and regulatory responsibilities

Appendix C: Indicative Governance and Responsibility Model

The successful implementation of a nationally aligned WAP interoperability framework will require collaboration between RIMs, RSOs, industry bodies, regulators and technology providers. The table below provides a high-level indicative governance model for key activities associated with the proposed Code of Practice.

Table 4
Indicative Governance and Responsibility Model

Activity	RIM	RSO	ARiSO	ONRSR	Vendor
Develop WAP Code of Practice	C	C	A/R	C	C
Define common terminology and operational definitions	C	C	A/R	I	C
Establish standardised event classifications	C	C	A/R	I	C
Define the minimum interoperable dataset	C	C	A/R	I	C
Establish governance and access principles	C	C	A/R	C	I
Implement interoperability interfaces	A/R	A/R	C	I	R
Maintain data quality requirements	A/R	A/R	C	I	C
Validate vendor conformance requirements	C	C	A/R	I	R
Conduct interoperability pilot programs	A/R	A/R	C	I	C
Review and update the Code of Practice	C	C	A/R	C	I
Regulatory oversight and guidance	I	I	C	A/R	I

Appendix D: Analysis of Existing Standards

Table 5

Existing Industry Guidance and Proposed WAP Interoperability Enhancements

RiSSB / ARiSO Document	Year	Primary Focus	Relevance to Horizons 7 Project	Gap Identified from Current State	Proposed Scope Contribution
AS 7450 Rail Systems Interoperability	2021	Establishes principles for interoperability across rail infrastructure, rolling stock, signalling, communications, and operations	Demonstrates that the Australian rail industry already recognises interoperability as a national issue	Does not define operational WAP telemetry exchange, metadata structures, event schemas, or cross-network condition monitoring interoperability	Define interoperable WAP operational data structures and exchange principles between RIMs and RSOs
AS 7666 Train Protection and Control Interoperability	2022	Framework for managing interoperability impacts associated with train protection and control systems	Shows existing interoperability focus within safety-critical railway systems	Focused on train control systems rather than operational condition monitoring and WAP telemetry interoperability	Develop standardised WAP event models, telemetry exchange structures, and interoperability guidance
Rail Systems Interoperability Guideline (RiSSB/ARiSO)	2022	Provides high-level interoperability guidance, migration principles, and collaborative planning approaches	Supports industry harmonisation and collaborative interoperability objectives	Remains high-level and principles-based with limited operational guidance for WAP data exchange or governance	Develop practical governance and interoperability guidance for WAP data exchange between rail organisations
AS 7739.1 Digital Engineering for Fixed Rail Infrastructure	2022	Establishes digital engineering concepts, including structured datasets, metadata, semantic interoperability, and lifecycle information management	Demonstrates industry movement toward harmonised digital data environments	Primarily focused on infrastructure/project digital engineering rather than operational WAP telemetry and analytics interoperability	Extend harmonised digital engineering concepts into operational WAP telemetry and analytics environments
RiSSB Condition Monitoring of Rolling Stock Guideline	2022	Provides industry guidance for wayside condition monitoring technologies, metadata, analytics, alarms, alerts, and data management	Strongly aligns with the Horizons project by recognising common data standards, metadata consistency, multi-network data integration, and analytics requirements for WAP systems	Informational and technology-focused guideline only; does not establish nationally harmonised WAP interoperability governance, operational taxonomies, standardised exchange schemas, access models, or vendor conformance requirements	Develop nationally aligned interoperable WAP terminology, metadata structures, event classifications, telemetry exchange principles, and governance models