ARAIL

Augmented Reality Transforming Australian Rail

The Orient Express

RISSB Horizons 6

The Orient Express

TABLE OF CONTENTS

1 INTRODUCTION

As the population in Australia's major cities continue to grow, there is a pressing need to enhance public transportation; ensuring efficient community mobility, bolstering community safety, and nurturing a sustainable future for the nation. To achieve this, the Australian rail industry is required to evolve its practices through innovative solutions and the integration of cutting-edge digital technologies. One such technology is the use of augmented reality (AR), which can have a variety of applications within rail. This report aims to explore one of these applications: the use of AR for rolling stock maintenance.

The Australian rail sector faces persistent challenges in maintaining ageing assets while meeting escalating demands for efficiency, safety, and sustainability. Traditional maintenance methods often prove costly, time-consuming, and prone to human error. Moreover, the imperative to minimise downtime and maximise asset utilisation underscores the urgency for innovative solutions.

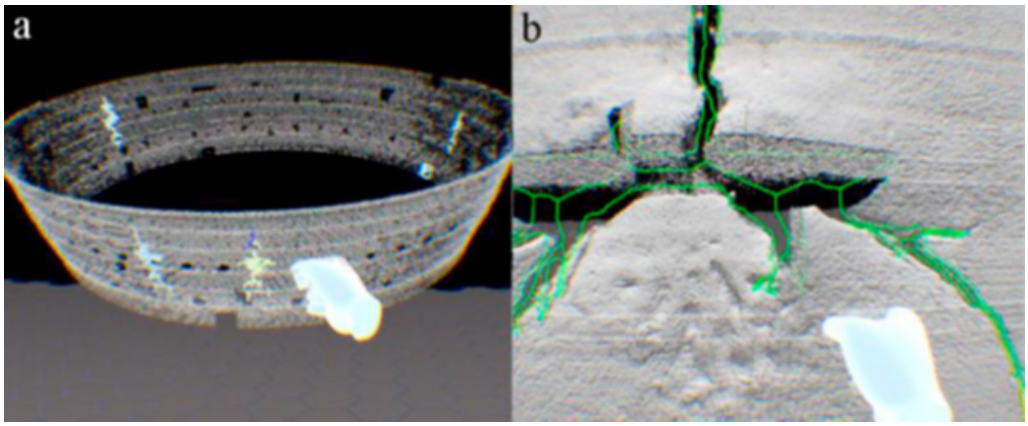
This report aims to analyse and provide an overview of a proposed AR solution for rolling stock maintenance. Implementation of AR technology in rolling stock maintenance promises significant benefits across the Australian rail sector. There are also opportunities for this technology to apply to other areas of rail including, but not limited to: other areas of maintenance, front-line operations, training and assessment, and inventory management.

1.1 AR CASE STUDIES ACROSS INDUSTRIES

AR has been widely adopted in various industries to enhance efficiency, streamline operations, and mitigate safety risks. Given its success elsewhere, AR holds significant promise for revolutionising rail maintenance, offering innovative solutions to improve operational practices and safety.

The aviation industry, closely related to rail in terms of safety-critical operations, has successfully integrated AR into several maintenance processes. For instance, AR is employed in the virtual inspection of aircraft engines, where automated crack detection systems digitise the entire surface of engine components, creating high-resolution 3D point clouds (see Figure 1). These point clouds enable precise automatic crack detection, and technicians can manipulate the data by scaling or changing the perspective to differentiate cracks from other surface imperfections, ensuring a more accurate assessment.

Figure 1. Aircraft engine visualisation (a) and crack area (b)



1.2 SOLUTION PROPOSAL

The proposed solution advocates for the integration of AR technology into rolling stock maintenance practices through a dedicated mobile/tablet application (app). AR will allow an overlaying digital information onto the physical rolling stock parts, facilitating real-time guidance and visualisation. There are several key benefits to rail operators to harnessing AR technology.

Figure 3. Key Benefits of the Proposed AR Solution

Maintenance Efficiency
The integration of AR into rail maintenance offers substantial improvements in efficiency and performance. With an AR-integrated app, maintenance personnel can access expert guidance, relevant documentation, and support in real time, regardless of their geographical location. This enables them to complete their tasks more efficiently, reducing the time rolling stock is out of service for maintenance. Additionally, the increased accuracy of maintenance procedures, guided by AR, ensures that all prescribed protocols are followed precisely, leading to greater reliability of rolling stock, greater safety outcomes, and a reduction in the need for emergency repairs.

The AR solution will also allow skilled maintenance staff to focus on higher-value tasks rather than being diverted to training duties. The technology can facilitate on-the-job learning for both new and experienced maintainers making it easier to incorporate new compliance requirements or updates to rolling stock models into daily operations. This seamless integration ensures that maintenance teams remain up-to-date and effective, further enhancing the overall reliability and efficiency of the rail system.

Cost Savings & Sustainability
The proposed AR solution will drive significant cost savings and enhance sustainability in rail maintenance through maintenance efficiencies. By minimising the time and frequency of maintenance activities, resource consumption is reduced (including energy and materials).

The solution's data logging capabilities will provide accurate insights into parts usage and maintenance needs, enabling better inventory and procurement lifecycle management. This reduces the risk of overstocking or understocking, minimising excess production and the environmental impact of surplus parts.

Additionally, predictive and condition-based maintenance models enabled by AI prevent emergency repairs and unscheduled maintenance by predicting failures before they occur. This proactive approach reduces the environmental consequences of sudden equipment failures (such as hazardous spills or emissions) and ensures components are replaced only when necessary, extending the life cycle of rolling stock parts and reducing waste.

Data Logging
With the solution's robust data logging capability, every maintenance action can be systematically logged into the system, creating a comprehensive digital record of all activities. This detailed documentation not only ensures accountability but also empowers informed decision-making across the organisation. Maintenance managers can use this data to assess the effectiveness of current practices, refine maintenance schedules, and make strategic decisions about resource allocation. The ability to access historical maintenance data also supports compliance with regulatory requirements and enhances the overall reliability of the rail system.

The continuous data capture is also crucial for the development of the app's predictive maintenance models by providing a rich dataset that can be analysed to identify patterns and trends. By understanding the conditions that lead to equipment failures or the need for repairs, the system can predict potential issues before they arise, enabling proactive maintenance. This predictive approach minimises unexpected breakdowns, reduces downtime, and optimises the use of resources.

Enhanced Safety
The AR solution significantly enhances safety for workers by providing real-time contextual hazard alerts, and identifying potential dangers in the environment (such as live wires, moving machinery, or areas with high temperatures). By overlaying these alerts directly onto the worker's field of view, AR enables them to take immediate and appropriate precautions, reducing the risk of accidents. Additionally, AR offers step-by-step procedural guidance, ensuring that maintenance tasks are performed correctly and safely, further mitigating the potential for errors or unsafe practices.

Customer safety is also improved through the solution's ability to issue compliance check reminders, such as emergency door release checks, allowing for the early detection and resolution of potential faults before they impact operations. This proactive approach helps maintain the integrity of safety-critical systems, contributing to a safer travel experience for passengers.

Moreover, the AR system's data logging capability plays a crucial role in upholding safety standards. By meticulously documenting all maintenance activities, the solution provides a comprehensive record that can be used for audits and reviews. This data ensures compliance with safety regulations and helps identify areas where safety protocols can be further improved.

2 CURRENT STATE

To evaluate the potential benefits of implementing an AR solution in rolling stock maintenance, we conducted an assessment of the current state of door maintenance across two different fleets: one intercity fleet and one urban fleet. The fleets selected are to provide a broad use case for the solution, given their different operational windows and maintenance demands.

Our analysis focused on door failure data as the pilot project for the solution will specifically be tailored to rolling stock door maintenance, with the potential to expand to further maintenance areas.

Figure 4. Door Faults Over a Year

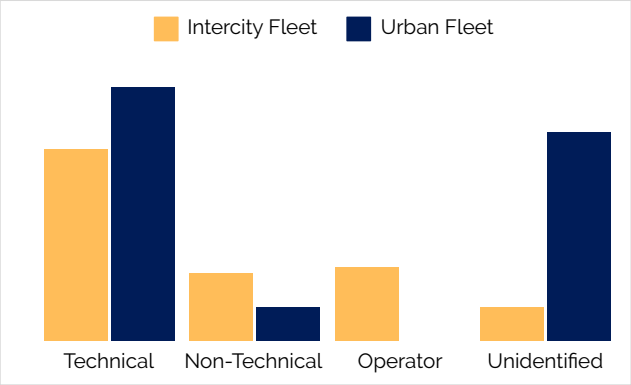
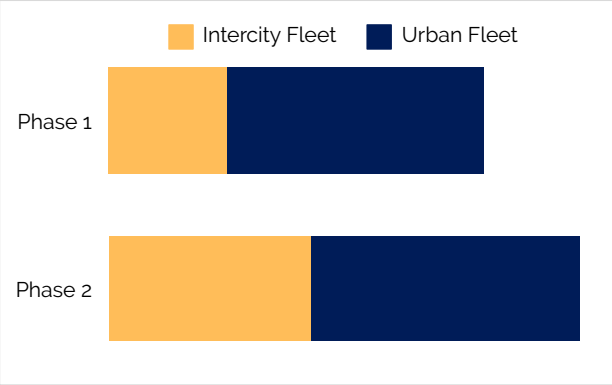


Figure 5. Potential Savings with AR Solution



The data in Figure 4 revealed a range of door faults which were categorised into technical, non-technical, operator and unidentified faults. The data was procured for a period of a year and revealed that a large number of technical and non-technical faults that could be addressed with the AR solution. There would also be potential savings to the unidentified faults as the app would be able to diagnose them using its AI features. Figure 5 synthesises the fault data for both fleets and the potential savings for each. This is depicted in two separate phases that the proposed solution will be executed in; Phase 1 includes the AR overlay and app development, and Phase 2 which includes AI integration.

Overall, the current state assessment underscores the potential for substantial efficiency gains and cost reductions through the deployment of an AR solution in rolling stock door maintenance, with a pilot project offering a promising first step toward broader adoption.

2.1 IMPACT ASSESSMENT

An impact assessment has been conducted in Table 2 below to consider any consequences to the implementation of the AR app solution. A rating scale of 0 to 6 was used to consider the risk levels. Table 1 provides example definitions of each impact level for operations, with 0 being no risk of impact and 6 being catastrophic impact.

The impact assessment conducted in Table 2, indicates a relatively low risk to the implementation of the proposed AR app, with the largest risk being the impact to a number of business stakeholders. This risk can be managed through adequate stakeholder management and communication plans throughout project implementation.

Table 1. Impact Level Definitions - Operations

Impact Levels						
0	1	2	3	4	5	6
No risk of impact on operational readiness	Low impact <24hr disrumption to train traffic - single line	Minor impact <72hr disruption to train traffic - single line	Moderate impact <120hr disruption to train traffic - single line <48hr disruption to train traffic - mainline	Significant impact >336hr disruption to train traffic - single line <72hr disruption to train traffic - mainline	Major impact <720hr disruption to train traffic - single line <120hr disruption to train traffic - mainline	Catastrophic impact Undefinable disruption to train traffic - single line <720hr disruption to train traffic - mainline

Table 2. Impact Assessment of AR App

Impact Category	Rating	Commentary/Justification
Business	3	Metrics can be developed by analysing actual hours taken to train maintenance personnel prior to integrating AR and comparing to this over time as the product is rolled out. Utilising more modern technologies could lead to disinterested personnel.
Operations	1	Application tool will be used mostly in depot environment when rollingstock assets are in planned maintenance or are already out of service due to a fault. Minor impact to operations and would be in line with existing maintenance practices.
Management Effort & Governance	3	Reasonable level of interaction within the company's current planned maintenance systems.
Scope of Impact	5	Many impacted stakeholders including maintenance staff, project managers, workshop supervisors, IT department, training, procurement teams, safety reps, quality assurance, engineers and relevant external stakeholders.
Change Fatigue Impacts	5	Software product rollout often causes change fatigue amongst employees. Utilising more modern technologies could lead to disinterested personnel
Financial	3	Risk that implementation of application goes over budget with little end product.
Health & Safety	2	There is some risk due to inaccurate procedures due to worksite and organisation differences. There may be insufficient facilities/resources to roll out product.
Environmental	2	Inaccurate procedures regarding worksites, differences across multiple companies.
Community	2	Due to initial inaccuracies in the product roll out stakeholders become dissatisfied.

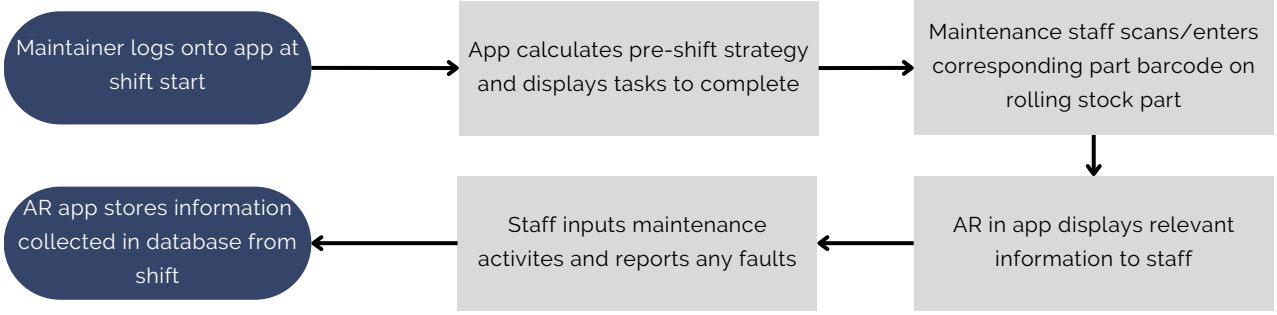
For detailed impact assessment, see Appendix 1.

3 SYSTEM DESIGN

The pilot project for this app solution will target rolling stock door maintenance, aimed at improving day to-day maintenance processes. Each maintainer will have one device with this software which they will log on to at the start of their shift. With the maintenance cloud database within the app, a pre-shift strategy will be calculated. This will provide the maintainer instruction on which jobs to undertake for their shift.

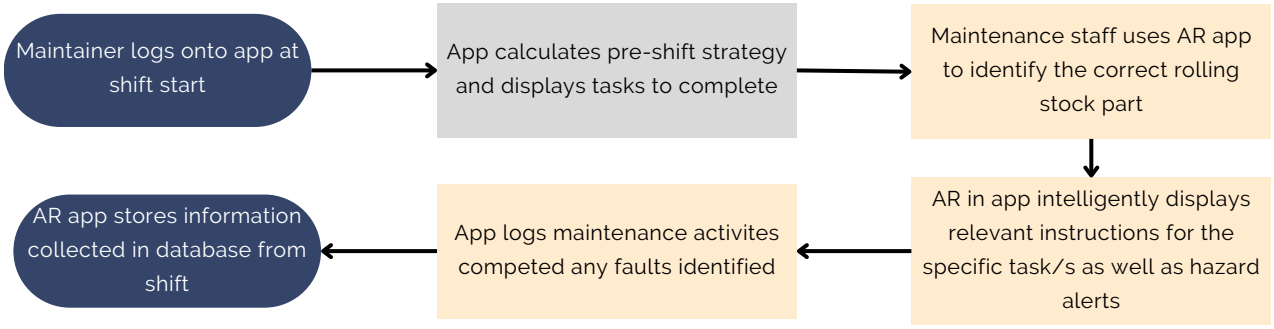
In **Phase 1 - AR App**, to complete tasks, personnel can scan existing barcodes located on a rolling stock part with the device's camera. In this view, relevant information pops up on screen via AR to assist maintainers with maintenance history, procedures, tools required, drawings and potential hazard warnings. As staff completes maintenance tasks, they input their activity and any faults identified within the app. This data will then feed back into the app's database to be used for the future pre-shift maintenance strategies. This process is illustrated in Figure 6.

Figure 6. Maintenance Process with App Solution - Phase 1



In **Phase 2 - AI Integration**, to complete tasks, personnel can point the device's camera at rolling stock parts and the app will highlight the location of the relevant part to be operated on. In this view, the app will scan the condition of the asset and synthesise this with the asset component data and its maintenance history. It will then identify the specific fix required and bring up the relevant instructions and tools required to complete it. The app will also be able to identify potential hazards in the environment, such as live wires, moving machinery, or areas with high temperatures. Maintenance activity and faults will be recorded by the app automatically, staff still have the option to manually override and enter information as required. The data is fed back into the app's database to be used for the future pre-shift maintenance strategies. This process is illustrated in Figure 7.

Figure 7. Maintenance Process with App Solution - Phase 2



3.1 PRE-SHIFT STRATEGY

The pre-shift strategy is calculated by the app at the start of a maintainer's shift. This strategy considers the skill set of the maintainer and determines the most efficient maintenance strategy for the depot. This outputs the jobs required to be undertaken during the shift; which is listed in order based on safety priority and maintenance periodicity (based on a predictive maintenance algorithm). The tools and PPE required to complete the listed jobs will also be provided. This will allow staff to plan their shift accordingly and work efficiently.

3.2 DATA LOGGING

The app will also have a feature to log data on the maintenance being taken place and any other faults that are recognised within a maintainer's shift. This information will also be stored in the data cloud, linked to the unique identifier for the relevant part.

The app's gathering of important operational metrics necessitates a strong and cohesive approach to safeguarding this information. The below considerations have been made to the data handling:

- All data, such as photos taken by staff and asset condition reports, will be securely stored in encrypted databases, managed in accordance with the Australian Privacy Act 1988 and relevant state legislation.
- Cloud-based storage that complies with the Australian Government's Information Security Manual enables the app to manage large volumes of data efficiently.
- Role-based access control ensures data integrity as only authorised users can view or modify specific information.
- Multi-factor authentication will be used to verify user identifies for an additional layer of protection.
- The app will receive ongoing updates with security patches to address vulnerabilities and ensure resilience against emerging threats.

3.3 USER INTERFACE DESIGN

A possible rough design of the user interface of the app is provided below in figures 8 to 11.

Figure 8 - Log In Screen

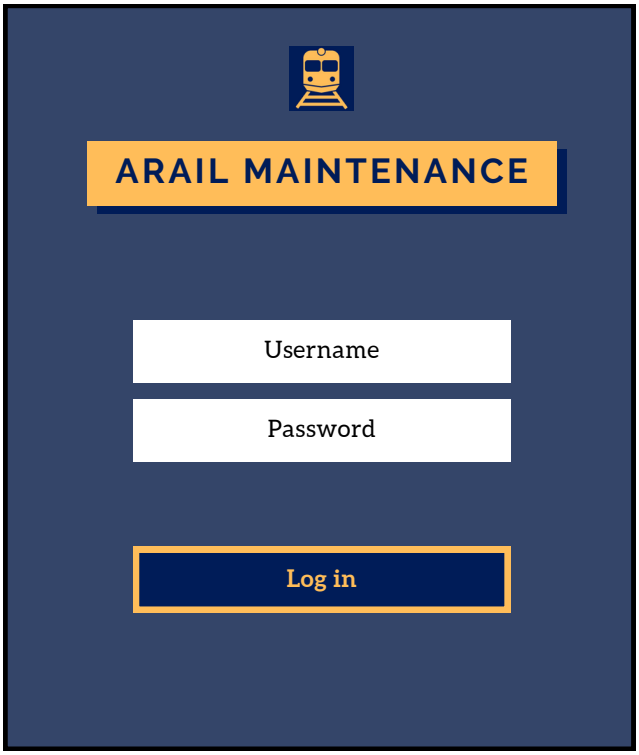


Figure 9 - Pre-shift Strategy Page

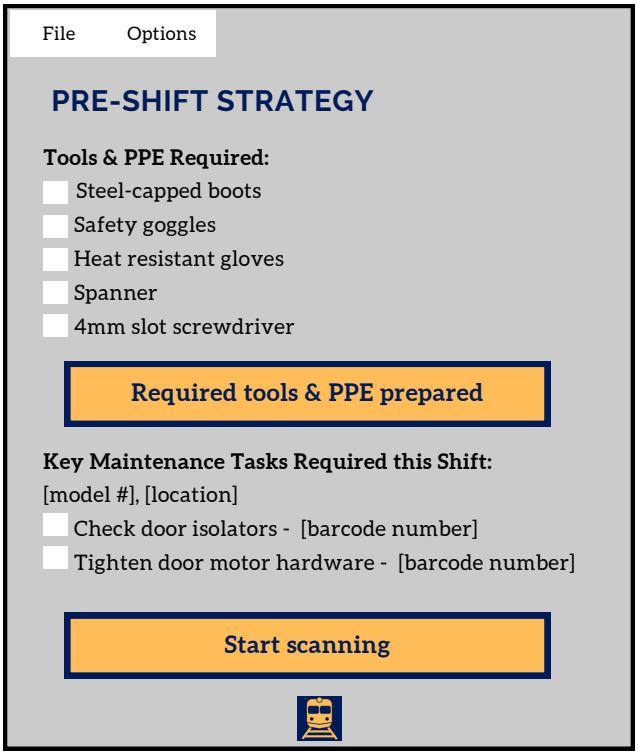


Figure 10 - AR App Camera

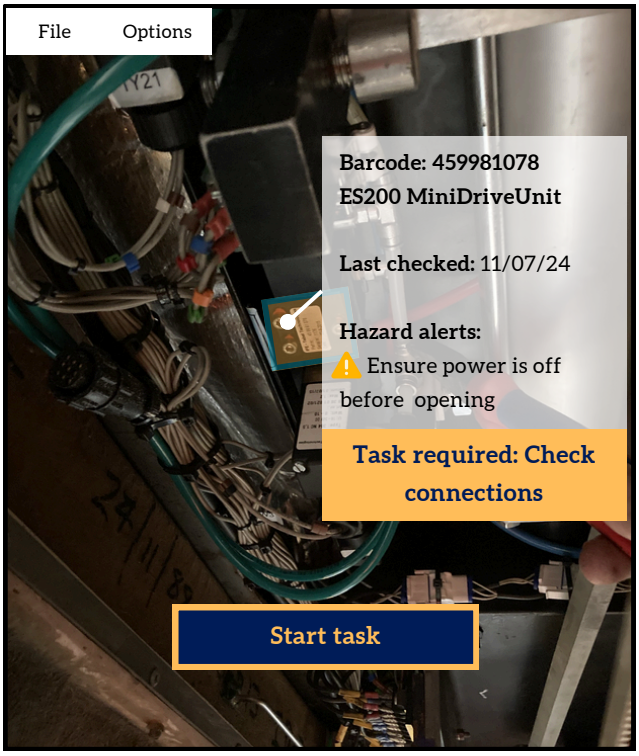
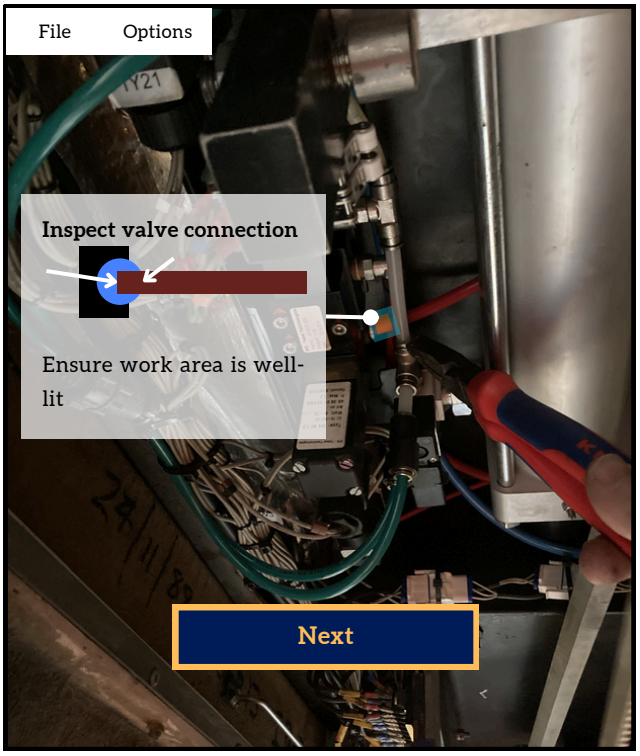


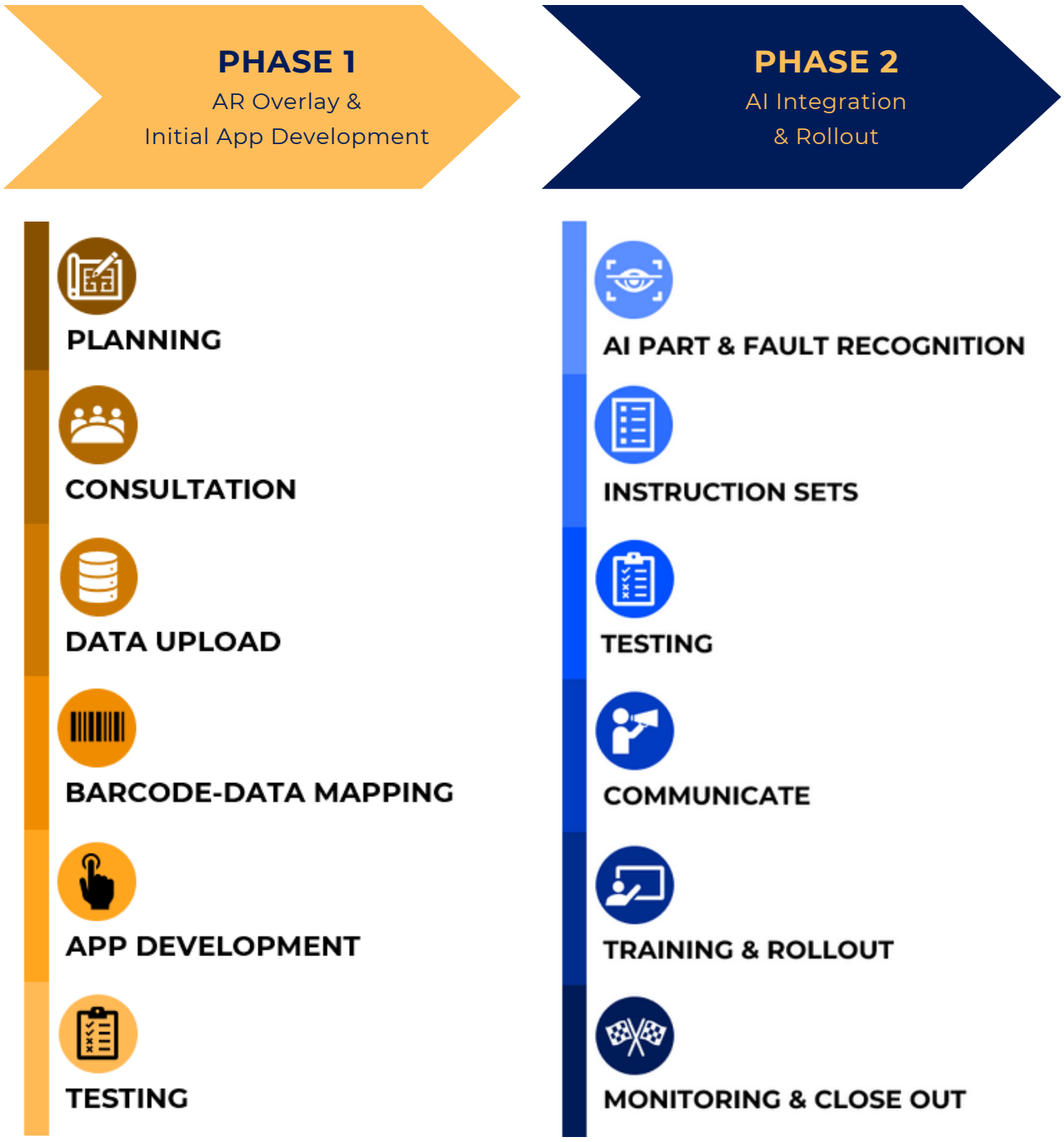
Figure 11 - Instructions Overlay



4 IMPLEMENTATION PLAN

The proposed implementation plan will be rolled out in two phases to delineate two major technologies to be implemented. Phase 1 will involve the initial planning and development of the readily achievable application features, whilst Phase 2 will involve the integration of AI.

Figure 12 - Implementation Two-Phased Process



4.1 PHASE 1 - AR OVERLAY & INITIAL APP DEVELOPMENT

Planning
In this stage, the organisation will work in conjunction with the app development team to identify resources required, assign project roles and responsibilities, and create a detailed project plan.

Consultation
During consultation, the project team will consult with subject matter experts within the organisation and ensure that all stakeholders are identified to create a responsibility assignment matrix (e.g. RASCI). Some stakeholders involved in this project would be:

- Depot Management: Responsible for overseeing the implementation and ensuring it aligns with the depot's strategic goals.
- Maintenance Staff: Technicians and engineers who will use the new app and whose workflows will be directly affected.
- Project Manager / Shift Manager / Lead Technician: The app will help reduce the load on planning, executing, and overseeing.
- IT Department: there will be an increased demand on this service to roll out the program and maintain.
- Training Department: Develops and delivers training programs for staff to effectively use the new tool however this has the potential to the rolling Stock system training.
- Procurement Team: Handles the purchasing of the new tool and manages vendor relationships.
- Health and Safety Officers: Ensure the new tool complies with safety regulations and does not pose any risks to staff.
- Quality Assurance Team: Ensures the new tool meets the required standards and does not negatively affect maintenance quality.
- RAMS Engineers: This will facilitate these functions and help provide quantifiable information.
- Legal/Contracts Team: Make changes to contract to reflect changing technologies or maintenance schedules
- App Development Team: Provides the app and may offer support, training, and maintenance services.
- Regulatory Bodies: Ensure the tool meets industry standards and regulatory requirements.

Business requirements, constraints and scope will also be gathered in this stage.

Data Upload
The project team will be required to locate and upload the existing maintenance procedures, drawings and maintenance history into the app's cloud database.

Barcode-Data Mapping
Rolling stock door part barcodes will need to be recorded and linked to the relevant uploaded data in the cloud database.

App Development
The app's user interface and the bulk of its features will be developed by the app development team in this stage.

Testing
The first phase of testing will commence to ensure that the app works as expected through user acceptance testing (UAT), feedback will be gathered and any initial changes will be made.

4.2 PHASE 2 - AI INTEGRATION & ROLLOUT

AI Part & Fault Recognition

This will be the major feature to be developed in phase 2, where AI will be trained through the feeding of image sets to be able to recognise rolling stock door parts and any faults.

Instruction Sets

A suite of maintenance instructions for an array of door fault scenarios will be uploaded into the app's database and will be used to the train the AI to recognise certain maintenance requirements or fault scenarios. These will be the specialised instructions that will pop up in the relevant area on screen, in the AR camera interface used by maintenance staff.

Testing

A second round of testing will ensue on these major updates to the app to ensure that the AI and data uploaded work seamlessly and as expected. Further UAT will be conducted with relevant maintenance personnel.

Communicate

Throughout the project, a communication plan will be followed to ensure that all the identified stakeholders are kept informed and the process is as transparent as possible. This will also allow the project to rollout and accepted into the business process smoothly.

Training & Rollout

A training needs analysis will be conducted to determine the type of training the organisation would need including the mode of training.

Options that can be provided for an organisation:

- Training on how to use the high level functions of the application, e.g. how to activate the camera, how to navigate the user interface, how to access instruction sets.
- Modular training on how to use the application for specific purposes, i.e. how to identify a brake disc using the app, how to use the app to provide instructions on this particular door system for this particular train.
- Operators develop their own training and standard instruction documentation provided.
- Train the trainer courses

Modes of training:

- Digital training implemented through learning management systems such as Cornerstone or BlackBoard.
- In class training involving a classroom environment and using a PowerPoint and activities to explain concepts.
- Onsite/practical training with trainers attending onsite in depots.

The devices for maintenance will be rolled out here for use.

Monitoring & Close Out

Upon close out of the project, handovers must be completed to the relevant personnel to ensure the continuation of the new processes, any remaining activities are finalised and ongoing support will be provided by the app development team for ongoing security patch updates and bug fixes and support hotlines.

5 FUTURE OPPORTUNITIES

There are many opportunities for this application technology to be further developed through expansion of this technology to other areas of maintenance including other areas of rolling stock maintenance and network maintenance, as well as opportunities in operational roles and training.

For example, the AI feature of the app could play a pivotal role in revolutionising station maintenance by automating the identification of assets and their maintenance needs. Through this application, station staff would merely need to take a photo during their routine inspections. The app would then assess the condition of the asset, automatically logging its status and flagging any maintenance requirements.

This approach not only streamlines the inspection process but also reduces the need for manual oversight, allowing rail operators and maintainers to concentrate their efforts on actual maintenance rather than inspections. Over time, the app will collect valuable data on asset conditions, maintenance patterns, and other relevant metrics, which can be used to fine-tune maintenance schedules, anticipate future issues, and improve overall asset management strategies.

This efficient system requires no additional training beyond basic app usage, enabling station staff to seamlessly integrate it into their daily routines, ultimately maximising manpower and operational efficiency. This approach could also be adopted for inspections of assets in any area of the rail systems where an onsite staff is present as the app allows the staff to perform inspection without any additional training or qualifications.

6 REFERENCE LIST

Augmented and Virtual Reality for Inspection and Maintenance Processes in the Aviation Industry - H Eschen, T Kötter, R Rodeck, M Harnisch, T Schüppstuhl - Procedia manufacturing, 2018•Elsevier

Application of Augmented Reality for Aviation Equipment Inspection and Maintenance Training - CC Peng, AC Chang, YL Chu 2022 8th International Conference on Applied System Innovation (ICASI), 2022

APPENDIX 1 - FULL IMPACT ASSESSMENT

Impact Category		Rating	Assessment	Commentary/Justification
Business	What is the maximum level of reasonable consequence that this change may impact on the organisation, including structure, head count, training and competency?	3	• Moderate impact • Undesirable • Moderate failure to provide a competitive service - cost and efficiency. • Inability to demonstrate moderate improvement of performance capability on rolling monthly basis. • Moderate loss of customers • Moderate difficulty to attract / retain critical / capable staff	Metrics can be developed by analysing actual hours taken to train maintenance personnel prior to integrating AR and comparing to this over time as the product is rolled out. Utilising more modern technologies could lead to disinterested personnel.
Operations	What is the maximum level of reasonable consequence that this change may impact on organisation day-to-day operations?	1	• Low impact < 24 Hour disruption to train traffic - single line.	Application tool will be used mostly in depot environment when rollingstock assets are in planned maintenance or are already out of service due to a fault. Minor impact to operations and would be in line with existing maintenance practices.
Management Effort & Governance	What is the maximum level of reasonable consequence that this change may impact on organisation existing systems?	3	• Moderate interaction or impact on organisation's existing systems. Some sub-dependencies and integrations required but with redundancy included to mitigate vulnerability to existing systems. • A moderate event which requires additional resources and management attention to effectively manage.	Reasonable level of interaction within the company's current planned maintenance systems.
Scope of Impact	What is the number of business groups to be impacted by this change?	5	• (Executive) or more Business units and/or systems	Many impacted stakeholders including maintenance staff, project managers, workshop supervisors, IT department, training, procurement teams, safety reps, quality assurance, engineers and relevant external stakeholders.
Change Fatigue Impacts	Is this change a stand-alone initiative or part of a series of changes conducted either at the same time or over a protracted period, contributing to 'change fatigue'.	5	• Part of a series of changes to a multiple areas of the business (high impact and/or extended duration)	Software product rollout often causes change fatigue amongst employees. Utilising more modern technologies could lead to disinterested personnel
Financial	What is the maximum level of reasonable consequence (financial impact) to the business for any rectification or recoverable position works required, in the event of a failure of the change?	3	• An event leading to a negative impact on PBT in one year between $100k - $1m • Moderate loss of on-going funding • Moderate revenue shortfall (5% > 10%)	Risk that implementation of application goes over budget with little end product.
Health & Safety	What is the maximum level of reasonable consequence that this change may impact on the Health & Safety of organisation's employees / contractors, outside of TasRail's current controls, mitigations or expertise?	2	• Change can put an individual in a situation that could lead to a Medical Treatment Injury (either during implementation or once live) • First aid treatment • Moderate property damage	There is some risk due to inaccurate procedures due to worksite and organisation differences. There may be insufficient facilities/resources to roll out product.
Environmental	What is the maximum level of reasonable consequence that this change may impact on the Environment?	2	• Works occurring within frequently (daily) trafficked area lightly • No known sensitive listings within 10km of site within TasRail Sensitive Listing Database • Minor environmental damage (< 1 year duration) in a limited area not controlled by organisation.	Inaccurate procedures regarding worksites, differences across multiple companies.
Community	What is the maximum level of reasonable consequence that this change may impact on the community / external parties?	2	• Minor tangible expressions of mistrust amongst a portion of community members who have some influence on local public opinion. • Stakeholders express minor dissatisfaction informally. • Minor numerous community complaints to business direct with no required follow up after initial addressing • Minor impact to day-to-day activities of local community (immediate surrounds) • Minor reparable damage to item of low cultural or heritage significance	Due to initial inaccuracies in the product roll out stakeholders become dissatisfied.