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Ken Erickson Innovation Award Submission

Automated Rail Infrastructure Inspection System (ARIIS) by Future Maintenance Technologies

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Future Maintenance Technologies Pty Ltd

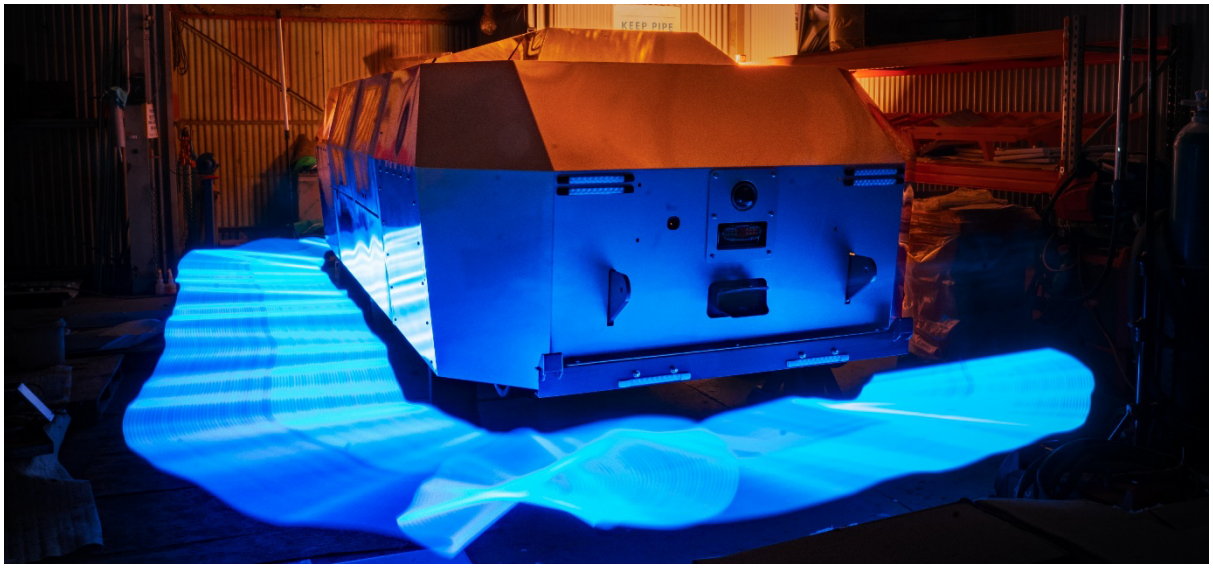
1 Introduction

The Automated Rail Infrastructure Inspection System (ARIIS) developed by Future Maintenance Technologies (FMT) is a novel rail vehicle that conducts detailed track and rail infrastructure inspections. ARIIS is a brand-new design with flexibility as a core design element. ARIIS is a flexible platform can be outfitted with different sensor modules tailored for specific rail infrastructure inspections, allowing a broad and adaptable inspection capability.

ARIIS is supported by control and analytics software to facilitate autonomous capture and analysis of asset data to determine asset condition.

Using state-of-the-art lasers, cameras and sensor technology, ARIIS delivers a safer, efficient and cost-effective solution for rail infrastructure owners and maintainers. ARIIS is unique in the industry through its inspection capability, its autonomy, and fit-for-purpose data insights capability.

The first ARIIS was designed and built for operation in Dubai Metro, deployed on-track in December 2023.



Features and Operation

ARIIS is designed as a flexible platform, enabling additional sensor capability modules (along with associated analytics algorithms) to add infrastructure inspections over time. The ARIIS deployed in Dubai Metro operates as a towed vehicle. As the ARIIS platform is flexible, propulsion and autonomy can be added over time to produce a fully autonomous Rail Infrastructure Inspection Rail vehicle delivering further benefits in safety, operational efficiency and accuracy.

Operations

ARIIS leaves the maintenance depot or siding and navigates to the inspection area (this is typically a large section of the network), conducting a range of inspections, including track geometry, overhead wires, and structures. During inspections, ARIIS collects high-resolution imagery and profile data using a sophisticated array of sensors. After performing inspections, ARIIS returns to its Charging & Communications Dock, where data is processed, analysed, and transferred to the FMT insights platform for ingestion into client systems or for visualisation of information by client

staff. FMT worked closely with the Dubai Metro to ensure ARIIS operates within Dubai Metro's maintenance concept, causing minimal impact on rail operations.

Technological Advancements

ARIIS incorporates a comprehensive suite of sensors, including Rail Profile & Geometry Sensors, 3D Cameras, LiDAR Sensors, Overhead Wire Sensors, and Creep Measurement Sensors. These sensors utilise High-Speed Laser, Accelerometers, GPS, RGB Optical Sensors, and Infra-Red Optical Sensors to provide accurate measurements of rail profile, defects, overhead wire geometry, and temperature. ARIIS can be configured for full autonomy with GOA4 signalling or equivalent.

ARIIS incorporates both onboard and wayside processing – meaning safety critical alerts can be analysed and sent in near-real time. Non-safety critical inspections are processed on a dedicated wayside server and then integrated with Client Systems through APIs.

Key Personnel

Saad Khan (Co-Founder: Sales & Marketing)

David Philpot (Co-Founder: Technical)

Ben McKelvey (Co-Founder: Business Development)

Loic Ayoul (Co-Founder: Business Development)

Owen Plagens (Co-Founder: Business Strategy)

Paul Clarke (Legal, Commercial, IP)

Aysha Khan (Marketing Specialist)

2 Contents

3 Submission Criteria

3.1 Difficulties Overcome

There were several difficulties that were overcome with ARIIS including the following:

- ***Detailed rail network design data was not readily machine readable***
  - Developed processes and software toolsets for processing scans of detailed rail network design data with error checking.
- ***Operating Concept that works within operational constraints***
  - Designed to complete inspections within tight maintenance windows.
  - Real-time alerts for detected critical issues using onboard processing.
  - Large battery capacity to provide flexibility of storage between inspections.
  - Designed to operate in harsh and extreme climate in Dubai.
- ***Limited space for sensors due to constraints of kinetic envelope and position of 3rd rail***
  - Novel use of sensor technology to work within limited available space.
- ***Required accuracy of rail kilometrage measurements***
  - Integration of INS datasets with encoder sensor data
- **Highly precise measurements**
  - Structure designed to be fit for purpose, and allow flexible and precise positioning of sensors
  - Calculation of positioning of sensors relative to wheels and centres of rotation
  - Development of calibration rig and calibration processes
- Delivery Timeframe
- Flexible platform – designing a flexible platform to enable rail networks to select modules and capability to configure it to a network.

3.2 Contribution / Impact to Rail

ARIIS makes a substantial contribution to the rail industry by automating infrastructure inspections. One of the most notable aspects of ARIIS is its autonomous data collection and processing as well as its ability to be configured for autonomous navigation.

Additionally, ARIIS brings the following significant benefits to the industry:

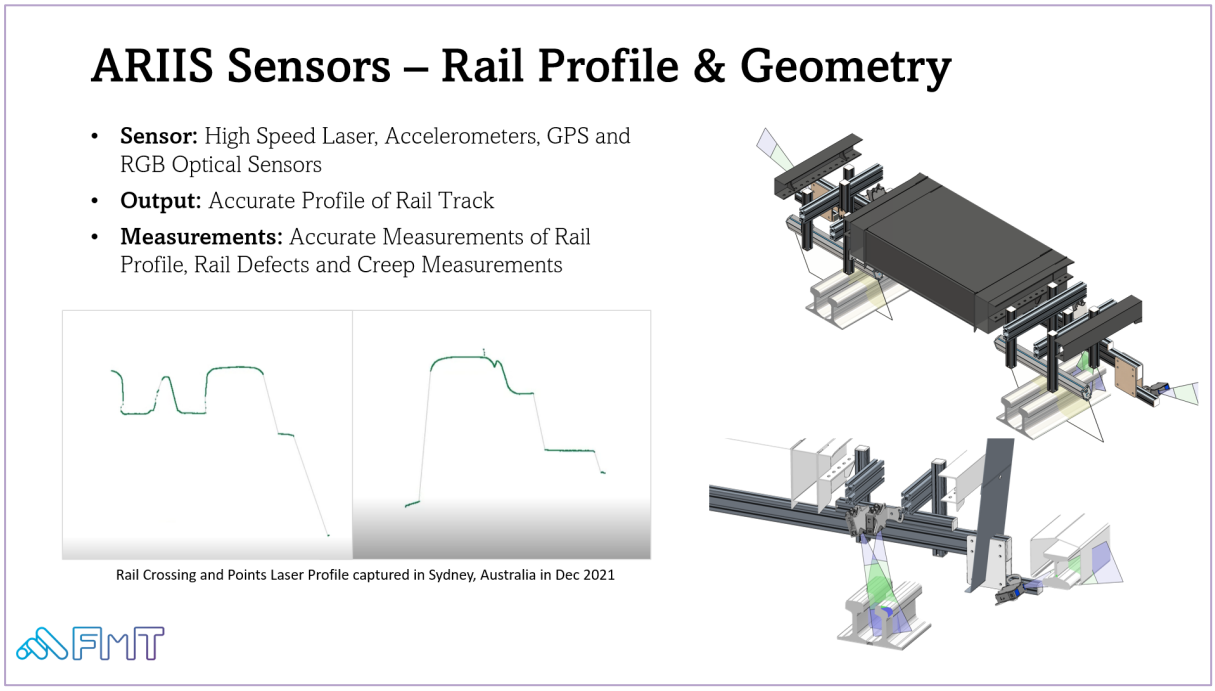
- reduction in manual inspections, along with reduction of safety risks associated with performing manual inspections in the rail corridor.
- greatly reduced cost associated with performing more frequent inspections.
- reduced wear of rollingstock that traverse the infrastructure, along with costs and downtime associated with rollingstock maintenance.
- reduced interruptions and speed restrictions for train / tram services.

- greater understanding of infrastructure condition, empowering decisions that reduce asset life-cycle costs.

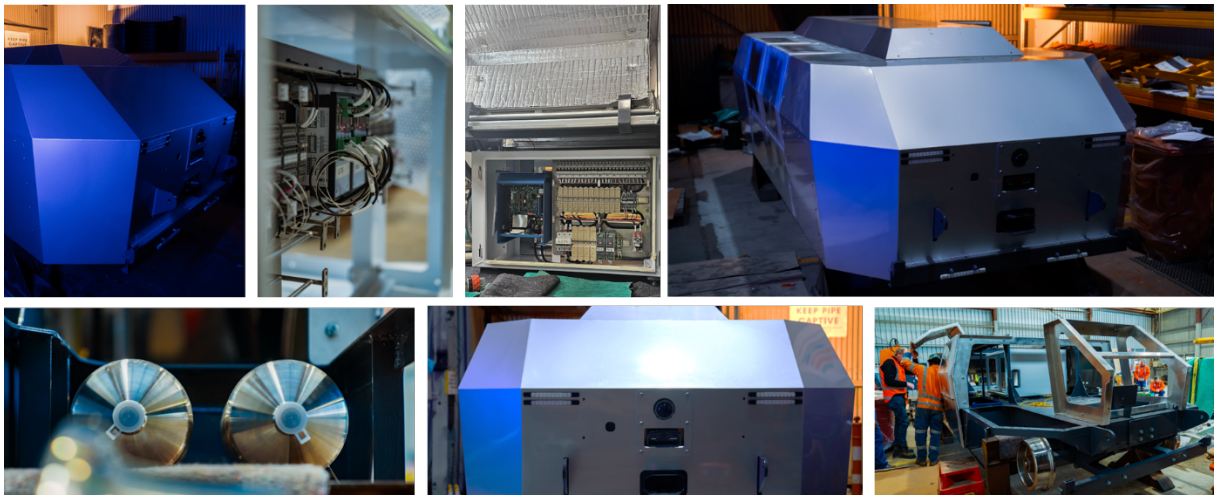
ARIIS's advanced sensor technologies, including LiDAR, laser, and optical sensors, enable precise and reliable detection of rail track defects and geometry issues. The system offers a comprehensive range of pre-built inspections, covering track geometry, 3rd Rail, overhead wires, and structures. By ensuring accurate and reliable inspections, ARIIS enhances the safety and integrity of the rail network, reducing the risk of incidents and contributing to the overall efficiency of rail operations.

3.3 Technical Input

ARIIS incorporates state-of-the-art technology, including rail profile and geometry laser sensors, Line cameras, 3D cameras, LiDAR sensors, Inertial Measurement Units (IMU). These sensors provide accurate measurements of rail infrastructure, including track geometry, rail defects, and 3rd Rail characteristics.



During the Design and Build of ARIIS in 2023, the project had 10 core FMT team members covering core areas such as Engineering Design, Project Management, Procurement, Data Science and Software Development. Throughout the Design and Build, FMT involved numerous Australian rail expertise and partnerships from Mechanical Design Electrical Design, ICT Design, PLC Programming and Fabrication and Fitting, and the team grew to over 30 to complete the project.



3.4 Degree of Innovation in Rail Aspects

ARIIS showcases a high degree of innovation in rail infrastructure inspection. The most common methods currently used for similar results include labour-intensive manual inspections. While other comparable solutions are in present in the market, ARIIS stands out through its ability to perform a greater range of inspections, and its operational flexibility to perform inspections on specific parts of the network. Table 1 below exhibits the key differentiators between ARIIS and current market solutions:

	ARIIS	Portable inspection equipment	Train-Mounted Systems	Loco-Based Systems	Manual Inspections
Network coverage	Comprehensive and flexible network coverage	Short track sections at a walking pace	Restricted by train movements resulting in limited network coverage	Flexible network coverage	Walk the track and sample measurements
Automation	Automated and efficient	Semi- automated	Limited automation	Manual operations pose risks	Manual operations pose risks
Accuracy	Accurate and repeatable	Dependent on calibration and correct use	Accurate and repeatable	Accurate and repeatable	Prone to human error
Personnel Requirement	Human-independent	Required to be transported to inspection site	Dependent on train crew	Requires crew to drive and monitor	Manual labour required
Cost Considerations	Efficient and cost-effective	Not specified	Dependent on number of trains that have system installed, and modifications to trains	High operational costs	Manual labour costs
Flexibility in Inspections	Highly configurable platform	Limited configurations	Specific inspection capabilities	Limited flexibility	Limited configurability

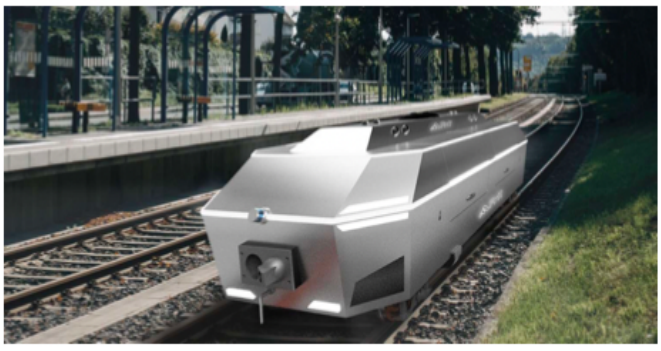
Operational Speed	Up to 25km/hr	Up to 16km/hr	Dependent on train speed	Dependent on loco speed	Slow
Battery Life	Runs for approximately 10 hours	Not specified	Dependent on onboard systems	Not specified	Not applicable
Scalability	Highly scalable with additional algorithms	Not specified	Limited scalability	Not specified	Limited scalability
Overall Evaluation	Superior, efficient, and adaptable	Limited capabilities	Restricted by operational constraints	Costly with manual involvement	Slow, inaccurate, risky

Table 1 - Key differentiator Table

3.5 Contribution to Safety

The existing structure for Track Geometry & Infrastructure Inspection Courses involve manual visual examinations, precise measurement of track geometry using specialised equipment, and subsequent analysis of recorded measurements to identify potential safety issues. ARIIS, in contrast, revolutionises this formula by automating key safety critical interfaces of the inspection process, removing skilled technicians from the danger zone.

By greatly reducing the need for personnel to enter the rail corridor, ARIIS drastically reduces safety risk and removes safety hazards altogether. Through advanced sensors and cutting-edge technology, ARIIS further automates additional labour-intensive inspections such as turnout inspections.



The system not only streamlines the measurement of track geometry but also automates the identification of asset defects impacting on overall rail system safety. The system also provides near real-time communication of safety-critical alerts through onboard processing and Machine learning algorithms. Through 5G comms, ARIIS has the capability to alert safety critical defects before first run operations.

3.6 Systems Assurance

ARIIS ensures systems assurance through its dedicated on-board servers, which handle data analytics and historical data storage. The inspections performed by ARIIS and their outputs are

aligned with Technical Maintenance Plans (TMP) to ensure greater or equivalent assurance when compared to alternatives, while providing systematic and comprehensive assessments.

3.7 Commercial benefit

ARIIS allows the following Business Benefits to be realised:

- ***Capital Cost –*** *ARIIS typically has 1-5 times reduction in capital cost compared to similar inspection capabilities.*
- ***Flexible platform –*** *means that further benefits can be gained over time, rather than a fixed benefits at time of acquisition.*
- ***More inspections –*** *when compared to train mounted system, ARIIS provides more functionality for rail infrastructure inspections.*
- ***Safety –*** *reduces requirement for people to be in the danger zone and thus significantly reducing safety risk.*

ARIIS prevents the need for people to enter the Rail Corridor to perform inspection tasks on Rail Infrastructure. ARIIS ensures that Rail Infrastructure inspection is conducted reliably to ensure the safety and integrity of the rail network.

- ***Operational Efficiency***

ARIIS operates within engineering and maintenance hours therefore reducing the requirements for possession.

- ***Accuracy***

ARIIS ensures that all Rail Infrastructure measurements are performed with high accuracy and repeatability.

ARIIS records all historical data that can be interrogated without manual handling.

- ***Life-Cycle Benefits -*** *ARIIS delivers significant life cycle benefits, through reduced safety risk, maintenance efficiency, maintenance accuracy, operational flexibility of when inspections are completed, while having both lower CAPEX and OPEX than comparable systems.*

As an example for an Australian Metro network, we can use Sydney Trains. There are 8 territories on the Sydney Trains network and ~250 staff employed to perform Rail Infrastructure Inspections and Maintenance. These track inspections and examinations are the estimated man hours are estimated in the table below;

	Approx. Annual Tool Time	Automated by ARIIS
Walking Patrol	30,000 man-hours	Partly
Detailed Walk	10,000 man-hours	Partly
Turnout Inspections	10,000 man-hours	Completely
Welded Track Stability Analysis	25,000 man-hours	Completely
Detailed Sleeper Examination	1,000 man-hours	Completely

Rail Wear, Corrosion and Condition Analysis	1,250 man-hours	Completely
Other Inspections	40,000 man-hours	Partly
Total	117,250 man-hours	40%
Total Man-Hours made Available for Overdue Corrective Maintenance	Approx. 45,000 man-hours of tool-time per year	
Estimated Labour Savings	10FTE per Territory = Circa $15M/year	
	*Additional Equipment, Transport and Safety savings not accounted	