AI Deployment on Greenway and Active Travel Infrastructure

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Introduction

Transport Infrastructure Ireland (TII) is pioneering the use of artificial intelligence (AI) to support the sustainable management of Ireland's Greenways and Active Travel (G&AT) networks.

This emerging approach uses AI tools for real-time condition monitoring, predictive maintenance, and asset performance analysis across walking and cycling routes. AI models process sensor and image data to detect deterioration trends, identify safety risks, and aid in the decision process for prioritised maintenance and renewal interventions. This data-driven decision support enhances investment planning, asset preservation, safety and accessibility of active travel infrastructure. The system also supports TII's broader goals of promoting low-carbon, inclusive mobility by aligning asset management practices with user demand and accessibility needs.

By applying AI to G&AT networks, TII is improving resilience, operational efficiency, and sustainability in line with traditional asset management practices. This innovative use of technology allows for smarter allocation of resources, improved user satisfaction, and more sustainable network management. TII's approach looks at comparing AI outputs with machine survey data recorded using a motorised-bike (XenoBike) which is 4D LiDAR and 2D camera-based enabled. The AI solution reinforces the value of digital tools in delivering sustainable asset management for active travel networks.

Hybrid Approach to ATI Pavement Condition

TII's challenge is to develop a data-driven decision support system that enhances investment planning, asset preservation, safety and accessibility of the G&AT network. The default approach would be to apply the same network condition survey methodology currently used on TII's national road network. However, conventional machine-based network condition surveys can be expensive and require a lot of manual interpretation and analysis. This approach is time-consuming, error-prone, and not cost-effective for G&AT networks. Therefore, TII is developing a hybrid approach to assess the condition of the G&AT network. This hybrid approach will combine machine-based survey data and an AI system capable of identifying pavement surface defects. It is envisaged that both systems will be used to supplement each other, to enable more effective data driven decision making. Combining proven machine-based network data with AI pavement analysis delivers the following benefits:

- **Optimised asset management** protects investment, improves safety, reduces carbon, and supports sustainable G&AT networks.
- **Automated defect detection** reduces human error, lowers costs, and speeds up analysis.
- **Rapid AI outputs** eliminate long machine-data processing cycles and support faster decisions.
- **Contribute to reduce TII's carbon footprint** by improving network condition and encouraging public use.
- **Automated defect mapping** improves work programming and network safety.
- **Ancillary asset mapping** tracks signage, lighting, and barriers to improve inventory accuracy.

Figure 1 –Benefits of a Hybrid Approach

Given that AI pavement condition assessment is relatively new and constantly evolving, the application and integration of this data poses several challenges.

- No current industry standard for G&AT network surveys
- AI platforms differ in capability and outputs
- Models require validation for Irish G&AT conditions
- Limited Evidence Base due to few peer-reviewed studies for G&AT applications

Figure 2 –Implementation Challenges

To address these challenges, TII is working with strategic partners Vaisala and PMS Ltd. to investigate an AI approach leveraging machine data from Xenobike (manufactured by XenomatiX) and Road AI (Vaisala's product), supporting G&AT maintenance and asset management in Ireland.

Machine Data Collection - Xenobike

XenoBike is a four-wheel, electric bicycle equipped with XenoTrack road lidar technology and a complete 6D scanning kit. XenoBike is specifically engineered to assess the condition of footways and cycleways, for measuring profiles and identifying potential hazards like cracks, potholes and bumps, and optimising resource allocation for cost-effective maintenance.

Figure 3-Xenobike

AI Data Analysis – Vaisala Road AI

The Road AI data is presented on a web GIS platform. The computer vision trained data layers be configured to display various parameters such as:

Road Surface Condition	Asphalt Condition	Various defect classes	Various asset classes

The longitudinal evenness of cycle tracks is similar to those of other pavement surfaces and is expressed as a measure of the variations of the longitudinal profile. In Belgium, the evenness of a pavement is evaluated by the so-called Evenness Coefficient (EC) for a certain wavelength λ. A theoretical EC of 0 corresponds with a perfectly smooth surface. The higher the EC, the rougher the surface. This method was developed by the Belgian Road Research Centre (BRRC) in 1981, initially to evaluate the longitudinal evenness of road pavements.

Pilot Project

In Ireland, TII's first-of-its-kind pilot project mounted a Road AI-enabled smartphone on the Xenobike to collect imagery and machine condition data simultaneously. The project validated Road AI survey results against Xenobike data, informing TII's future pavement monitoring strategy for the G&AT network. Selected sites represented a diverse range of G&AT construction types, ages, and locations across Ireland. Surveys began in late 2024, with data collection aligned to TII's April–September annual road condition survey to avoid anomalies associated with winter weather.

Results

Figure 4 shows the Road AI data output. In this case the geographical data presents road surface condition on the scale of 0% to 100%. This score is based on a weighted combination of defects identified on the video survey.

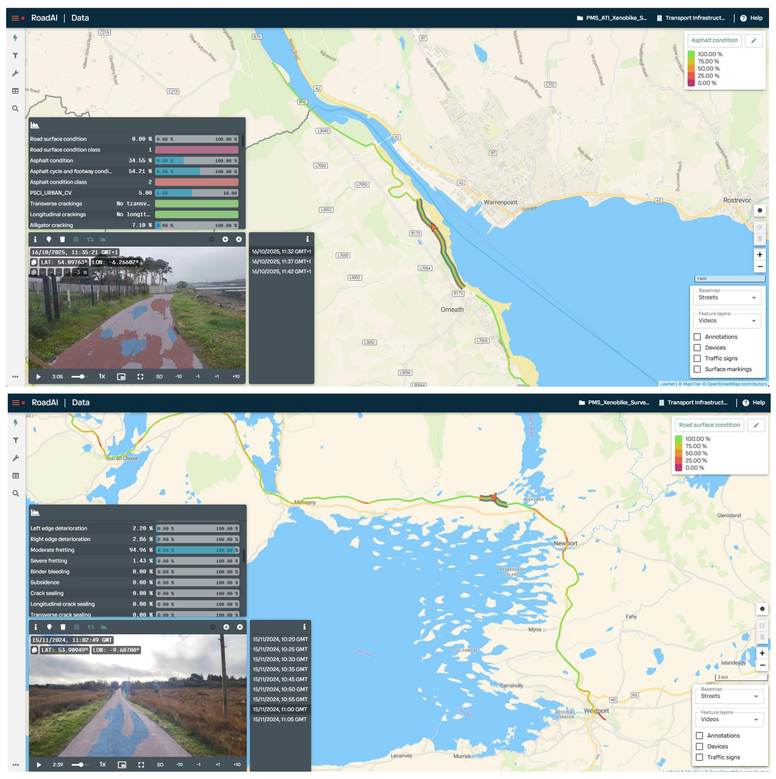

Figure 4 –Road AI web platform output

The initial data from the Xenobike survey is being analysed and processed to evaluate the appropriateness of its various derived parameters for Irish conditions, such as the evenness coefficient as shown below in Figure 5 with an overall distribution shown in Figure 6.

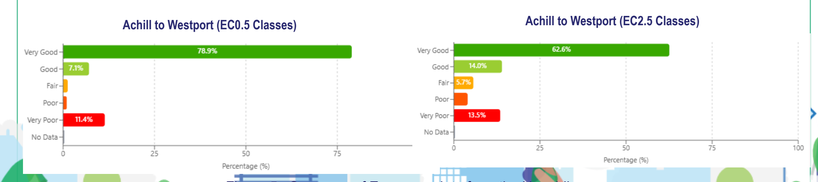

Figure 5 –Summary of Evenness data from the Xenobike

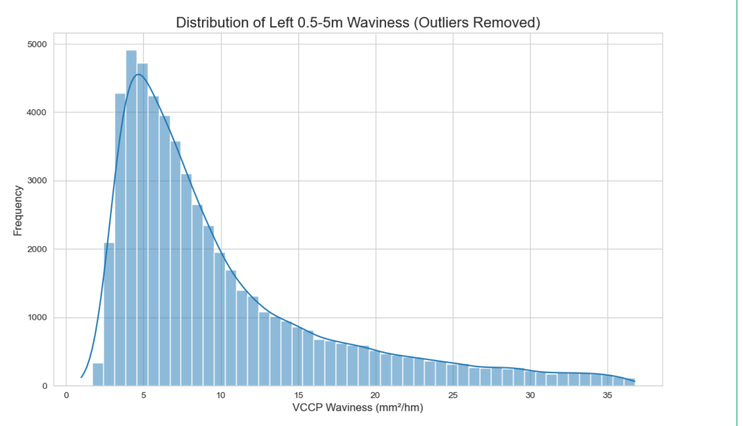

Figure 6 –Evenness Coefficient (0.5m) Distribution

Next Steps - AI vs. Machine Data

Figure 7 shows an initial comparison of the AI data against the machine data. It shows some trends in peaks and troughs between the Road AI Pavement Condition Index and the Evenness Coefficient from the machine data; a strong correlation between these two parameters is not expected. The next steps will be to compare more like-for-like parameters, such as cracking and potholing between RoadAI and Xenobike outputs

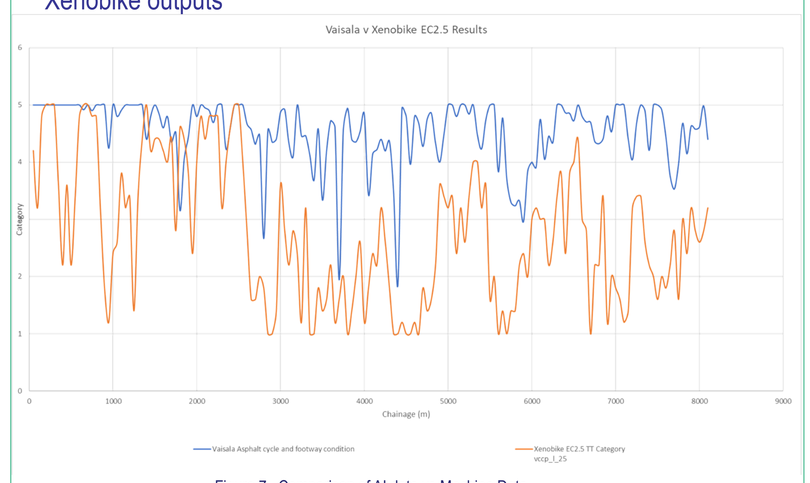

Figure 7 –Comparison of AI data vs Machine Data

Figure 8 shows the combined classification of ATI pavement condition on a scale of very good to very poor

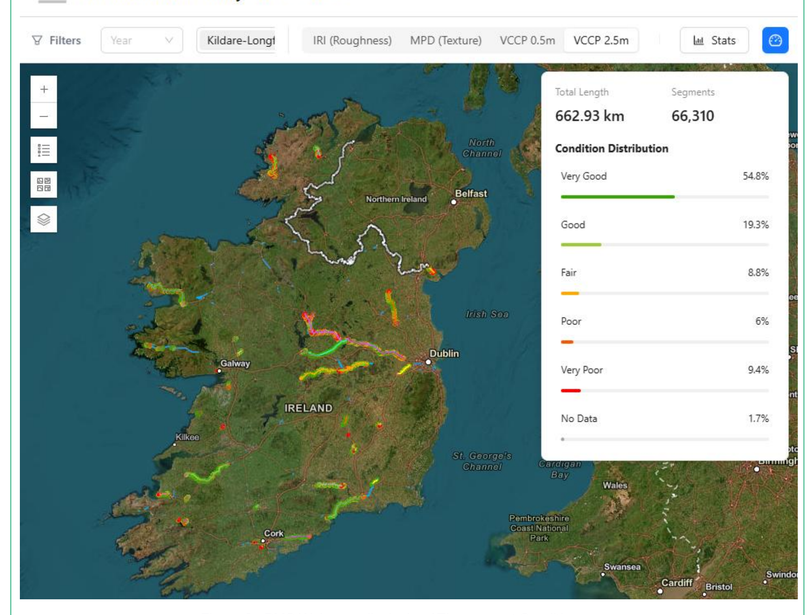

Figure 8 –PMS Web map displaying ATI pavement Condition

Conclusion and Future Development

The current approach taken to the maintenance of the G&AT network must be updated based on active travel's increased priority and the significant investment in new G&AT network routes. It is vital that a more systematic and proactive approach is taken to the management of the network in the future. TII is improving resilience, operational efficiency, and sustainability in line with traditional asset management practices. This innovative use of technology allows for smarter allocation of resources, improved user satisfaction, and more sustainable network management. TII's approach looks at comparing AI outputs with machine survey data recorded using a motorised-bike (XenoBike) which is 4D LiDAR and 2D camera-based enabled. The AI solution reinforces the value of digital tools in delivering sustainable asset management for G&AT networks.

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