# AI-based Predictive Maintenance System for Tuning Unit

In a rapidly growing, densely interconnected metro rail network, unscheduled train stoppages on a route not only impair quality of service on that particular route but can also cause service degradation of the network at large. We recognize the critical importance of metro network uptime not only from an economic point of view, but also, more importantly, from the service quality perception standpoint.

Track systems (e.g., EBI Track 300) employed by metro rail systems on the trackside uses Audio Frequency Jointless Track Circuits to ensure safe train detection and track occupancy. A critical component of this system is the Tuning Unit (TU), which is a passive device used to couple and tune the frequency response between the track and transmitter/receiver circuits. Each TU operates at a specific frequency pair (e.g., 6100 Hz–7700 Hz, 6900 Hz–8500 Hz, etc.) and is designed to exhibit selective impedance characteristics for effective frequency isolation. However, under environmental stress (temperature and humidity fluctuations) the TU can exhibit flickering output voltages, voltage surges, and component-level failures, potentially due to drift in component characteristics.

The **AI-based TU Predictive Maintenance System (AI-PDMS)** developed by Verit Alworx non-invasively gathers, processes and analyzes real-time data to predict impending TU failures. This prevents unscheduled train stoppages and allows the field units to take a suspect unit out of service and replace it with a good one in the scheduled maintenance time window. The high frequency field data coupled with component characterization and hardware system analysis is used to model TU behavior through machine learning algorithms for the purpose of predicting impending failure and Remaining Useful Life (RUL) prediction.

TU-level Instrumentation

Each Tuning Unit (TU) in the monitored Track Circuit is equipped with **non-invasive sensors** to capture both voltage and temperature parameters. These sensors are high-impedance, non-intrusive probes operating in the tuned band and introduce **no loading effect** on the TU or the track circuit. All voltage and temperature readings from the TUs are routed to an edge data acquisition module that forwards the data to the central server over a secure 4G/LTE link.

Short Circuit with Train Presence
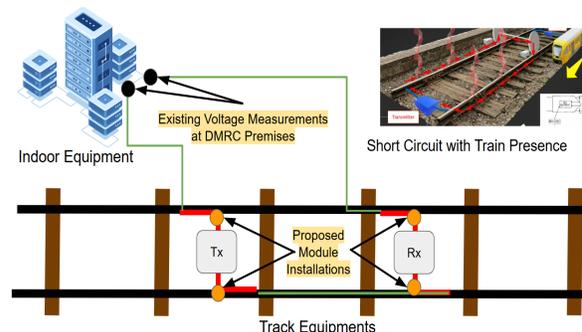
Real-Time Monitoring and Analytics

The data collected at the central server is used for generating a dedicated internal dashboard – that provides real-time visualization of input and output voltage waveforms; temperature trends of each TU; automated warnings and early failure indicators; historical charts, drift envelopes, ML-based anomaly detection; and, advanced analytics, ML model validation, and, research-driven continuous improvements to the prediction algorithm.
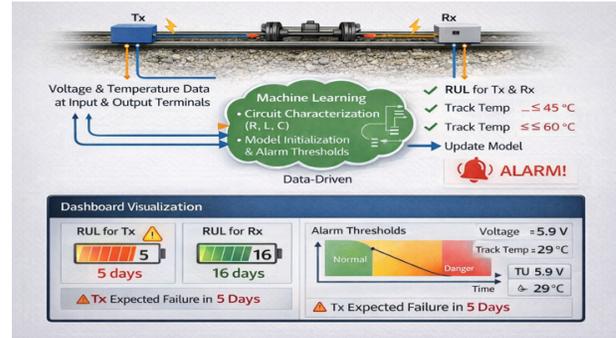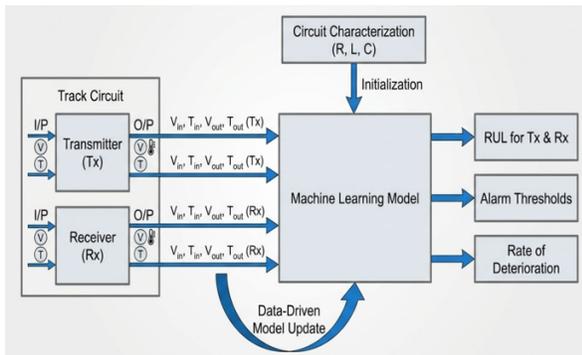
Machine Learning Model for RUL Prediction

Voltage and temperature measurements from the input and output terminals of both Tx and Rx are continuously fed into a data-driven ML model, which is initialized using circuit characterization parameters such as R, L, and C. The model estimates Remaining Useful Life (RUL), generates intelligent alarm thresholds, and quantifies the rate of deterioration for proactive decision-making.

State-of-art AI-based PDMS

The TU PDMS developed by Verit Alworx represents a state-of-art, AI-based solution for extending critical asset life. It is an open system designed for continuous improvement and scalability As new field data becomes available, the machine learning model is periodically updated to improve accuracy and adapt to evolving operational conditions. Further, this system can be seamlessly integrated with existing asset management systems.

The Verit AI engineering team has a strong record of IP creation and the experience of working with top global companies, in addition to successfully delivery of indigenous R&D and projects of national importance. Our mentors, who are among top industry leaders in their respective fields, provide us with deep strategic insights and expand our reach into the target domains. We have the right skills, passion and goal focus to design, develop and deliver state of art customized agentic AI solutions and products.

We will be delighted to co-create with you pathbreaking agentic AI solutions that deliver persistent ROI and elevated quality of service.

Contact us today for a meeting or demo: Web: www.veritaiworx.com *| Email:* info@veritaiworx.com