AI and Data Intelligence in Smart Railway

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20 September 2024

MTR
SMART RAILWAY
SMART MOBILITY • SMART MAINTENANCE •
INTELLIGENT SAFETY • GO GREEN

Why do we need to build Smart Railway?

Higher expectations from stakeholders

- Railway Service Quality
- Customer Experience
- Fare and Revenue
- Commitment on ESG

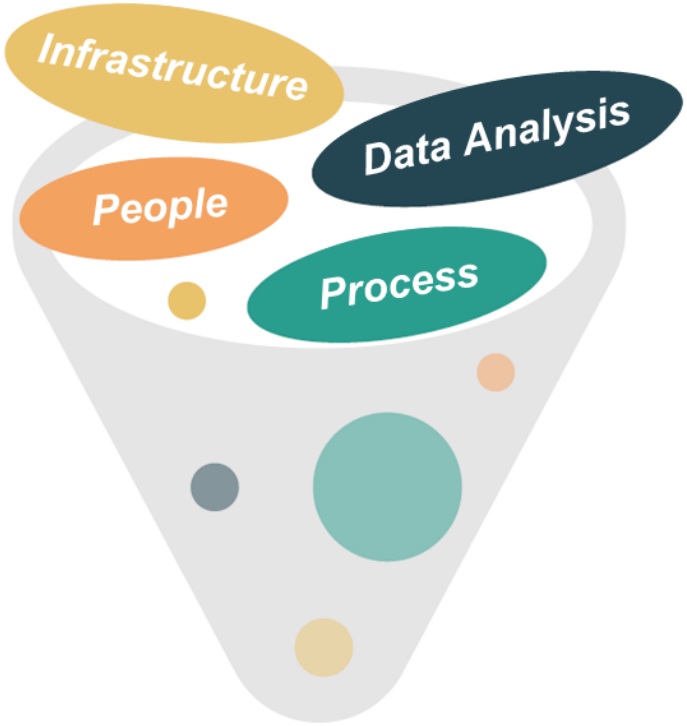
Marco and I&T development

Talent Shortages

Long-terms growth and financial sustainability

Major asset renewal

How are we building Smart Railway?



Smart Railway

Contributing to the building of a Sustainable Future

Infrastructure

IoT sensors · QR codes · Cloud platforms · Wi-Fi · EAMS · MTR Mobile · Digital twins

Data Analysis

Pax · *O&M* · *Asset* · *Data Center* · *AI* · *ML* · *VA*

People

Cultivate Innovative & Growth Mindset

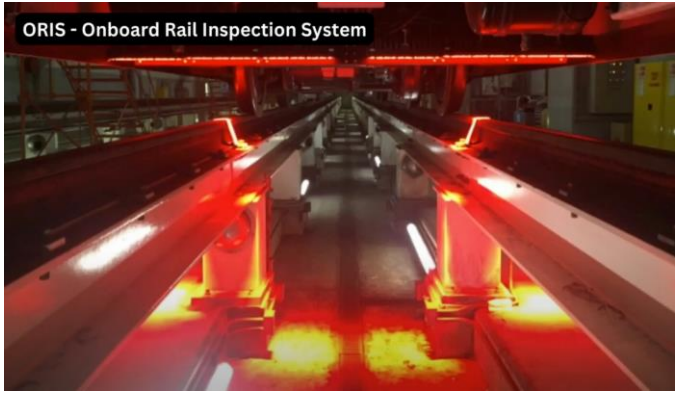
New Organisation Talent Development

Process

Re-engineer for Effectiveness

Data-Driven Decision-Making

Smart Maintenance



Objectives

Smart Maintenance

Intelligent Data-Driven Maintenance

Connected
real-time site data at fingertips; faster response

Foresighted
AI-enabled; predict & prevent failures

Intelligent Advisory
AI-enabled recovery assistant; faster recovery

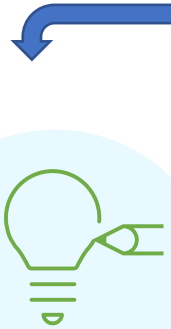
Process Transformation

Efficient & Effective
digitalized & streamlined process

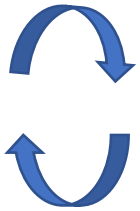
Maximize Maintenance Window
automation by robotics and remote systems

0 to 1 - Innovation Process

Continuous Improvement



Ideation



Iterative process

Incubation

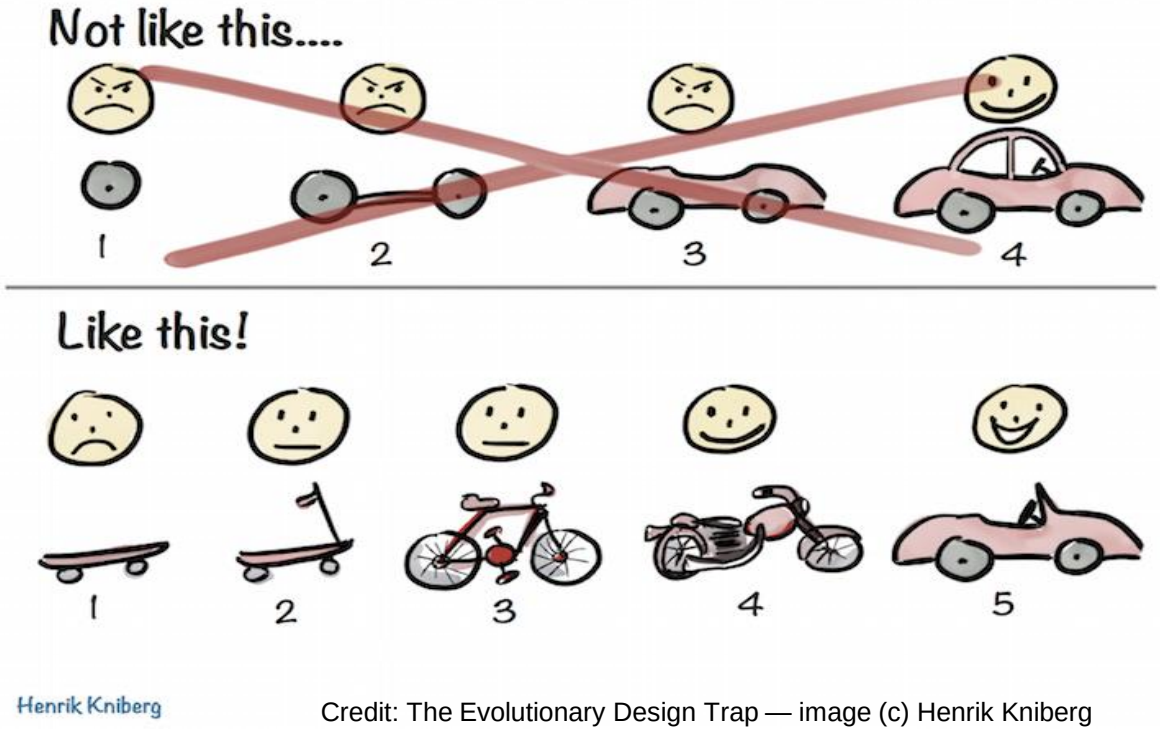
Integration

Define the desired outcome
Prioritize the project goals

Technical development
Validate the outcome

Operational Preparedness
Pilot operation and feedback

What Innovation Looks Like ..



Credit: The Evolutionary Design Trap — image (c) Henrik Kniberg

From Pilot Success to Fleet Adoption (1 to Many)

❑ Powered by 3 Digital Factories

Data Solutions

- ***Meaningful data at the right time and the right place***
- ***e.g. eForms, dashboard, data analytics, IoT sensors***

Railiverse

Image Sensing Solutions

- ***Concurrent monitoring and analytics of real time situation, early alerts***
- ***e.g. ORIS, pantograph monitoring LiDAR, CCTV with VA***

InnoRailEye

Robotics solutions

- ***Standardization of work output, repetition and around-the-clock service***
- ***e.g. Station Cleaning robots, workshop AGV, iWMC***

Robotic Factory

Innovation Hub (Innovation as a Service)

Understand & analyse business needs / pain points

Conception + Seeding

Inn Hub Operations
Innovation as a Service

Co-create solution with technology partners

Incubation + Prototype Trials

Implementation& scale up by *Business Segments*

Two-hour “golden window”

Traffic Hour

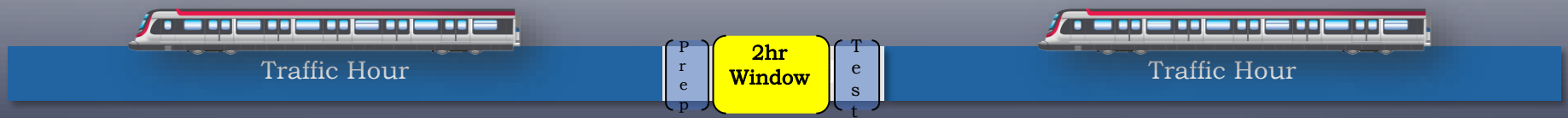
Prep

2hr Window

Test

Traffic Hour

Two-hour “golden window”



There is a need to:

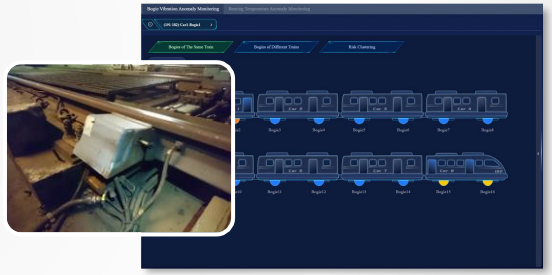
- **Overcome the limitation of conducting inspections solely during non-traffic hours**
- **Provide an early detection on failure with appropriate follow-up to improve maintenance efficiency**

Two-hour “golden window”

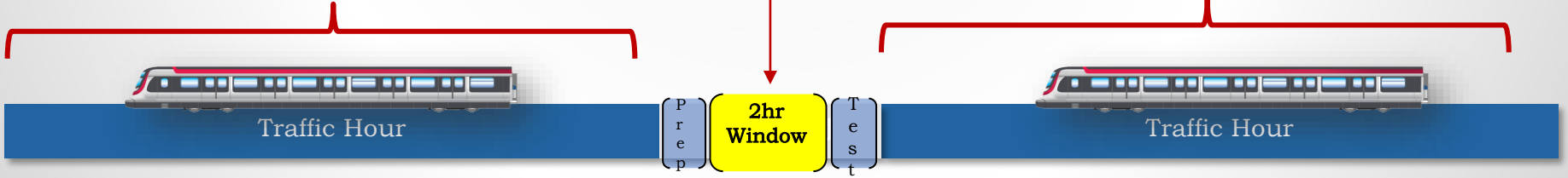
- Through smart sensors, on train and track, for continuous data collection of railway assets during passenger service in traffic hour
- Strengthens real-time monitoring, while big data analysis helps maintenance team make better use of non-operating hours, improving maintenance efficiency.

Smart Passenger Instrumented Revenue Train (SPIRT)

Improving Work Efficiency and Effectiveness



Smart Train Wheel Inspection System



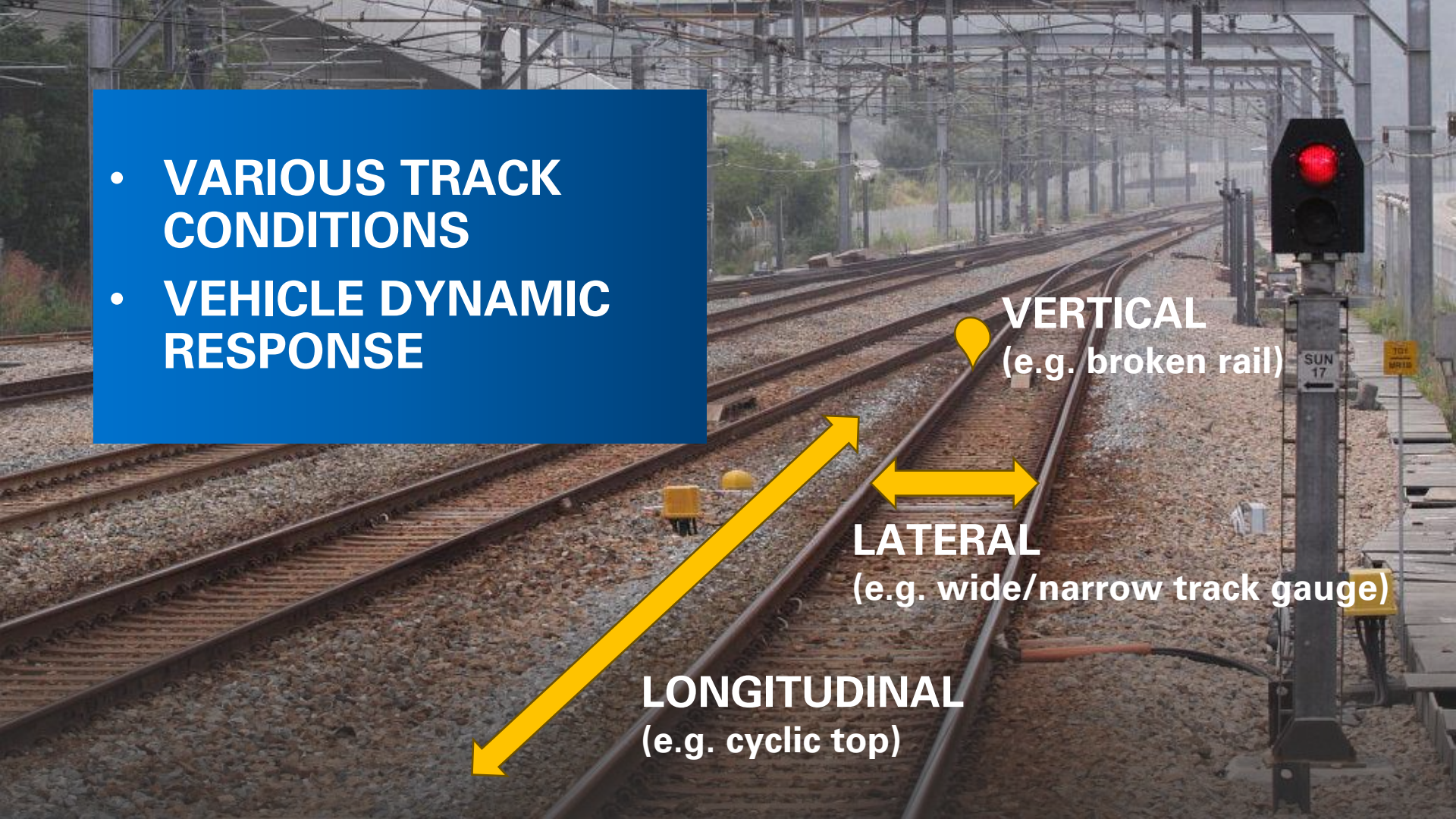
SPIRT

SMART PASSENGER INSTRUMENTED REVENUE TRAIN

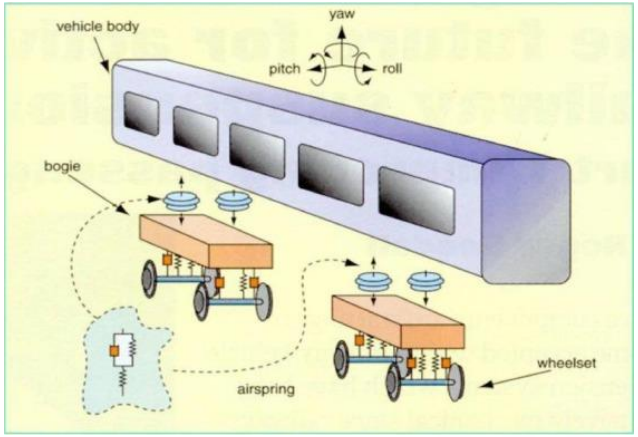
MANAGE AT FINGERTIPS

ON-TRAIN MONITORING

EARLY MAINTENANCE ALERTS


• VARIOUS TRACK CONDITIONS
• VEHICLE DYNAMIC RESPONSE
VERTICAL
(e.g. broken rail)
LATERAL
(e.g. wide/narrow track gauge)
LONGITUDINAL
(e.g. cyclic top)

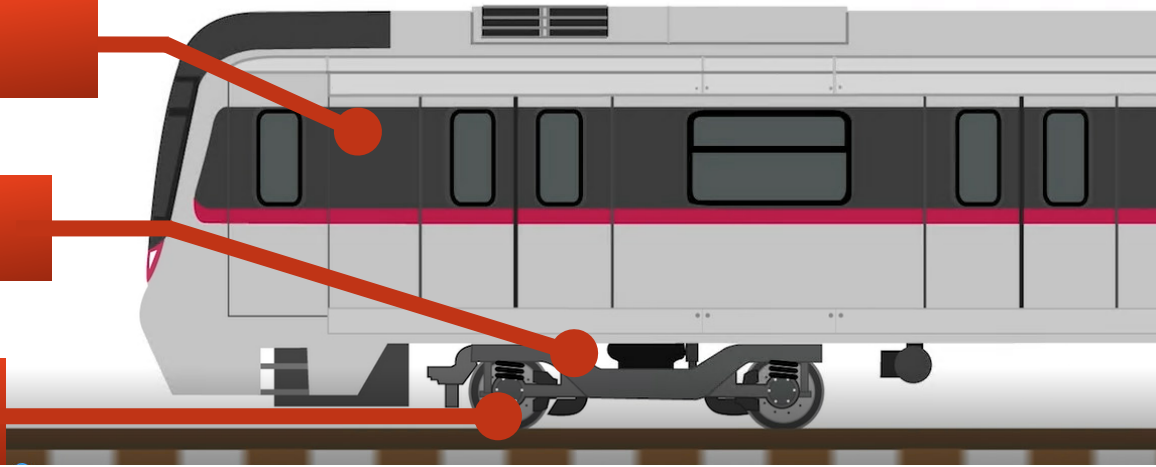
TRACK-VEHICLE-PASSENGER SYSTEM MONITORING BY INTERGRATED SENSING



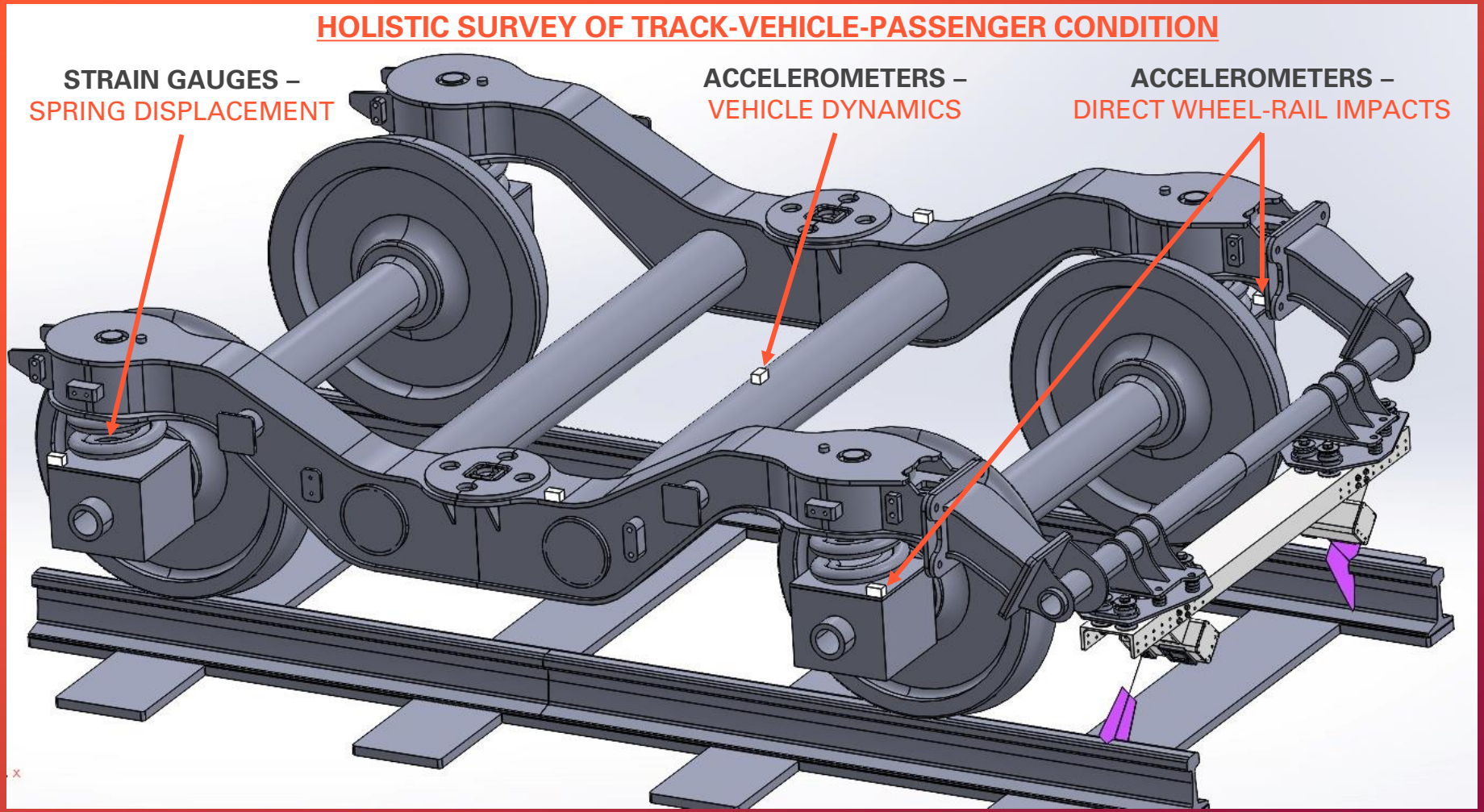
Tier 3 – Passenger Level

Tier 2 – Vehicle Level

Tier 1 – Track Level



HOLISTIC SURVEY OF TRACK-VEHICLE-PASSENGER CONDITION

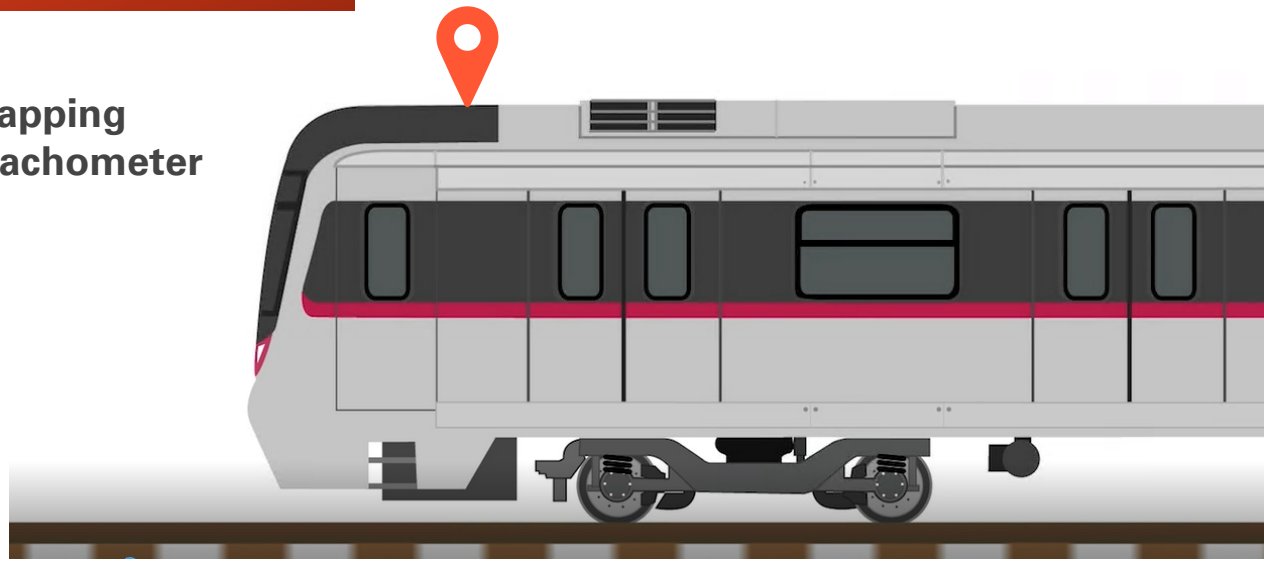


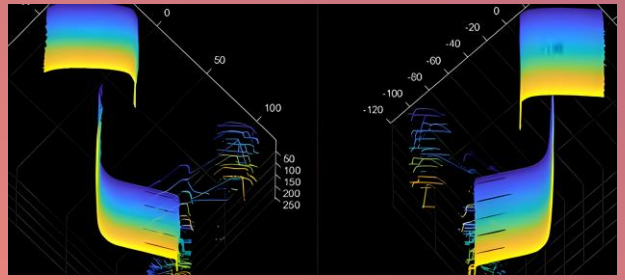
UNDERGROUND + ABOVEGROUND

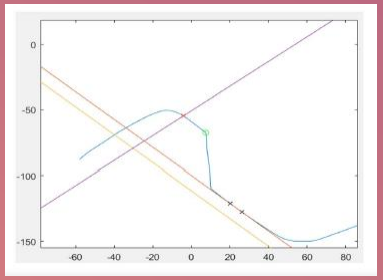
TRACK LOCATION TRACKING

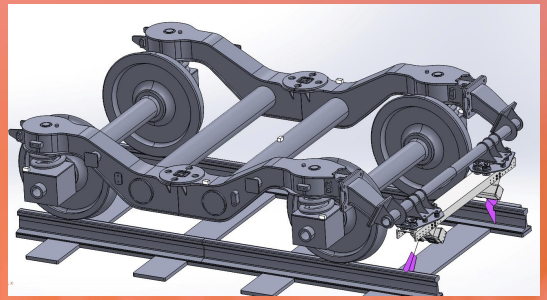
1m Accuracy

- ✓ Differential GPS
- ✓ Track Configuration Mapping
- ✓ Train Speed - Radar/ Tachometer









PROPRIETARY ALGORITHMS & MACHINE LEARNING
(with high accuracy under dynamic responses)

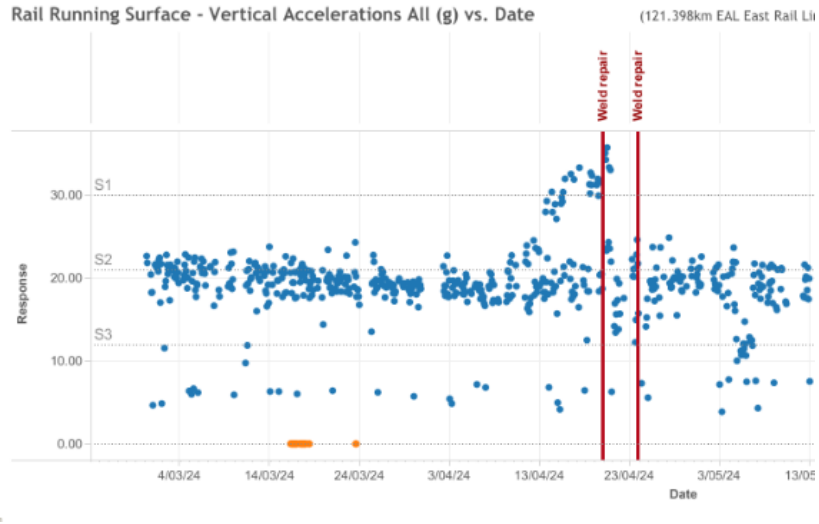
INTEGRATED DATA FROM SERVICING TRAINS

DETERMINE DEFECT, SEVERITY & LOCATION

- Wide/narrow gauge,
- Broken rail/ uneven track surface/ track surface defects,
- Vehicle bounce, etc

EARLY ALERT FOR MAINTENANCE - PREVENT FURTHER DETERIORATION

Sample Case



Before

After

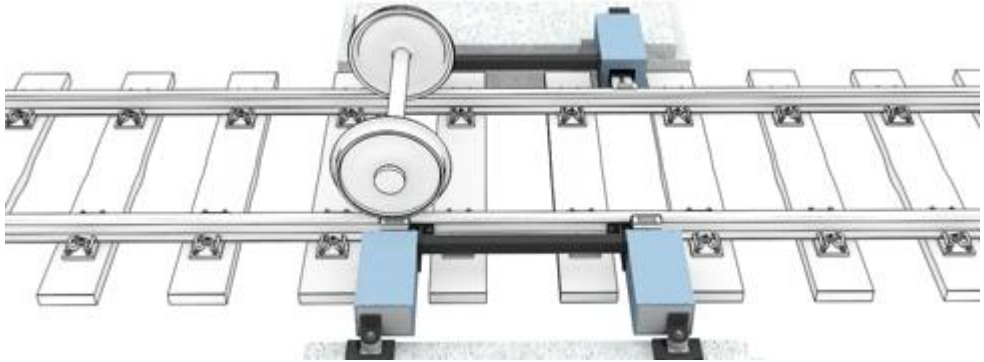
The monitoring system continuously collects data to help detect early signs and potential problems, allowing the team to address issues proactively and carry out predictive maintenance.

Maintenance of Train Wheels

- The train must be return to maintenance pit for inspection.
- Maintenance interval is fixed according to car-km.

Inspection System on the Market

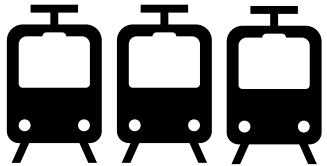
Vision System



Ultrasonic System

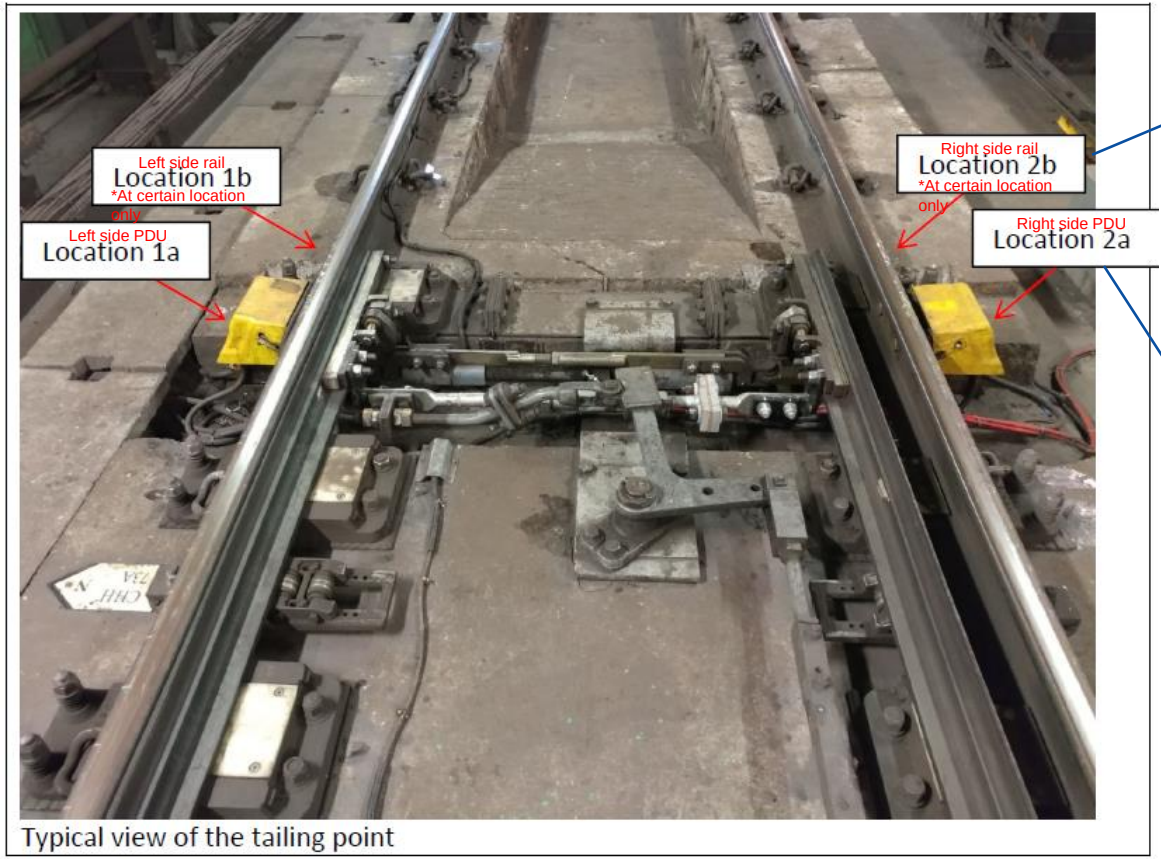
Our Solution

No hardware installation cost



Monitor status of the whole train fleet

Predict the trend of deterioration in wheels



Typical view of the tailing point

Typical instrumentation on the field side of the corresponding Stockrail Rail web

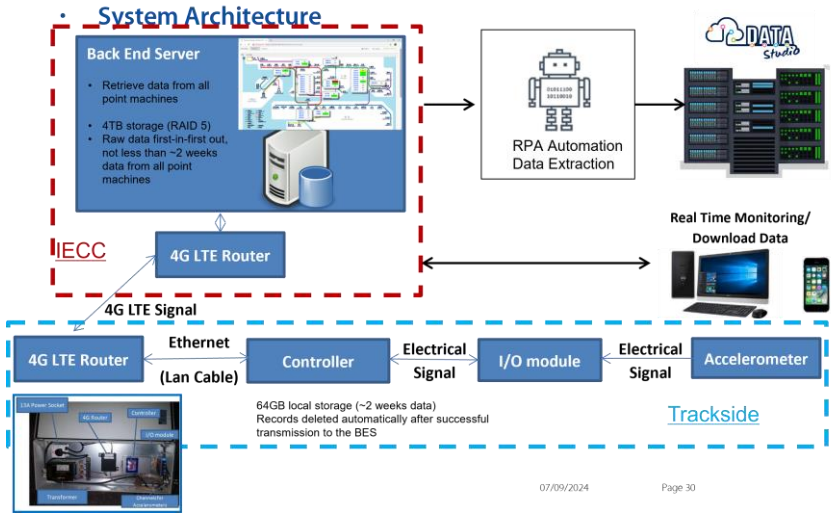
1b & 2b
For Rail Vibration Monitoning

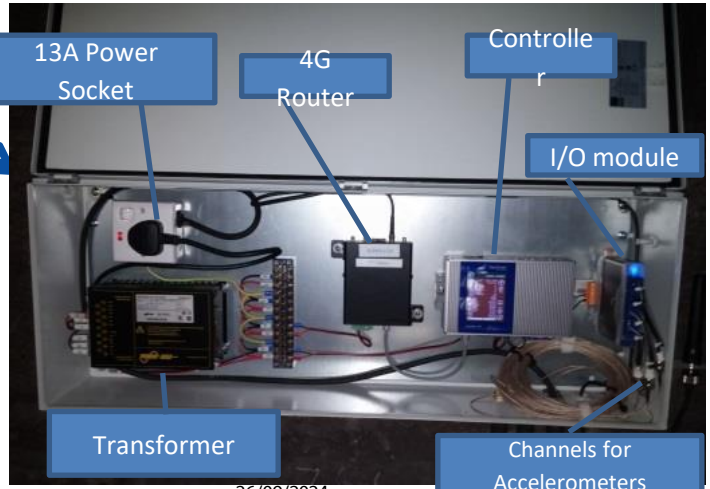
Typical instrumentation on the clamplock lockbody

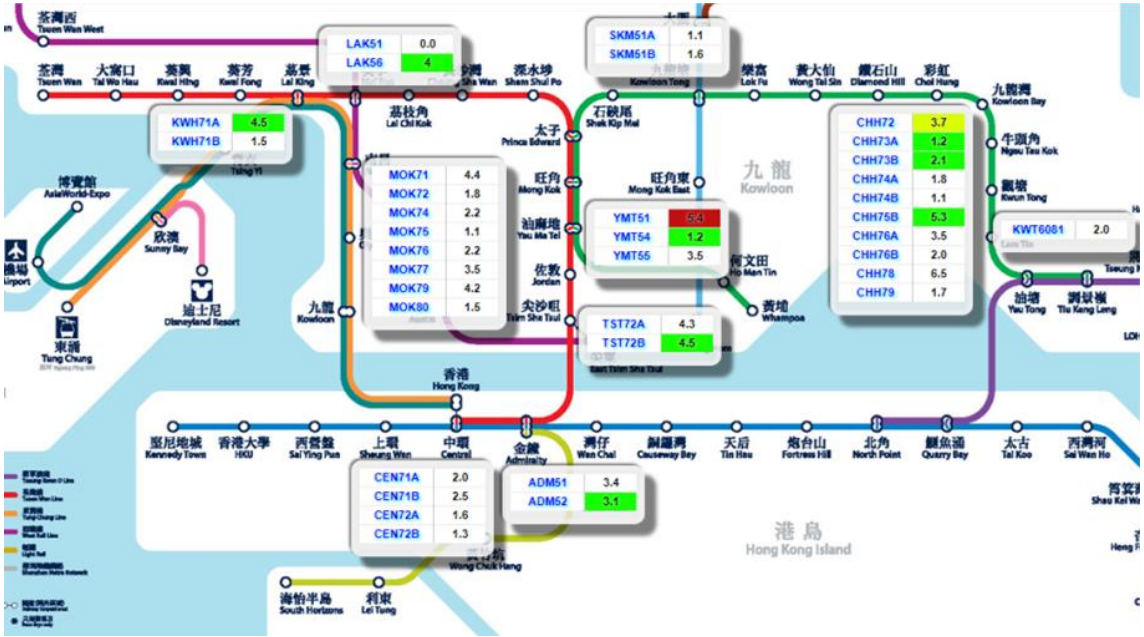
1a & 2a
For PDU Vibration Monitoring

• Trackside Setup

• System Architecture







Network of Point Vibration Sensors in MTR

Data Feature Engineering

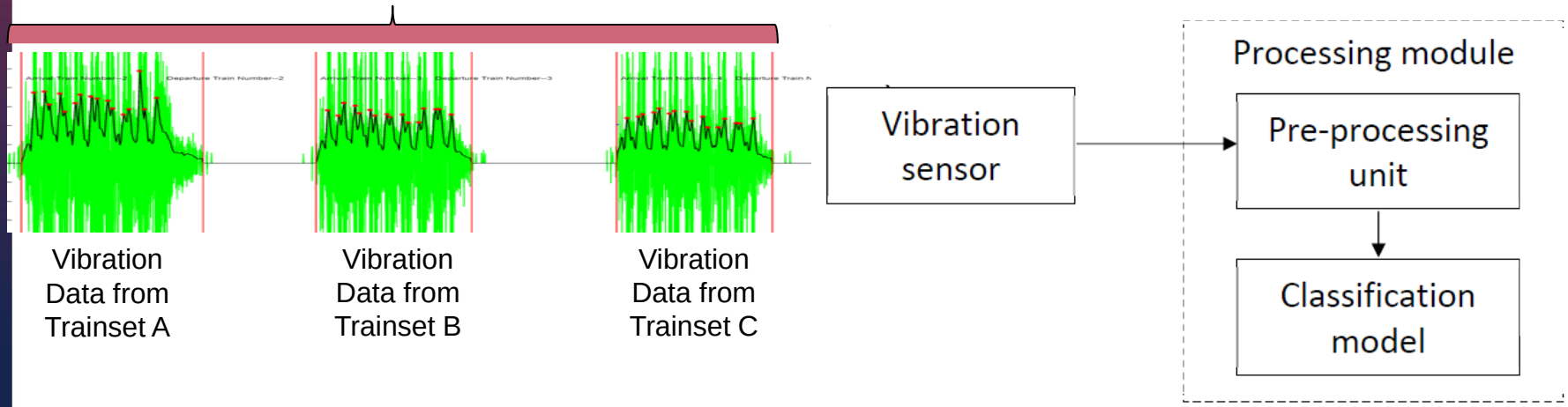
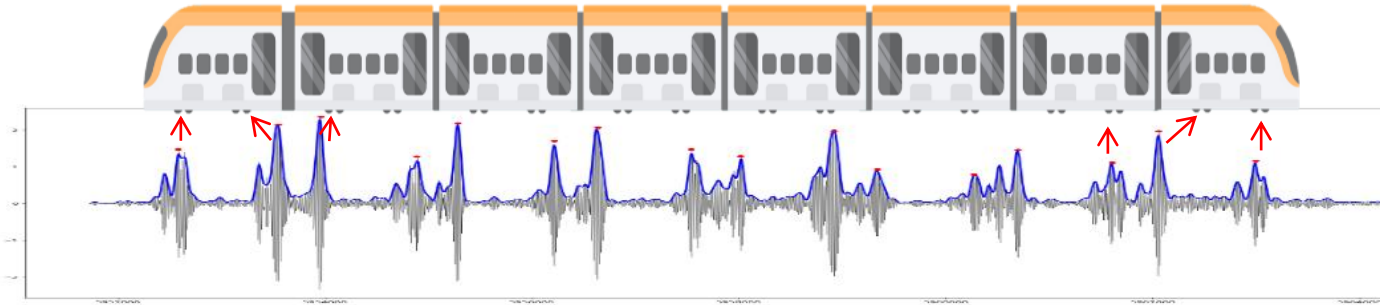


Fig. 2

Step 2- Classification mode

Machine Learning Algorithm:

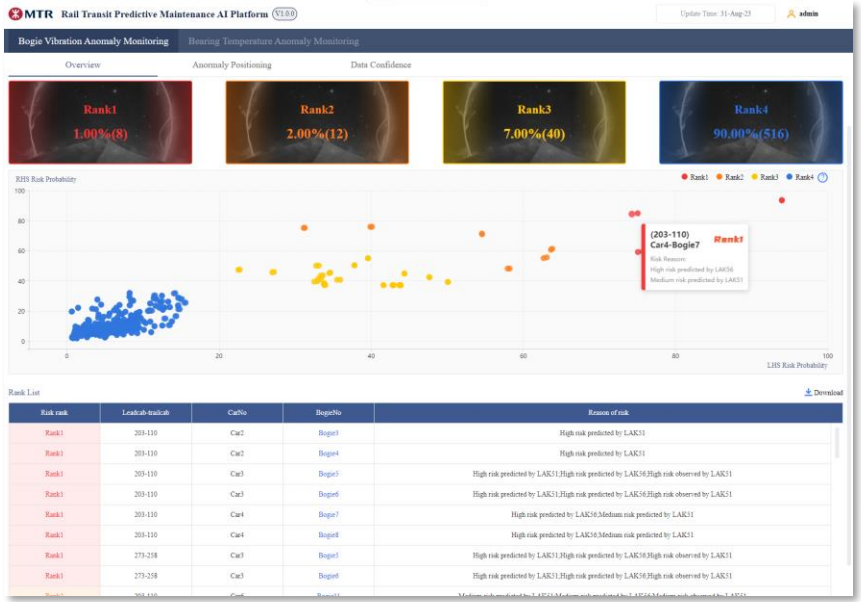
- Develops algorithm on Bogie identification
- The algorithm detect the wheel-rail interacting time.
- The program calculates the local maxima by machine learning.
- From validation ~90% Accuracy



Bogie Universe

Bogie Risk Rank

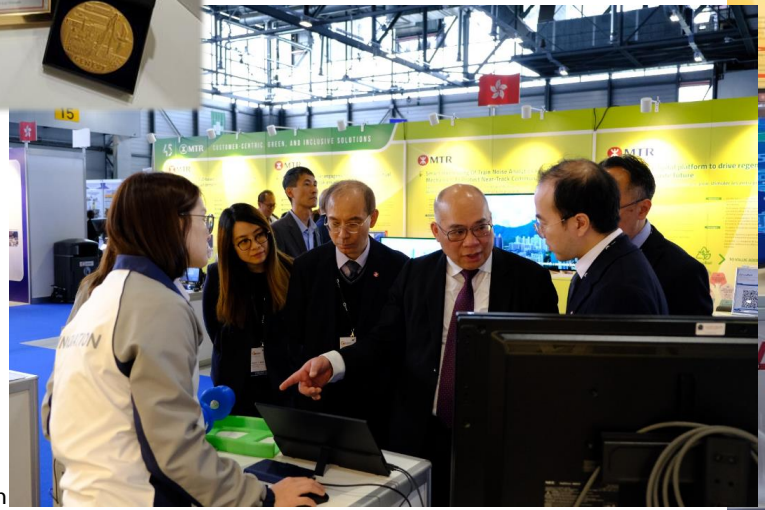
Defect **prediction** and maintenance prioritization



Bogie Health Profile

User interface for **monitoring**

Geneva Inventions 2024



MTR Corporation

The Smart Railway Journey Has Begun