NDT-RELIABILITY

THE ROLE OF RAILWAYS

APPLIED VALIDATION

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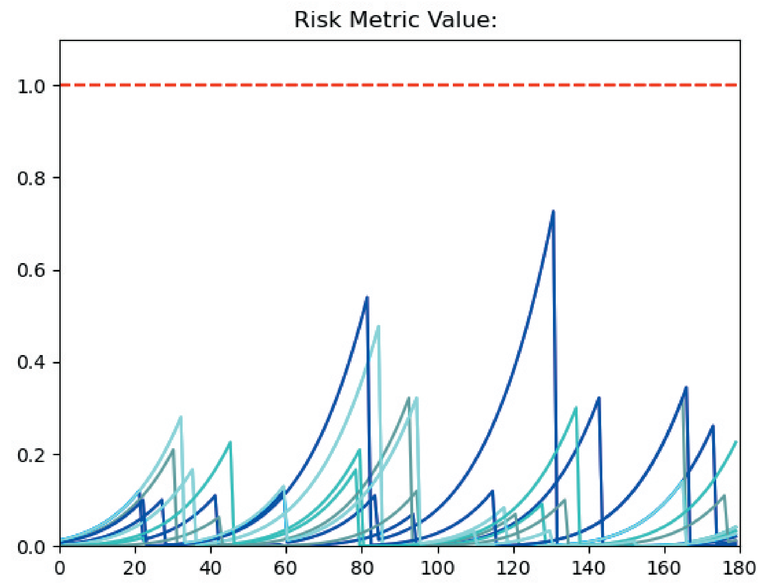
NDT reliability is commonly used—and often mandatory—in the field of public and military aviation due to the potential disastrous consequences of a failing part. However, it is not as widely used in the railway industry. This discrepancy may be due to the origins of NDT reliability evaluation, which focused primarily on aviation.
In recent years, advancements have made these evaluations more cost-efficient, providing the potential for broader application across various industries. These industries, which also rely on NDT to prevent catastrophic failures, can now adopt advanced NDT reliability models to enhance maintenance routines and improve overall quality.

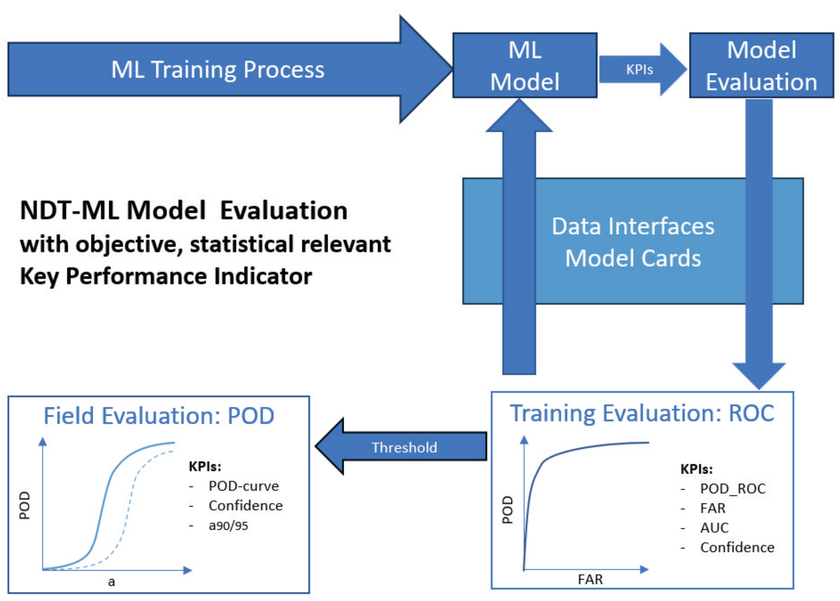
Predictive Maintenance

In an ideal scenario, testing should be conducted at the optimal point in time, using the most appropriate method. This is particularly crucial given the unpredictable nature of loads and fatigue in rail materials. Conducting tests too early incurs unnecessary costs, while testing too late can lead to devastating catastrophic events.
To optimize the testing procedure, especially with variable inspection intervals, it is essential to understand the testing capability and to monitor the loads. This approach ensures that inspections are both timely and effective, balancing cost efficiency and safety.
The Probability of Detection (POD) provides a crucial insight into the effectiveness of an inspection method, specifically addressing the question of the largest defect that might be missed during inspection. By integrating validated fracture mechanics models with the POD of the testing equipment and the interval to the next inspection, a risk metric value (RMV) can be calculate. This RMV is a comprehensive measure that combines the following elements:
Fracture Mechanics Models: These models predict the progression and potential failure of defects within the rail material.
POD of Testing Equipment: This determines the likelihood of detecting defects of various sizes.
Inspection Intervals: The time between successive inspections, which affects the probability of detecting defects before they become critical.



By maintaining the RMV below a specific threshold, the safety of the rail network can be ensured. This method allows for a prioritized approach to inspections, making it easier to plan and manage the order of testing specific rail segments based on their RMV. However, for this approach to be effective, the POD must be accurately evaluated.

AI Support - Optimising NDT on Rails

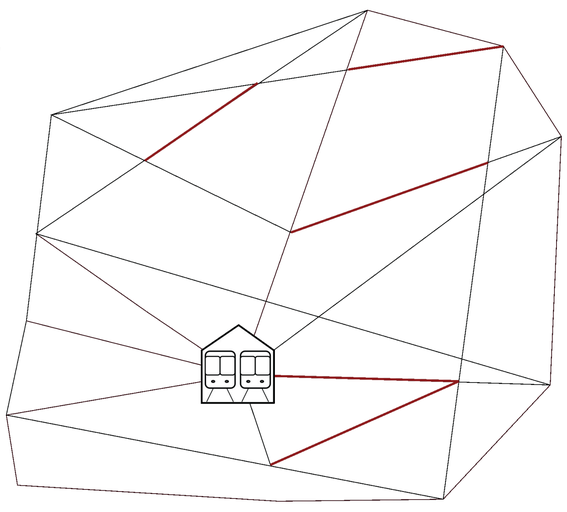


To gain trust in AI for Non-Destructive Testing (NDT), the algorithm must consistently perform according to the established criteria of NDT Reliability. This reliability is typically defined by the system's ability to detect, characterize, and minimize false calls. One of the most critical parameters in this context is the Probability of Detection (POD), which provides an objective measure of an NDT method's detectability across a range of defect sizes. To objectively evaluate AI algorithms within NDT, the RESa score has been developed. The RESa (Reliablity of Evaluation Study) score is a metric designed to assess and compare the performance of AI algorithms in NDT against traditional testing scenarios.
The task of the RESa is to evaluate AI's capability to detect defects across different scenarios and defect sizes, aligning with the traditional NDT methods.

$$RESa = \frac{a_x}{a_{IC}}$$

Advanced Method of Routing Problem

To efficiently manage the testing and maintenance of rail infrastructure, prioritization and optimal resource allocation are essential. The Risk Metric Value (RMV), which leverages the Probability of Detection (POD), serves as a critical tool for this purpose. By incorporating RMV into advanced logistical models such as the Vehicle Routing Problem (VRP), it is possible to optimize the routing of testing trains to ensure thorough and timely inspections while considering the reliability of the testing systems and the potential loads of the rail sections.
The VRP is a combinatorial optimization problem aimed at determining the most efficient routes for a fleet of vehicles to service a set of locations. In the context of rail inspection, the vehicles are testing trains, and the locations are rail segments.By integrating RMV into the VRP, we can prioritize rail segments based on their risk levels and plan optimal inspection routes accordingly.



This methodology enhances safety, reduces costs, and improves the overall reliability of the rail network. Not only leveraging advanced statistical and logistical models but also aligning with modern practices in predictive maintenance and risk management.

Based on the AI system developed by in AIFRI - a collaboration project, funded by the research program mFUND IT, tools are used to improve the maintenance of rail-infrastructure.