ETH zürich

Center for Sustainable Future Mobility (CSFM)

On board Monitoring for Integrated Systems Understanding & Management Improvement in Railways (OMISM)

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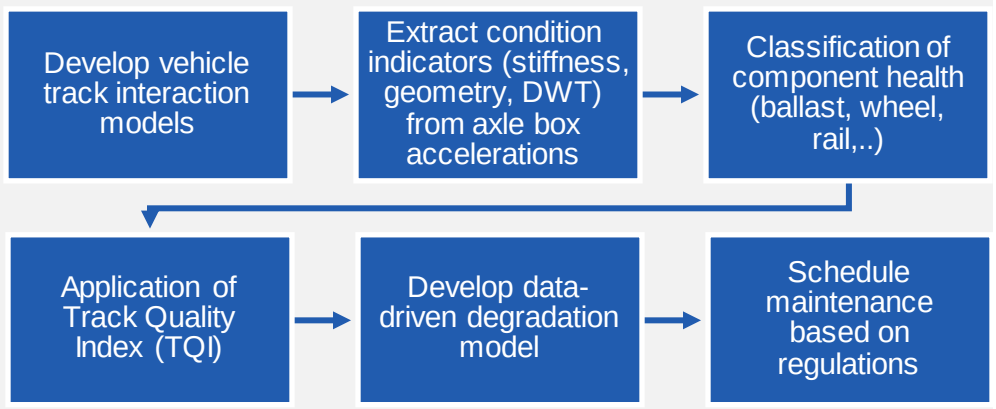
1 Introduction

OMISM aims to exploit the power harnessed from On Board Monitoring (OBM) data from in-service trains. We develop new approaches and models assess the condition of railway infrastructure, and use this to build decision support tools for optimal maintenance scheduling with considerations of practical regulations.

2 Methods

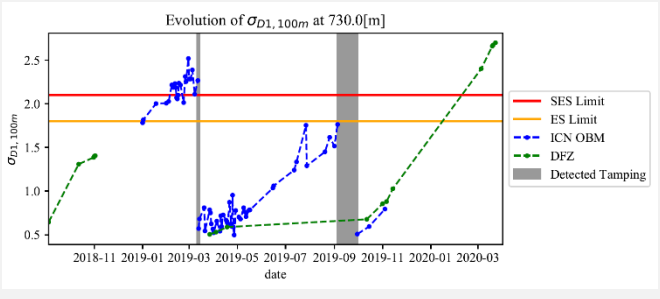
- **Work Package 1 (WP1):** Development of data-driven and hybrid indicators of condition. Hybrid models rely on physics drawn from vehicle-track interaction models that allow tracking of vehicle-track forces and accelerations. Data-driven detection of track stiffness and classification of irregularities (surface defects, insulated joints, welds).
- **Work Package 2 (WP2):** The different characteristics between various Track Quality Index (TQI) are analyzed, while some are used to develop Markov or linear regression track degradation models. The relations between TQI and related true/false alarm failures are investigated with effects on availability and costs evaluated to achieve effective maintenance scheduling.



The process flowchart for the OMISM project

3 Data description

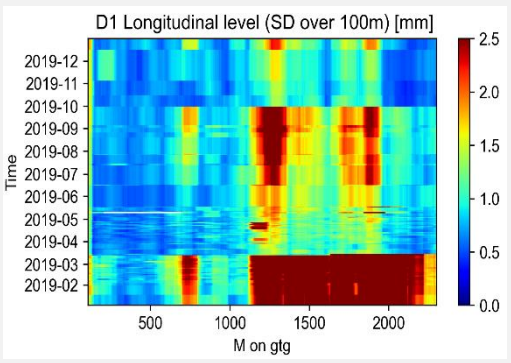
- **Fixed asset information:** components, load, maintenance history.
- **DFZ data:** Measurement data, such as vertical defect, horizontal defect, twist, gauge and etc., measured by a specialized diagnostic vehicle with high precision sensors, at scarce intervals.
- **Processed ICN data (OMISM):** On Board Monitoring (OBM) acceleration data from in-service ICN trains with frequent measurements. Processed to meaningful indicators by OMISM. Time history of track deviations in short (squats, welds …) to long wavelengths (track geometry).
- **ZMON data:** Condition logs from all performed inspections including visual and DFZ train inspections.



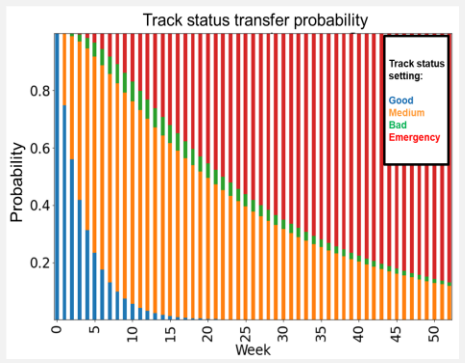
The standard deviation of D1 Longitudinal level over 100 meters for ICN and DFZ data at 730 m.

4 Results and discussion

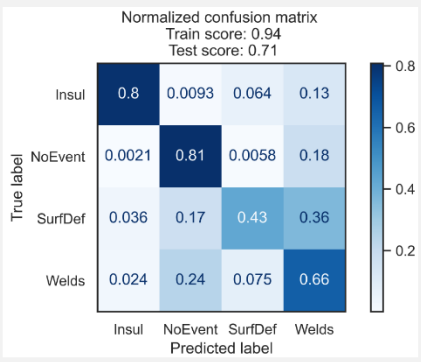
- Results show that despite lower precision, OBM data can better capture the degradation process of the track than traditional inspection train data (DFZ) due to higher data frequency. Several applications of this new data set are therefore explored (short wave defect detection and prediction).
- The developed OBM-based degradation models closely follow the trend captured by DFZ data, which proves its capable of scheduling maintenance with performance similar to DFZ data in long term. Its capability of showing detailed degradation process also made it useful for scheduling urgent maintenance.



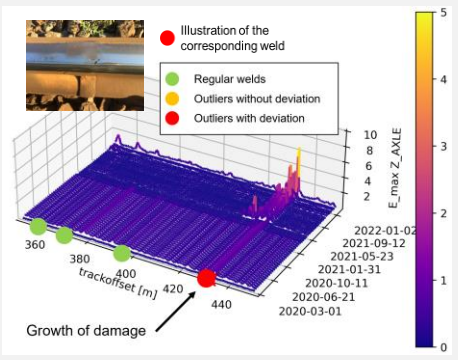
The heatmap for ICN data for the standard deviation of the D1 longitudinal level



The developed Markov prediction model based on ICN data



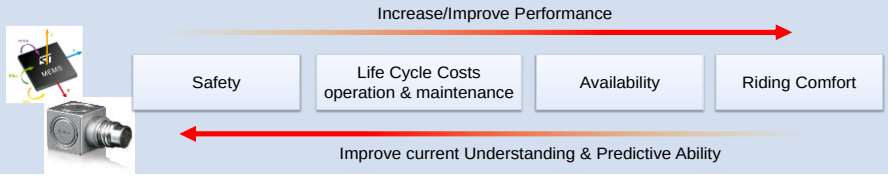
Random forest for short wave defect classification.



Weld condition monitoring using time series analysis and Bayesian Networks.

5 Conclusion and expected impact

- OMISM achieves a paradigm shift with OBM:
  - OBM data can be collected at a much higher frequency and low-cost, without affecting the traffic.
  - Equivalent track geometry between DFZ and OBM in average.
- Lower cost OBM techniques prove mature to assist in practical infrastructure management and predictive maintenance.
- Further work in **WP1** will extend data-driven defect classification bringing expert input in the loop. **WP2** will extend true/ false alarm failures prediction to support the scheduling of maintenance.



References

1. Yan, Tzu-Hao, and Cyprien Hoelzl. "OMISM-On board monitoring for integrated systems understanding & management improvement in railways." International Rail and Mobility Conference (nextRail19). 2019.
2. Hoelzl, Cyprien A., et al. "Axle Box Accelerometer Signal Identification and Modelling." Model Validation and Uncertainty Quantification, Volume 3. Springer, Cham, 2020. 87-92.
3. Hoelzl, Cyprien A., et al. " On-board monitoring for smart assessment of railway infrastructure: A systematic review", The Rise of Smart Cities, Butterworth-Heinemann, 2022. 223-259
4. Yan, Tzu-Hao, and Cyprien Hoelzl. "Prediction of optimal track renewals from acceleration based longitudinal level." Ongoing paper, 2022

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