Graz University of Technology
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Intelligent Track Maintenance Works

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Prologue

Maintenance is…

- Inspection
- Failure Repair
- Maintenance
- (partly) Renewal | Improvement

Condition-based Maintenance

Predictive Maintenance

Prescriptive Maintenance

Measuring
Automatized & Loaded | Standardised & Re-producible

Post-Processing
Positioning & Precise-Positioning | Outlier Detection & Cleansing

Data Analysis I
Descriptive | Statistics (Regressions) | Prognosis

Data Analysis II (Time Series netwide)
Descriptive | Statistics (Regressions & Matrices) | Prognosis (Life Cycle)

= Intelligent Maintenance? Intelligent Maintenance Planning…

Prescriptive Maintenance

The main aspect of this next step in maintenance planning is the analysis of the asset beyond the next maintenance intervention.

We forecast how the asset will behave due to the maintenance foreseen.

Topics:

- Maintenance Type ✓
- Intervention Level ✓
- Quality Improvement ✓

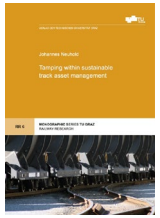
Descriptive data analysis only works with fixed „parameters"

Analysis executed for track tamping (ballast maintenance):

Strong influence of the intervention level on

- quality reached after maintenance
- quality deterioration after maintenance

Maintenance planning (prescriptive) needs to base on variable intervention levels → today's regulations?



Neuhold, J.: Tamping within sustainable track asset management, 2020

Quality improvement as statistical, average value in descriptive modelling

What happens during the maintenance process?

Paradox: We know that quality and its behaviour over time is highly variable, but we execute maintenance with constant parameters

Time to move on towards intelligent Maintenance Works!

Desired Maintenance Process:


Maintenance Planning | Prescriptive Maintenance → optimal point in time for Maintenance


Detailed Assessment of current Asset/Component Condition
Measuring and Analysis live(!) on-board the Maintenance Machinery!


Maintenance Execution due to current Asset/Component Condition
Defining Machine Settings and Working Speed


On-board Quality Control


Upload of Asset Condition Data for back-office Analysis (Prescriptive Maintenance)

Track Tamping

Maintenance Planning

Detailed Assessment of current Ballast Condition

The maintenance work Levelling-Lining-Lifting-Tamping is executed in order to re-establish track geometry in vertical and lateral direction.

Tamping treads the ballast bed, but does not maintain the ballast

Tamping needs certain ballast properties → Ballast Assessment

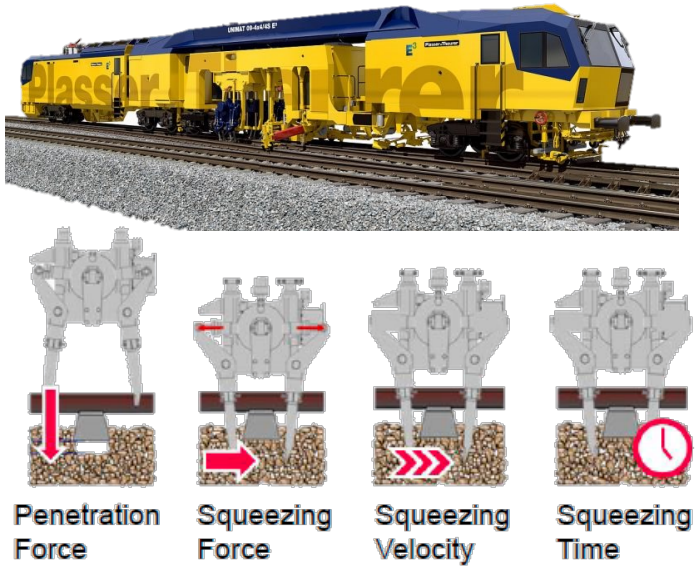
Ballast Assessment

Ballast assessment is a tricky job as we do not measure the ballast properties, but the (relative) geometry of the ballast bed in standard inspection.

Special analyses help to get a good estimate on the ballast condition from the wave-length specific longitudinal measurement (Fractal analysis).

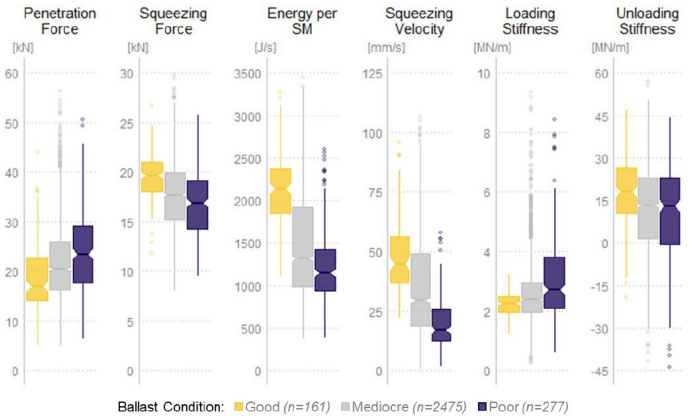
Ground Penetrating Radar can also provide data for a ballast condition assessment – but not as a standardised, frequent and netwide measuring up to now.

→ Assess ballast quality while tamping: the BETamp Project (EBW with P&T, ÖBB and SBB)



Example: it needs a higher penetration force in case of poor ballast

First Task: Learn which parameters are good indicators for the "ballast quality"



Track Tamping

Again, it will take years, but it's worth the effort!
(And we will be faster due to our new tools and skills)

Maintenance Planning

Detailed Assessment of current Ballast Condition

The maintenance work Levelling-Lining-Lifting-Tamping is executed in order to re-establish track geometry in vertical and lateral direction.

Tamping treads the ballast bed, but does not maintain the ballast

Tamping needs certain ballast properties → ballast assessment

Tamping also deteriorate ballast quality

Maintenance Execution due to current Ballast Condition
Defining Squeezing Force, Squeezing Time, Frequency, Number of Penetrations → Working Speed

On-board Quality Control

Upload of machine settings used and measured forces → back-office Analysis → estimated/expected Quality Improvement of next Tamping → Tamping still the right Choice? (or Ballast Cleaning?)

Intelligent Track Maintenance Works

For other maintenance works, it might be less sophisticated.

Rail Grinding

- Maintenance Planning | Prescriptive Maintenance → constant intervention level (e.g. 1mm crack depth)
- On-board Quality Control (crack-free rail)
- Maintenance Execution in accordance with Component Condition
  Working Speed → Temperature → Pre-damage of Rail Surface (White Edging Layer)

Intelligent Track Maintenance of tomorrow will be

data-driven, algorithm-based Maintenance Planning
based upon a long-term Optimisation, technically and economically

&

data-driven, algorithm-based Maintenance Execution
based upon a long-term Optimisation, technically and economically

And the biggest challenges will be to get this implemented at the infrastructure managers.

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