Using Measuring Data to Improve Maintenance Planning and Quality*

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*AKA: Capitalizing on Remote Diagnostic Technologies for Measuring Track Geometry: Identifying the Parameters Being Measured and How the Information is Used as Part of an Integrated Maintenance Strategy That Reduces Life-Cycle Costs
Agenda

*What I will present today*

- Our approach to using measuring data for planning and quality checking track tamping maintenance operations
  - Short general summary about the maintenance cycle
  - Information about measuring data
  - Parameters important for tamping
  - Tamping Planning Algorithm for IRISSYS
  - Improvement due to Tamping analysis
  - Conclusion and final remarks
(Tamping) Maintenance Planning Cycle

*Inspection, analysis (planning), and realization*

- Inspection
  - Run a measuring car, and collect data
- Analysis
  - Look at the data, and generate need
  - Then plan how to get it realized
- Realization
  - Carry out the work in track
- Inspection, analysis, (re-work)…
Inspection

Collect the condition data of the track

- A universal measuring car operates in Denmark six times a year

- It collects data for both permanent way and OCS, with up to 120 km/h, for every 250 mm (sample rate), for a lot of parameters...
Result: A huge data set (even for our small network)

Let me illustrate...

- If we print a measuring campaign of our entire network (3200 km) out on A0 paper (841x1189 mm) with standard text size, and put them on a football field we would end up with:
  - 57150 pieces of paper, each containing 56 meters of data, which will cover 14.2 acres or 8½ football fields.
Processing the data

*Identifying bad track condition*

- Imagine: You get 1000 of these pages in hand, and must find all the places where one of the values exceed a specific threshold...
  - You would go “blind” after a few pages
- The best way to avoid this is to convert the numbers to graphs and color the thresholds
  - That makes it significantly easier to read
- Or even better; make a computer analyze the data for you
Condensing the data

*Finding a good indicator for need of track tamping*

- Track tamping is the process of improving geometric track quality by lifting and lining the track, while tamping the ballast to maintain correct geometry.
- Experience in Rail Net Denmark shows that 90% of all tamping is caused by level (vertical) geometry.
Level (vertical) geometry

Continuous vertical deviation from reference line

- The raw input, one measurement each 250 mm, is not very useful when planning for an entire network
- Therefore, the standard deviation is calculated for each 200 meters
  - When this exceeds a specific threshold (gets green), the track should be tamped next year
Tamping planning by hand

*In time of memorial (4 years ago)*

- My first task as student helper: Plan tamping from measuring diagrams showing level standard deviations, and put it into an Excel-sheet...

- A job quickly getting routine...
I am an engineer, so I thought: “It must be possible to do this in an easier way”

And that resulted in a custom university course

- Together with a fellow student, I made a special course at the university in coorporation with Rail Net Denmark and created the Tamping Planning Algorithm for IRISSYS (BDK’s measuring data asset management system)
Tamping Planning Algorithm

A-grade and €34.000 granted by the manager – and now used as standard

- After the university project was finished, the section manager for tracks granted €34.000 for its programming
- And now it is used as standard tool in BDK for planning preventive tamping
Tamping Planning Algorithm (TPA)

So what is it..?

Apart from “just” making the same as on paper, the TPA was enchanted by adding different optimizations:

- Transition curve analysis
- Smart distance between tamping sections
- Inclusion of nearby isolated defects
- Intersection analysis of obstructions
- Defect growth rate projection analysis
- And planned for the future: Interface to SAP (BDK’s enterprise resource planning system)
Tamping Planning Algorithm

*Transition curve analysis*

- A tamping machine can neither start nor stop in a transition curve
- The curvature register is implemented in IRISSYS
- So if the requirement based on standard deviations starts/stops inside one, it is automatically extended
Tamping Planning Algorithm

Smart distance between tamping sections

- A tamping machine is large, and it is time consuming to stop, move, and start
- So in some cases it is more feasible to make continuous tamping
- This is implemented in the algorithm
Tamping Planning Algorithm

Calculation of smart distance

- The smart distance is calculated by:
  - Working speed ($V_J$)
  - Transport speed ($V_{SP}$)
  - Time for start/stop ($t_{AR}$)
- For a P&T 08-32, by Danish operational rules, it is about 312 meters

\[ d \leq \frac{2t_{AR}}{\frac{1}{V_J} - \frac{1}{V_{SP}}} \text{ if and only if } \frac{1}{V_J} > \frac{1}{V_{SP}} \]
Tamping Planning Algorithm

*Inclusion of nearby isolated defects*

- If there is an isolated defect nearby a tamping section, it is cheaper to include it in maintenance tamping than doing spot tamping
- This analysis is iterated three times in the algorithm
Tamping Planning Algorithm

*Intersection analysis of obstructions*

- Master data regarding components which must be dismounted prior to tamping has been imported to IRISSYS
- These obstructions are found by simple intersection analysis
Tamping Planning Algorithm

Defect growth rate projection analysis, $\Delta \sigma_H$

- To substitute the knowledge of the track engineers about problem spots, a defect growth rate projection has been implemented.
- It is empirically based on a percentile of all gradients between measurements of standard deviation within the previous 3 years.
Tamping Planning Algorithm

Result of algorithm

- The execution of the algorithm is prepared by priming all parameters
- After that an application is executed
- And two hours later, the entire requirement for preventive tamping is ready
  - Due to its speed, it is easy to create several scenarios for the management to choose from according to budget-restraints
Tamping Planning Algorithm

*SAP interface*

- To ease the communication with the contractor, an interface to SAP (ERP-system) is being designed at the moment.
- When it is implemented all work orders will be send automatically to SAP, and the current status back to IRISSYS.
- In SAP it will be possible to have the full asset overview, including activities not planned in IRISSYS.
Then the action is carried out...

*But*, is it done correctly?
Improvement due to tamping

Comparing standard deviations before and after tamping

- A high standard deviation trigger tamping, hence tamping must reduce it, and the size of reduction equals improvement due to tamping
- This can also be analyzed in IRISSYS
Improvement due to tamping

How to do the analysis by hand

1. Find tamping sections
2. Find $\sigma_H$ before tamping
3. Find $\sigma_H$ after tamping
4. Find difference $\Delta \sigma_H$
5. Make regression analysis on $\sigma_H$ before vs. $\Delta \sigma_H$
6. Compare benchmark value $(\Delta \sigma_H @ \sigma_H$ before $= 1.5$ mm)
Improvement due to tamping

Doing the same in IRISSYS

1. Open and execute application

That’s it – 30 seconds later the report is ready

Result: If $\sigma_{H_{\text{before}}} = 1.5$ mm then $\Delta \sigma_H = 0.367$ mm
Improvement due to tamping

What can that be used for...

– The number itself might not say much, but it has a large practical value
– It is incorporated in TAM II (Track Analysis Model), to predict number of tamping needed in a track’s life span
– Different machine and/or contractors can be benchmarked at their quality
Improvement due to tamping

*What can that be used for...*

- From benchmarking our own contracting department we have increased the quality with up to 37.5% over three years
- This has a 30 year LCC value of €200 million
Conclusion

Of the presentation

- By having an integrated measuring data analysis software, it is possible to analyze huge amount of measuring data in a fraction of the time it takes manually, and thereby making more effective use of the valuable time – and getting more effective maintenance.
Contact details

I am very interested in contact/networking regarding this subject – you are also welcome in Copenhagen for a discussion.

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