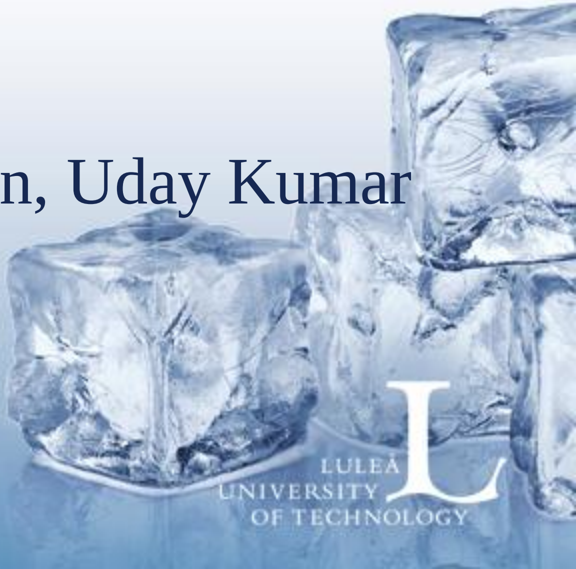
Luleå Railway Research Center JVT

Optimum Allocation and Utilisation of track possession time: A case study of tamping

Stephen Famurewa, Tao Xin, Arne Nissen, Uday Kumar



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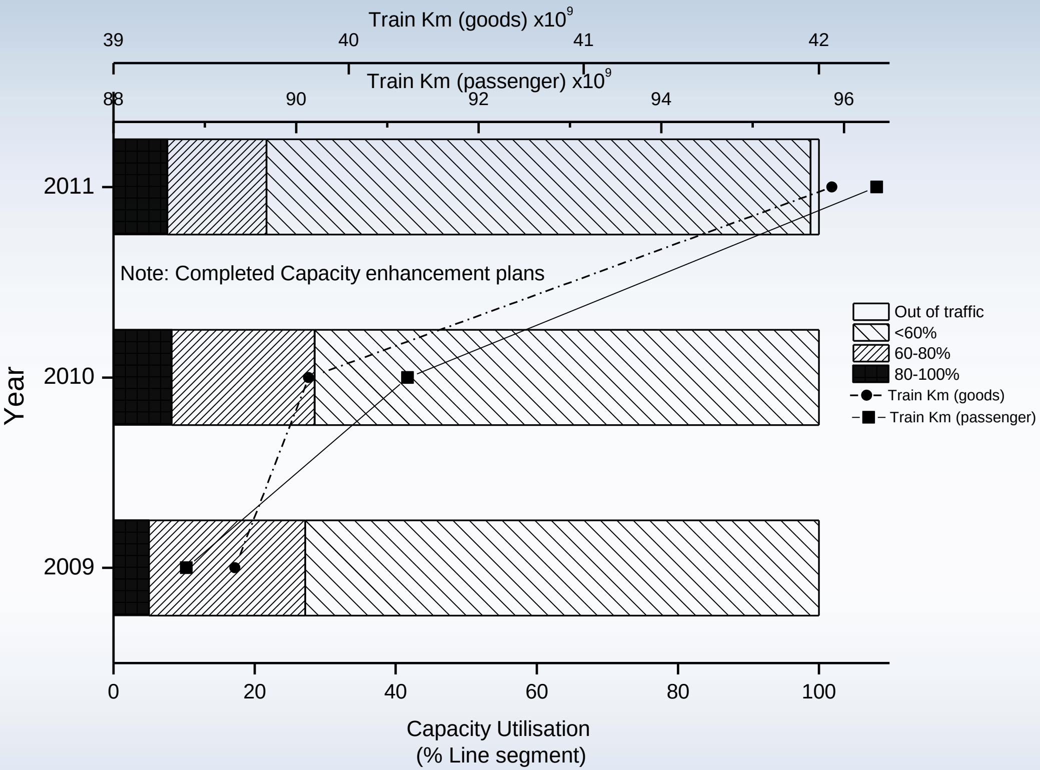
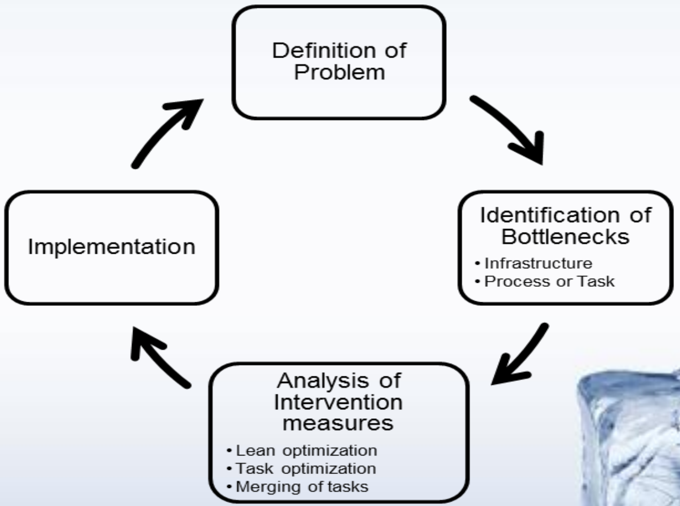
Introduction to project



Capacity assessment of Swedish transport administration network



Maintenance improvement Framework

Introduction to article

- Railway transport is expected to be competitive and sustainable transportation.
- Competitiveness requires increase in quantity (capacity) and quality of service.
- Sustainability ensures tomorrow's competitiveness is not limited by present performance.

Research Question

- Decision support for allocation and utilisation of track possession time (efficiency).

- Strategy to support quality (effectiveness) and sustain quality of track .

Track strategy =

Investment strategy + Maintenance strategy

Existing infrastructure

Railway Track Behavior

- Patience? During a period of inadequate maintenance, it is a relatively long time before the track shows signs of stress

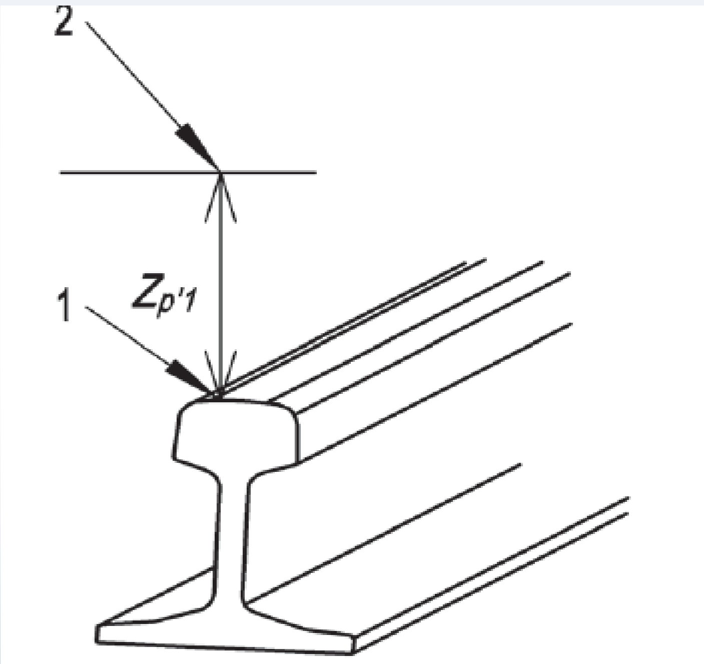
- Anger? The track reacts badly & irreversibly to a prolonged maintenance deficiency and could result into undesired consequence

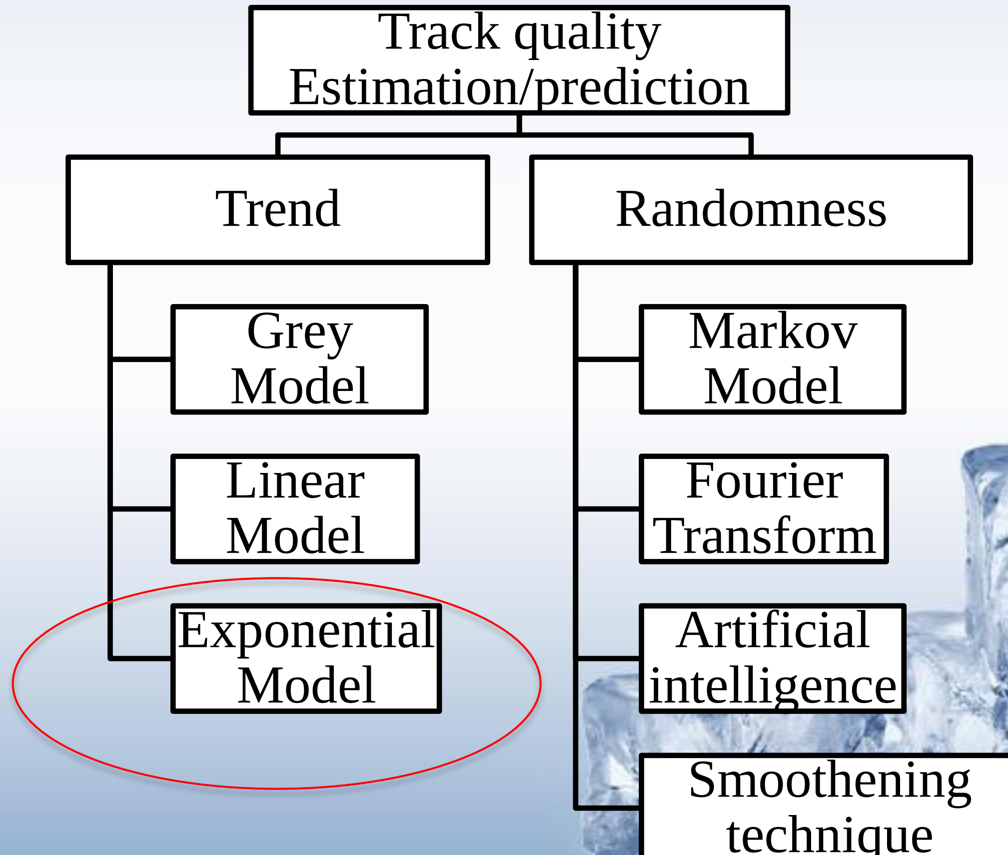
- Should we understand it then we can manage it- Track geometry parameters map this behavior

Conventional or derived parameter

Railway track behavior

- Track geometry quality EN 13848 1-6





Track geometry prediction

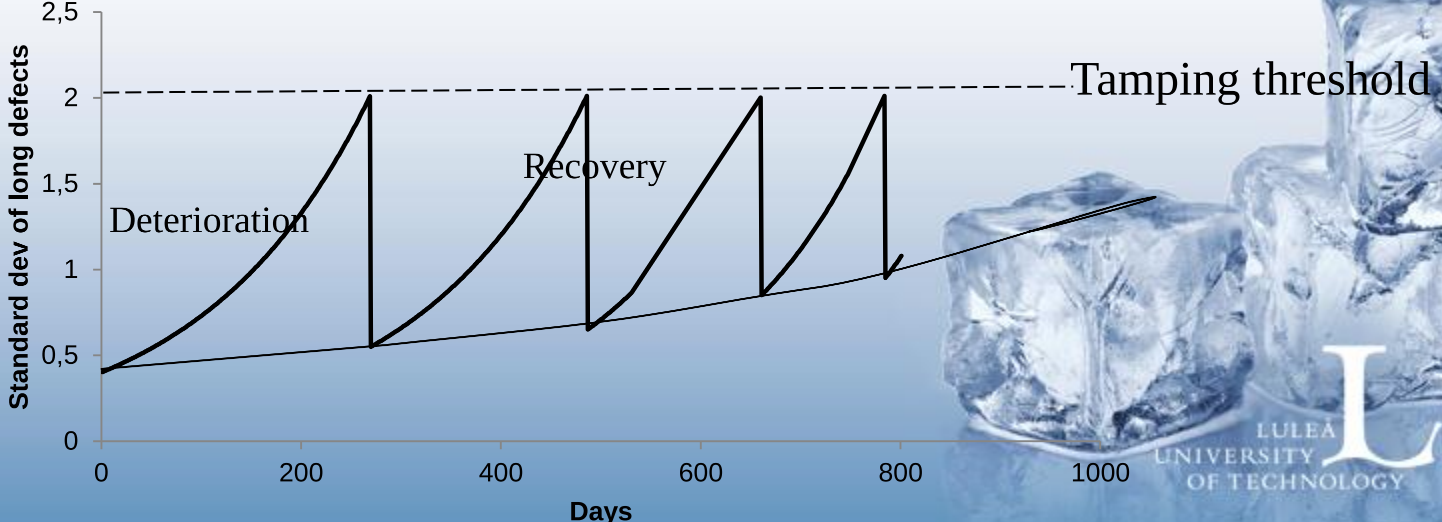
- Good track quality deteriorates slowly while poor one does rapidly

$$\frac{\Delta\sigma}{\sigma} = b$$

$$\frac{d\sigma}{dt} = b\sigma$$

solving the differential equation

$$\sigma = \sigma_o e^{b*t}$$



Existing tamping strategies

- Assumed degradation rates of the track geometry,
- Known critical/problem spots
- Track geometry data showing where problems are emerging
- Availability of the tampers itself
- Correction of isolated defects (c-failures)
- Line tamping when TQI becomes very low
- Advantage of short term saving but long term cost

Proposed strategy

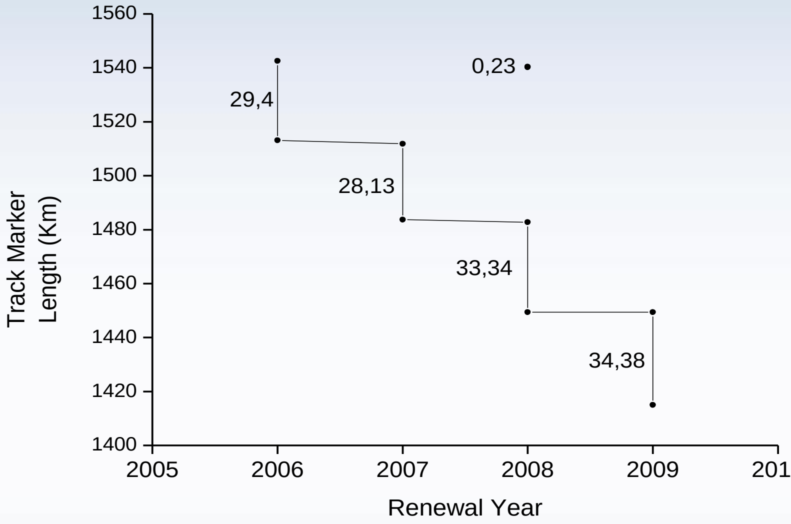
- Line tamping using mulitple sleeper tamper
- Spot tamping
- Both are based on longitudinal defect

Track possession time➔ Systematic + Spot tamping

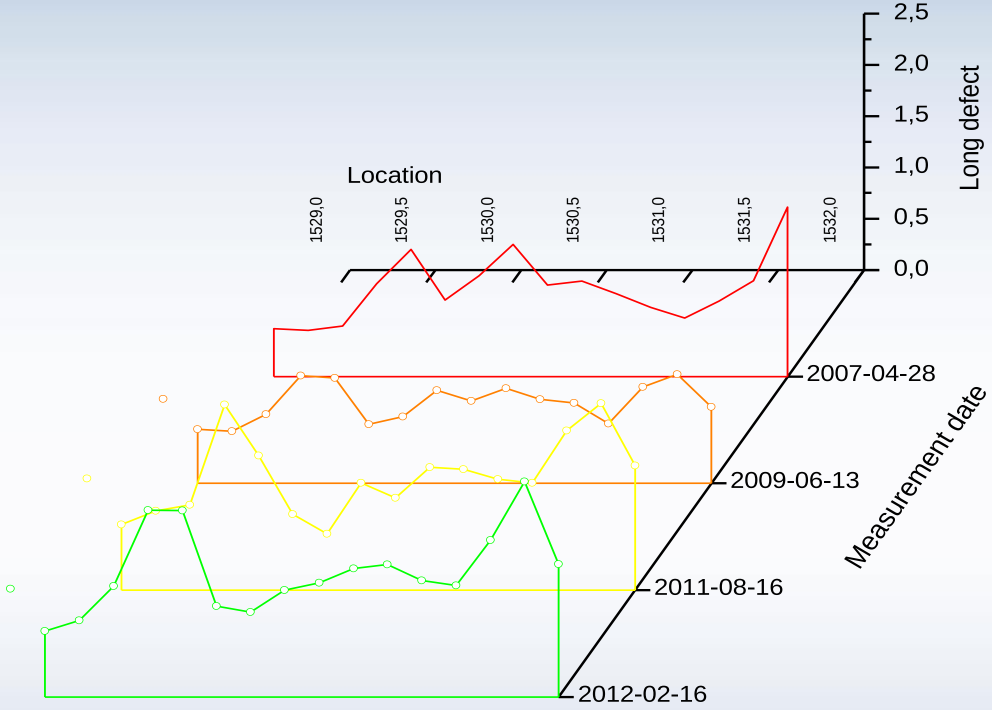
- Fix the root cause of isolated defects and not tamping

Case Study

- Northern section of iron ore line
- Length considered is ca 134km
- Divided into 200m segment
- Renewal period 2006-2009
- Special treatment for S&C, critical areas (stations) with recurrent c- failures or irregular measmt

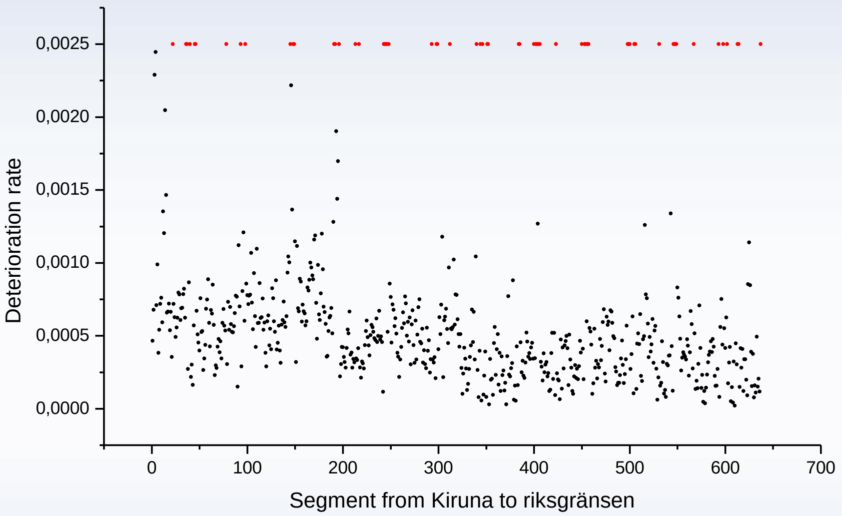


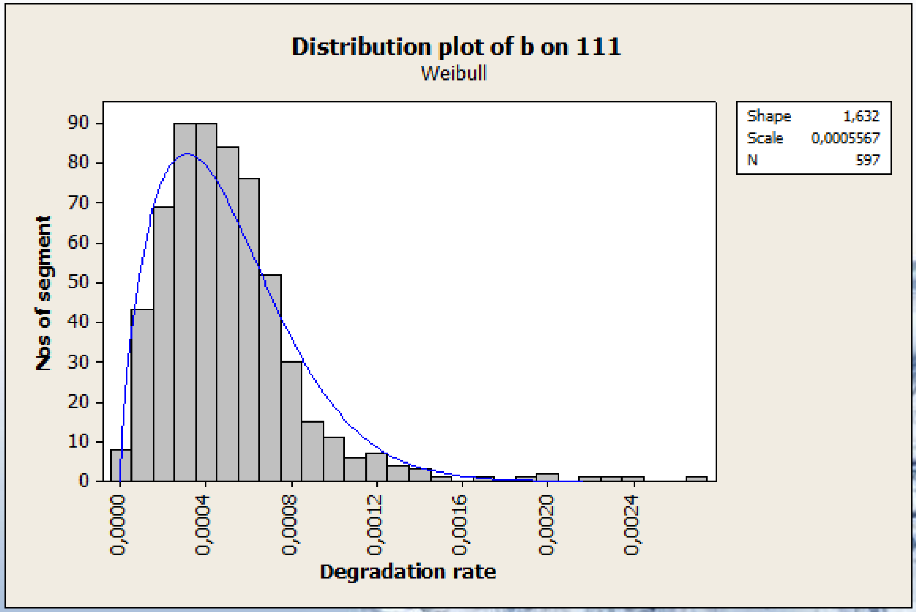
Track geometry measurement data



20 inspections from April 2007- Aug 2012

b with distance





Distribution of b

Modelling process

INPUT

V=tamping speed
u=travel speed
t_p=prepratn time
n=nos of segments
σ
b=degradatn rate
C_p
C_f
η_p
η_c
σ_p
σ_c
N_{np} = 1,2,3,......10
N=2years, 730 days

→

MODELLING PROCESS

Tamping strategy
1. Direct
2. Distributed

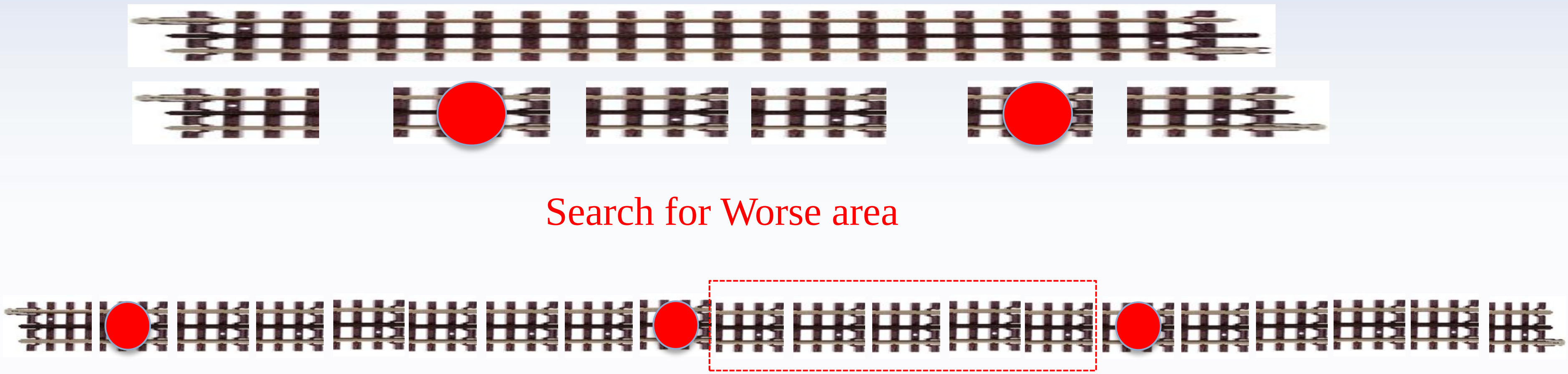
→

OUTPUT

N_{sp},
N_{sc},
$T.C_p$, $T.T_p$
$T.C_c$, $T.T_c$

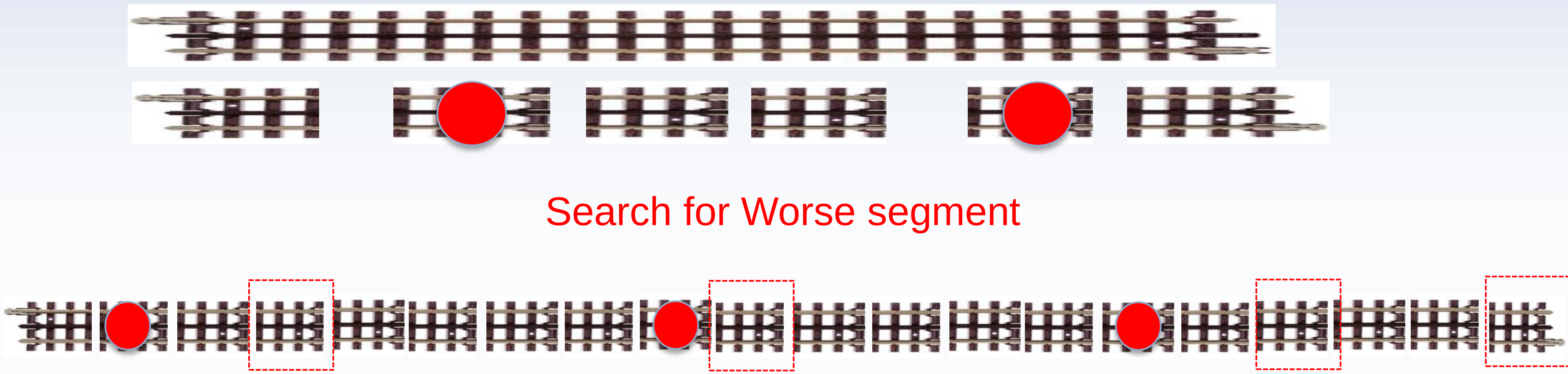
TC
TT

Modelling Process
Strategy 1: Direct

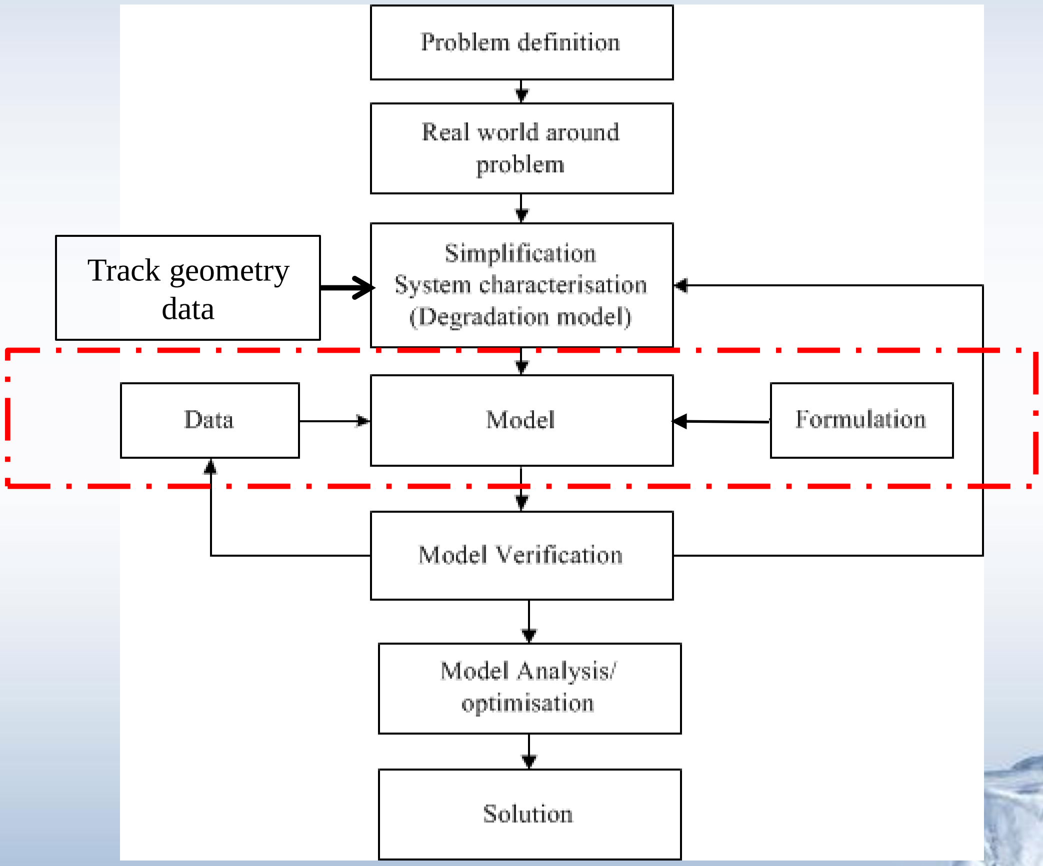


Each segment is characterised by σ, b, description of the quality and its evolution over time

Modelling Process
Strategy 2: Selective



Optimization Framework



Flow chart

Model Formulation

<u>Constraints & Limits</u>

Growth of defects $\sigma(s,t)=\sigma_o e^{b_s*t}$

When to tamp $\bar{\sigma}(nm,t)=\frac{1}{nm}\sum_{s}^{s+nm}\sigma(s,t)\geq\sigma_p \qquad (s=1,\cdots,N-nm)$

Otherwise when $\sigma(s,t)\geq\sigma_c$

Limit for a shift $\frac{s_o d}{v}+\frac{\Delta s_p d}{u}+\frac{(s_o+\Delta s_p)d}{v}\leq 6 \qquad (d=200m)$

Recovery or improvement

Table B.4 — Longitudinal level – AL – Standard deviation

EN:13858-5

Speed (in km/h)	Standard deviation (in mm) $D1$
$V \leq 80$	2,3 to 3
$80 < V \leq 120$	1,8 to 2,7
$120 < V \leq 160$	1,4 to 2,4
$160 < V \leq 230$	1,2 to 1,9
$230 < V \leq 300$	1,0 to 1,5

Model Formulation

Number of segments

$$N_{p(c)} = \sum_{1}^{s} \sum_{1}^{730} f\left[\sigma(s,t) - \sigma_{threshold}\right]$$

$$f(x) = \begin{cases} 1\,(x \geq 0) \\ 0\,(x < 0) \end{cases}$$

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Objective Functions

$$Total\ \cos t = \sum_{1}^{s} \sum_{1}^{730} \left(c_p * f_p + c_c * f_c\right)$$

$$f_p(s,t) = \begin{cases} 1, & \sigma(s,t) \geq \sigma_p \\ 0 & else \end{cases} \quad , \quad f_c(s,t) = \begin{cases} 1, & \sigma(s,t) \geq \sigma_c \\ 0 & else \end{cases}$$

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Optimization

i. The problem is a mixed binary non linear programming

ii. The optimization is done using FORTRAN.

iii. The expected output include

Result

- Estimation of tamping need (nos of segment that will require tamping over a period of time)
- Optimum number of systematic tamping for a given period of time
- Number of spot tamping for a given period of time under a specified specified preventive
- Expected track possession time for different scenario of the parameter combination

Conclusion

- Estimation of maintenance need is facilitated with this approach.
- The booking of tamping machine is enhanced and planning of tamping action.
- Desired geometrical quality of track can be supported and sustained in an effective way.
- Implementing this approach with a proactive way of treating isolated failure will contribute to long term cost saving and reduced track possession time.

Future work

- Introduction of multiple machine parks
- Emperical study of recovery or improvement.
- Accomodation of critical spots into the model
- Consideration of bandwith of exponential growth.
- Validation of model and improvement.


Plasser & Theurer

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THANKS

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