Framework for Railway Phase-based Planning

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Agenda

- Introduction
  - Track Behavior
- Life Cycle Cost
- Phase-based Planning Framework
- Policy Discussion and Case Study
- Conclusions
Introduction - Background

- Performance
  - Better Punctuality
  - More trains per hours
  - Longer operation hours
- Reliability

- Budget pressures
- Operational restrictions

How to improve the cost efficiency of railway infrastructure projects?
**Introduction - Track Behavior**

\[ Q = Q_0 \times e^{-b \times t} \]

- \( Q_0 \) denotes the initial track quality
- \( b \) is the rate of deterioration over time \( t \).
Life Cycle Costs approach

Reducing maintenance cost without reducing maintenance itself!
Why Life Cycle Costs – An Example

Achievements from the both sides?

- Higher quality Track
- Cheaper LCC (10%)
The Limitation of the Existing LCC Approach

- Planned Costs
- Unplanned Costs
  - Repairs
  - Track availability
- Passenger Loss
- Train Operators Costs
  - Train-Buses
  - Announcements
  - Rolling Stock Maintenance
- Riding Comforts
  - Vibration
  - Noise
  - Accidents
- Pollutions

![Image of graph showing Standard- vs. Postpone Maintenance]

<table>
<thead>
<tr>
<th>LCC</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Costs</td>
<td>130%</td>
</tr>
<tr>
<td>+ Train penalty</td>
<td>166%</td>
</tr>
<tr>
<td>+ Interates rate 3%</td>
<td>132%</td>
</tr>
<tr>
<td>+ Passenger Loss</td>
<td>142%</td>
</tr>
<tr>
<td>+ Working possessions</td>
<td></td>
</tr>
<tr>
<td>+ Train operators</td>
<td></td>
</tr>
<tr>
<td>+ Environment Impacts</td>
<td></td>
</tr>
<tr>
<td>...</td>
<td></td>
</tr>
</tbody>
</table>
Life Cycle Cost Scope

- A Larger LCC Scope
- Different Cost Types
- Planning is complex and time consuming
  → A planning framework is needed!
A Phase-based Planning Framework

Why phase-based?

- Input General Profiles
- Estimating Traffic
- Planning Maintenance and Renewals
- Possession Time Estimating
- Estimating the Failure Penalty
- Estimating the costs for Train Operators and Passengers
- Output the Overview of the Life Cycle Cost Annuity
Framework Outputs

Cumulated NPV

Life Cycle Cost Annuity

Track Behavior and Life Time

Life Cycle Cash Flow (NPV)
## Case Study - Policy Discussion 1

<table>
<thead>
<tr>
<th>High Quality Track</th>
<th>Low Quality Track</th>
</tr>
</thead>
<tbody>
<tr>
<td>- High Construction Cost</td>
<td>- Low Construction Costs</td>
</tr>
<tr>
<td>- Maintenance every 5 years</td>
<td>- Maintain it every 3 years</td>
</tr>
</tbody>
</table>
High Quality Track vs. Low Quality Track

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Quality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial Investment</td>
<td>3.500</td>
<td>4.500</td>
</tr>
<tr>
<td>Track Installation</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Maintenance</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Life Time</td>
<td>21</td>
<td>32</td>
</tr>
<tr>
<td>Maintenance every</td>
<td>3 years</td>
<td>5 years</td>
</tr>
</tbody>
</table>
High Quality Track vs. Low Quality Track

Life Cycle Cost Annuity

- Depreciation
- Maintenance
- Delay penalty
- Annuity
- Planned Unavailable Hours per year

High quality Track (Life Time 32 years) vs. Low quality Track (Life Time 21 years)

100% vs. 132%
Case Study - Policy Discussion 2

Positive renew
- Renew the track system when it reached threshold

Standard renew
- Maintenance the track when it reached threshold

VS.
Positive Renewal vs. Standard Renewal

Life Cycle Cost Annuity

<table>
<thead>
<tr>
<th>Life Span (years)</th>
<th>A: Life Time 25 years</th>
<th>B: Life Time 28 years</th>
<th>C: Life Time 32 years</th>
<th>D: Life Time 35 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25</td>
<td>28</td>
<td>32</td>
<td>35</td>
</tr>
<tr>
<td>Maintenance Amount</td>
<td>4</td>
<td>5</td>
<td>7</td>
<td>10</td>
</tr>
</tbody>
</table>

- **Interest Rate**: 0%
- **Gross Maintenance cost**: 500 DKK/meter
- **Average delay minutes per train**: 5 minutes
- **Average Cancellation factor**: 15 minutes
- **DKK per delayed train-hour**: 5,000 DKK
- **DKK Per cancelled train-hour**: 100,000 DKK
- **Line Length**: 5,000 meter
- **Double Track**: yes
- **Initial Investment**: 6,000 DKK/meter
Case Study

Concrete Sleepers

• Long Service Life
• Less Maintenance
• Higher axle-load

Timber Sleepers

• Cheap
• Less heavy
• Absorb forces
Case Study - Assumptions

<table>
<thead>
<tr>
<th>Items</th>
<th>Concrete</th>
<th>Timber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Life (years)</td>
<td>35</td>
<td>25</td>
</tr>
<tr>
<td>Price (per track-meter)</td>
<td>4.500</td>
<td>4.000</td>
</tr>
<tr>
<td>Tamping every</td>
<td>5 years</td>
<td>3 years</td>
</tr>
<tr>
<td>Life Time (without maintenance)</td>
<td>12</td>
<td>9</td>
</tr>
</tbody>
</table>
Case Study - Life Cycle Cost Overview

Cumulated NPV

Life Cycle Yearly Cost

- Depreciation
- Maintenance
- Operational Penalty
- LCC Annuity
- Planned Possession Time
Conclusions

• Life Cycle Cost Approach can improve cost efficient

• A larger scope of Life Cycle Cost gives a better cost picture

The purpose is to develop a so-called “Railway phase-based planning toolkit”, to help decision-maker, from the Life Cycle Cost (LCC) perspective, to plan the railway infrastructure project more economically. The new toolkit will be able to calculate LCCs in phases. So the Infrastructure Manager (IM) can use the outputs to compare different proposals, and to identify the most cost efficient solution.

Reduce overall costs without impacting quality!
Questions?