Life cycle planning & optimisation making use of a calculation and simulation model

Railway network Asset Management
Strategic planning with Simeo™

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Agenda

1. Introduction : what answers to what questions
2. Example 1 : Railway network maintenance planning with budget constraints
3. Example 2 : Optimisation of maintenance plan
4. Example 3 : How to choose the best renewal scenario
**Strategic planning : objectives**

- Ensure alignment between maintenance planning strategy & AM overall performance objective

For decision making related to maintenance plans with measurable indicators:

- Infrastructure **performance**
- Management **of overall costs**
- Level of services, cost of risks...: **Residual risks**

**Strengthen & improve objectivity**

**Overall Asset Portfolio**
What answers to What questions?

▪ How to **negotiate** budget? ➔ Have objective arguments to negotiate upstream to decisions
  ✓ Long term **Needs**?
  ✓ Short term **Performance**?
  ✓ **Risk** from short to long term?

▪ How to deal with a budget plan? ➔ Identify levers to ensure to optimize **budget allocation** and reach objectives downstream to decisions
  ➢ Identify **Key maintenance action** for infrastructure performance
  ➢ **Minimize life cycle** cost
  ➢ Identify **potential saving opportunities** on the short term depending on:
    ✓ Expected performance targets
    ✓ Residual risks the Infrastructure is ready to cope with
What answers to What questions?

- Which parameter to play with to adapt my strategy and what would be the “price” to pay?
  - Lifetime extension vs failure probability
  - Maintenance intervals vs
    - Scheduled unavailability
    - Risk (unscheduled unavailability)
  - Maintenance typology vs criticality of risk

Scenarize and compare trends
Railway Network Exercise 1
Railway Network Exercise 1

- Network breakdown: railway network
  - ≈ 55km of tracks
  - 12 Switches and crossings, ≈ 1km
  - 4 bridges

- Type of assets:

<table>
<thead>
<tr>
<th>COMPONENT TYPE</th>
<th>Technical domain</th>
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<tbody>
<tr>
<td>Bridges</td>
<td>Tracks</td>
</tr>
<tr>
<td>Metallic bridge</td>
<td></td>
</tr>
<tr>
<td>Prestressed concrete</td>
<td></td>
</tr>
<tr>
<td>1971</td>
<td></td>
</tr>
<tr>
<td>Reinforced concrete</td>
<td></td>
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<tr>
<td>&lt; 1971</td>
<td></td>
</tr>
<tr>
<td>Switches</td>
<td></td>
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<tr>
<td>Straight track</td>
<td></td>
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<tr>
<td>Curved track</td>
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</table>
Age Pyramid (1/2)

- Tracks:
- Preliminary analysis of needs

Diagram showing age distribution of different types of tracks:
- Straight Track – 32y
- Curved Track – 30y
- Switches – 27y

Obsolete tracks highlighted in orange.
Age Pyramid (2/2)

- Bridges: Preliminary analysis of needs
  - Lifespan: 60 years

Investments to be planned within the next 4 years
## Asset Management Scenarios

- **Maintenance activities**
  - **CAPEX:**
    - Renewal of bridges
    - Renewal of tracks
  - **OPEX:**
    - Tracks: Grinding, tamping, and rail renewal (preventive maintenance)
    - Switches: Grinding and tamping (preventive maintenance)

- **Budget scenarios and maintenance strategies over 20 years (with Simeo™)**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Budget Constraint - Capex</th>
<th>Budget Constraint - Opex</th>
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</thead>
<tbody>
<tr>
<td>Sc1 - « free of constraints » → gross needs</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sc2 - Capex constraints (tracks only)</td>
<td>3’200 k€ / year</td>
<td>-</td>
</tr>
<tr>
<td>Sc3 – Capex and opex constraints (tracks only)</td>
<td>3’200 k€ / year</td>
<td>200k€ / year</td>
</tr>
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</table>

No Capex constraints for bridges
Sc1 – « Free of constraints » : Expenses vs ageing

- Gross needs: important investment needs on the short-term

On average, over 20 years, 3'600 k€/year spent on track renewal, 1'600k€/year spent on maintenance. 47 % of expenses on tracks between 2016 and 2036 should be spent in 2016......
Sc2 – « Capex constraints » : Expenses vs ageing

- Budget Constraints: Tracks’ CAPEX (3’200 k€ / year)

Although on average the invested amount is similar to the gross needs over the same period, the delays on investment lead to 25% of assets at risk over the next 16 years.
After 2023: one failure every 2.8km, unplanned interventions and additional costs
Sc3 – « Constraints on CAPEX and OPEX » : Expenses vs ageing

- Budget Constraints on Capex and Opex for tracks: what impact on lifecycle?

Maintenance restrictions are detrimental to ageing management: up to 50% of assets are at risk.
Sc3 – « Constraints on CAPEX and OPEX » : Risks

- Budget Constraints on Capex and Opex for tracks: what impact on risks?

The absence of preventive maintenance leads to premature ageing and to an increase in the number of failures after 2025.
Sc4 – « Optimisation » : Expenses vs ageing

- Invest differently ➔ invest at the right moment and on the right components
- Wait too long before investing ends up costing more : what is the key deadline ? how to preserve an acceptable performance level and quality of service ?

- Concentrate financial effort over the next 10 years and consider corrective maintenance to mitigate risks :
  - Concentrate effort between 2022 and 2026 (between bridge renovations) ;
  - Corrective maintenance compensates for lack of investment after 2026
Example 2 : Maintenance plan Optimisation

(1/5)

- Optimisation of maintenance plans covers three disciplines:

<table>
<thead>
<tr>
<th>Asset Management</th>
<th>Risk Management</th>
<th>Ageing Management</th>
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</table>
| Approach according to ISO 55.000 | Mapping your assets on two axes:  
- Probability of failure in line with the condition of the asset  
- Consequence of failure in line with the strategic objectives of your organisation  
Prioritise actions on riskier assets | Simulation of ageing of your assets aiming to:  
- Forecast failures  
- Plan predictive maintenance at the right moment  
- Balance OPEX with CAPEX |
| Better understanding of portfolio  
In control of budgets  
Alignment of management and operations | | |
Maintenance Plan Optimisation (2/5)

- Simplified maintenance plan (20 year)
- Fixed operational cost (blue bars)
- Increasing corrective maintenance cost due to an increase of defects as a result of an ageing portfolio (orange bars)
- Spread of renewal investments over 5 years after technical lifetime is reached (grey bars)
- Decrease in corrective maintenance cost after rejuvenation of portfolio through renewal investments (after 2033)
- Cumulative maintenance cost grows exponentially due to increase of corrective maintenance and becomes steeper when investments are realised (dotted line)
Maintenance Plan Optimisation (3/5)

- Looking at planned renewals (grey)
- Map the assets on matrix (probability x consequence)
- Prioritize renewals in red zone
- Reduce corrective maintenance by renewing riskiest assets
- Push less important assets (green & yellow) back in time (perhaps even over contract period)
- Reduction of cumulative expenses + control of risk
Incorporate increase of probability of failure due to ageing (e.g. bathtub curve)
Estimate effect of preventive maintenance actions on risks
Plan preventive maintenance actions to extend technical lifetime (light blue)
Push renewal investments back in time
Reduction of cumulative expenses
Reduction of corrective maintenance

The effect of a preventive action on the probability of a risk
Maintenance Plan Optimisation (5/5)

- Complexity increases with:
  - Heterogeneous asset portfolio (e.g. civil works and rolling stock)
  - Different ages and lifecycles in portfolio (existing, new)
  - Budget constraints and expenditure peaks
  - Multiple issues (financial, safety, environment, etc.)
  - Politics
Example 3: Maintenance hypothesis

- Maintenance costs
  - Model based on operating experience taking into account a preventive action after 8 years
Example 3: Scenario definition

- Asset management strategy
  - 2 maintenance options:
    - normal maintenance
    - heavy maintenance increasing lifespan
  - 2 renewal options
    - Replacement with same technology
    - Replacement with different technology
    → Impact on renewal direct cost

- 4 scenarios
  - Sc1-2: Normal maintenance then renewal around 2025
  - Sc3-4: Heavy maintenance allowing to postpone part of the renewal around 2040
Example 3: Results

- Which investment scenario is the best (financially)?
- What period of time are we considering? : short term, long term?

Cumulated total costs (CAPEX+OPEX)

Sc1-2: Normal maintenance then renewal around 2025

Sc3-4: Heavy maintenance allowing to postpone renewal around 2040

2 renewal solutions

- 2015-2023: best scenario: Sc 1&2
- 2015-2028: best scenario: Sc 1
- 2015-2038: best scenario: Sc 3
- 2015-2045: best scenario: Sc 1
Conclusions

- Added value of a simulation tool such as Simeo\textsuperscript{TM}
  - Be aware of the needs (what, where and when) from short to long term
  - Be able to optimise budget allocation / maintenance strategy over the time
  - Be able to “quickly” have objective arguments to defend a budget and a maintenance strategy

Reach the right balance according to strategic goals