HOW TO USE MODELLING FOR ASSET MANAGEMENT

Application for commuter lines

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HOW TO USE MODELLING FOR ASSET MANAGEMENT

Chapter 1 – Why does Asset management need Modelisation?

Chapter 2 – Modelisation for Infrastructure management after conception engineering

Chapter 3 – Modelisation for Infrastructure management before conception engineering

Chapter 4 – Conclusions & perspectives
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Chapter 4 – Conclusions & perspectives
1 - Why does Asset management need Modelisation?

- In the field of railways infrastructures, AM tends to preserve and enhance the railway network in order to make the best out of it:
  - public policies underpin this scheme: **which strategy for the network?**
  - the **time target** is necessarily middle, long or even very long-term as long as the sustainability of the network - or a part of it – remains secured.
  - Asset Management consists of driving the implementation of the network strategy under financial constraints, while minimizing the life cycle cost.

  - **Modelling** the impacts of the network strategy, on short and long scale, is a key point of the Asset management policy
1 - Why does Asset management need Modelisation?

**Defining the network strategy:**
- Future, performances, availability, reliability, failure duration...
- Network topology...

**Transforming the network strategy into:**
- **Maintenance policy:** Modelling the impacts of the maintenance need → Good balance between maintenance and renewal
  - Renewal programme
  - Maintenance programme:
    - per route
    - per line
    - per sub-network
- Analyzing the evolution of the behaviour of the assets and their components

**Under constraints:**
- limited financial capacities
- limited network capacity

**Planning the resources:**
- Network capacity and slots adjustments
- Industrial and human resources

**Realizing maintenance and works operations**

**Updating the knowledge of:**
- the assets
- the description of the components
- their behaviour
1 - Why does Asset management need Modelisation?

<table>
<thead>
<tr>
<th>Definition of the expected high level outputs of the network</th>
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<tbody>
<tr>
<td><strong>Route strategy</strong>: technical and economic performances per route: capacity, traffic density, budget</td>
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<thead>
<tr>
<th>Asset component</th>
<th>Operational component</th>
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<tbody>
<tr>
<td><strong>Assets strategy</strong>:</td>
<td></td>
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<tr>
<td>- definition of the maintenance optimization parameters (choice between maintenance and renewals)</td>
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<tr>
<td>- technical choices on components</td>
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<td>- definition of the inspections frequencies</td>
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<td><strong>Operational strategy</strong>: Operations and control of the network</td>
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<td>Network access optimization for Trains Operators</td>
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<tr>
<th>Route Asset Plans</th>
<th>Route Operational Plans</th>
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<tr>
<td>- Definition of route performance</td>
<td></td>
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<tr>
<td>- Definition of the number of maintenance and renewal operations and their costs</td>
<td></td>
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<tr>
<td>- Planning of renewal operations, important maintenance and enhancement works</td>
<td></td>
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<tr>
<td><strong>Taking into account Train Operators needs (number of slots, trains frequency) &amp; maintenance possessions needs</strong></td>
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<tr>
<th>Route Delivery Plans</th>
<th>Timetable and Access Planning</th>
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<tr>
<td>- optimization of operations organization (Maintenance and Renewals)</td>
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<tr>
<td>- confirmation of work conditions (possessions, budget, assessed detailed projects)</td>
<td></td>
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<tr>
<td><strong>Management of the impact of the required possessions with the slots demand</strong>, <strong>Timetable construction</strong></td>
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<tr>
<th>Execution of work</th>
<th>Network and Traffic Management Operation</th>
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<tr>
<td>Realization of operations:</td>
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<tr>
<td>Planning execution, supply chain, realization of works, tests, acceptance of the works, placing into service</td>
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<td><strong>(real time)</strong></td>
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Y-3 / Y-2 to Y/ M-6
1 - Why does Asset management need Modelisation?

- What need Asset Management Modeling in practice?
  - Obtain reliable deterioration models and survival models for all infrastructure components
  - Formalise the survival model for unreplaced components by fixing the failure rate $\lambda(t)$ in coherence with several covariates influencing the life span of the components
  - Formalise the existing economic link between maintenance costs and the volume of infrastructure renewal and capacity
  - Reduce costs by optimisation of the maintenance/renewal ratio, which is a major issue for infrastructure asset managers.
1 - Why does Asset management need Modelisation?

- The maintenance costs of the infrastructure are a function of various parameters → Impact estimated by modelling → Several parameters have a strong impact on the costs

Traffic and Speed
Rolling stock technologies
Track possession policy of the network
Infrastructure design & remote monitoring
Trains measurement systems
Maintenance politic & programming (current and renewal)

Rather YES

Rather NO

SNCF - INFRASTRUCTURE | ASSET MANAGEMENT & MAINTENANCE ENGINEERING
HOW TO USE MODELLING FOR ASSET MANAGEMENT

Chapter 1 – Why does Asset management need Modelisation?

Chapter 2 – *Modelisation for Infrastructure management after conception engineering*

Chapter 3 – Modelisation for Infrastructure management *before* conception engineering

Chapter 4 – Conclusions & perspectives
2 - Modelisation for Infrastructure Management after conception engineering

Four steps:

3 – Tools for **LCC calculation** at the national or route levels, including environmental effects, track possession and unavailability costs...

2 – Tools for the estimation of **maintenance needs** of the track (with different renewal strategies)

1 – Work of the **deterioration and failure laws** of each the track components

0 – **Data base** describing the population, the traceability of the maintenance operations, the traffic…
2 - Modelisation for Infrastructure Management after conception engineering

**Step 0:** Identification of the homogeneous track segments (RER Line)

- **Identification of the** several covariates influencing the life span of the components:  
  → traffic, rolling stock, environment,  
  → topology, passed maintenance policy…
2 - Modelisation for Infrastructure Management after conception engineering

Step 0: Identification of the homogeneous track segments (RER Line)

- Identification of the several covariates influencing the life span of the components: traffic, rolling stock, environment, topology, passed maintenance policy…
2 - Modelisation for Infrastructure Management after conception engineering

Step 1: Data bases for estimation of the Lifespan of the components

Maintenance, Condition of use... Data bases

Patrimonial Data bases

Common Data base

Configuration choice

Treatments / estimation of the parameters...

Results
2 - Modelisation for Infrastructure Management after conception engineering

Step 1: Lifespan of the component rail (RER Line)

- **Failure laws of rails / slabtrack:** the parameters of these laws are sensitive to rail hardness, to track topology (curves…), track type (with or without ballast) and aggressiveness of the rolling stock…
2 - Modelisation for Infrastructure Management after conception engineering

**Step 1:** Lifespan of the component rail (RER Line)

- **Failure laws of rails / ballasted track:**
  - the parameters of these laws are sensitive to rail hardness, to track topology (curves...), track type (with or without ballast) and aggressiveness of the rolling stock...
2 - Modelisation for Infrastructure Management after conception engineering

Step 1: Lifespan of the component welding (RER Line)

- Failure laws of aluminothermy welding:
  - the parameters of these laws are sensitive to track topology (curves...), track type (with or without ballast) and the condition of welding...
2 - Modelisation for Infrastructure Management after conception engineering

Step 1: Lifespan of the different components (RER Line)
2 - Modelisation for Infrastructure Management after conception engineering

**Step 2**: Estimation of maintenance needs (RER lines)

**Tools for estimation of track maintenance needs (EBM)**:

Principe / ballasted track:

1 – Cyclical or programmed operations:
   - Fixed charges determined by the standards for track surveillance, programmed maintenance, structure…

2 – Preventive conditioned maintenance:
   - Levelling maintenance charges: Interventions conditioned by the information coming from track surveillance. Probabilistic estimation of the intervention needs for a specific route, for a UIC group of routes…
   - Asset replacement charges: Interventions conditioned by asset defect detection… Probabilistic estimation of the failure laws of each asset
2 - Modelisation for Infrastructure Management after conception engineering

Step 2: Estimation of maintenance needs (RER lines)

• Estimation of the cost of each maintenance operation in regard of the traffic, the track possession conditions…

• The costs of track maintenance operation are higher for mass transit line that for conventional lines!

→ parameters $C_{\text{const}}, C_{\text{rempl}}$
2 - Modelisation for Infrastructure Management after conception engineering

**Step 2:** Estimation of maintenance needs (RER lines)

- Estimation of the number of failures requiring a maintenance estimation
- Valuation of the associated costs:

\[
C = \sum_{\text{Length}} \sum_{\text{Component}} c_{\text{const}} + c_{\text{repl}} \cdot N \cdot h(\text{age})
\]
2 - Modelisation for Infrastructure Management after conception engineering

**Step 3:** LCC calculation (RER lines) → Theory renewal planning

**Tools for estimation of life cycle cost:**
- Definition of theoretical optimal the components lifespan, for each configuration and for all type of track
- Calculation for each line of the theoretical renewal planning
- Adaptation of these planning in regard of the local maintenance units, the track possession conditions, the traffic evolution, the criticity of the line…
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3 - Modelisation for Infrastructure Management before conception engineering

Step -1: Make the right design choice in regard of the traffic (RER Line)
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→ Design choices could have a huge impact on a maintenance strategy and on the chances of reaching the right quality level (availability, security, safety…) with the economic target value

→ The terms of the requirements have to be chosen taking into consideration the context of use and the economic and organizational targets… which are not known by suppliers

→ These choice have to be done before the call for tender (construction or renewal of a track)
3 - Modelisation for Infrastructure Management before conception engineering

**Step -1:** Make the right design choice in regard of the traffic (RER Line)

Thanks to its experience of component and sub-system behaviour, the infrastructure manager:
→ specify and optimise new components to facilitate maintenance, taking into account usage, environment, specific quality targets,…
→ optimise the dimension of spare parts and the corresponding maintenance organisation.

*Examples:*
- ballasted track with PAD
- manganese or movable frogs
3 - Modelisation for Infrastructure Management before conception engineering

**Step -1:** Make the right design choice in regard of the traffic (RER Line)

→ Some under sleeper PAD have an influence on track lifespan and geometry
⇒ specific Cochet-Maumy parameters
⇒ lifespan of the ballast is equivalent to the lifespan of the concrete sleeper
3 - Modelisation for Infrastructure Management before conception engineering

**Step -1:** Make the right design choice in regard of the traffic (RER Line)

⇒ **Some frogs**

- have an influence on track lifespan and geometry
- ⇒ specific Cochet-Maumy parameters
- ⇒ lifespan of the frogs is higher with it is movable and installed of ballast
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4 - Conclusions & perspectives

This approach allows a good mathematic modelling of the intuitively perceived phenomena:
- regeneration vs. maintenance
- a system cannot last indefinitely

The calibration of the model was based on accessible real data.

The method is very general. This presentation shows that the application range is very wide. All replaceable infrastructure equipment can be used for such a study.
4 - Conclusions & perspectives

→ The battle for maintenance is won or lost at the system definition & design stage

→ This is essential to consider the industrial balance of the trio made up of “Maintenance costs – Network Performances – Quality”

→ A technical solution doesn't, on its own, produce the best answer!
Thanks for your attention

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