INTERNATIONAL UNION
OF RAILWAYS

MODELISATION TOOLS FOR ASSET MANAGEMENT

UIC Rail System Department

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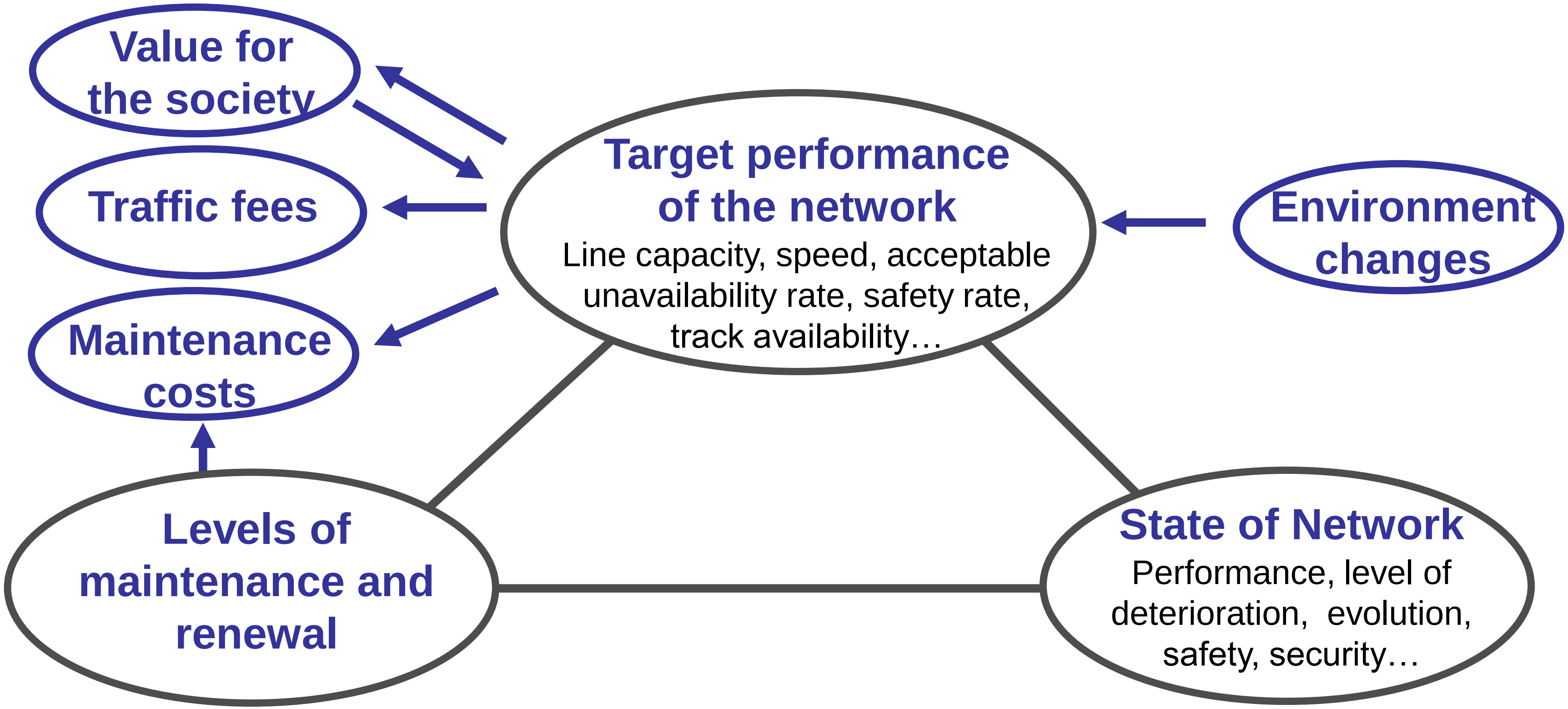
MODELISATION TOOLS FOR ASSET MANAGEMENT

1. Why does Asset management need Modelling ?
2. Modelling for Infrastructure management after conception engineering
3. Modelling for Infrastructure management before conception engineering
4. Summary

1 - Why does Asset management need Modelling?

Asset management : looking for the optimal balance



2- Modelling for Infrastructure Management after conception engineering

Three steps (example for track) :

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)

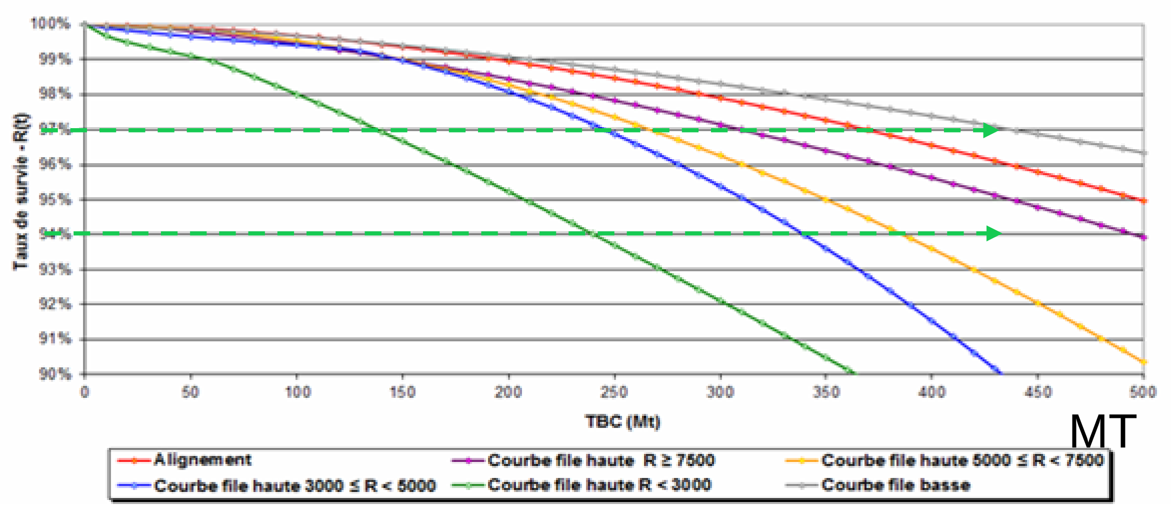
1 – Work of the deterioration and failure laws of each the track components

0 – Collect and Store in a coherent way data’s

2 - Modelling for Infrastructure Management after conception engineering

Step 1: Lifespan of the components (ballasted HSL)

- **Failure laws of rails** :
  - lifespan of the rails on a ballasted HSL is about 400MT with 3% of cumulative defects, 700MT with 6%
  - the parameters of these laws are sensitive to track topology and aggressiveness of the rolling stock…



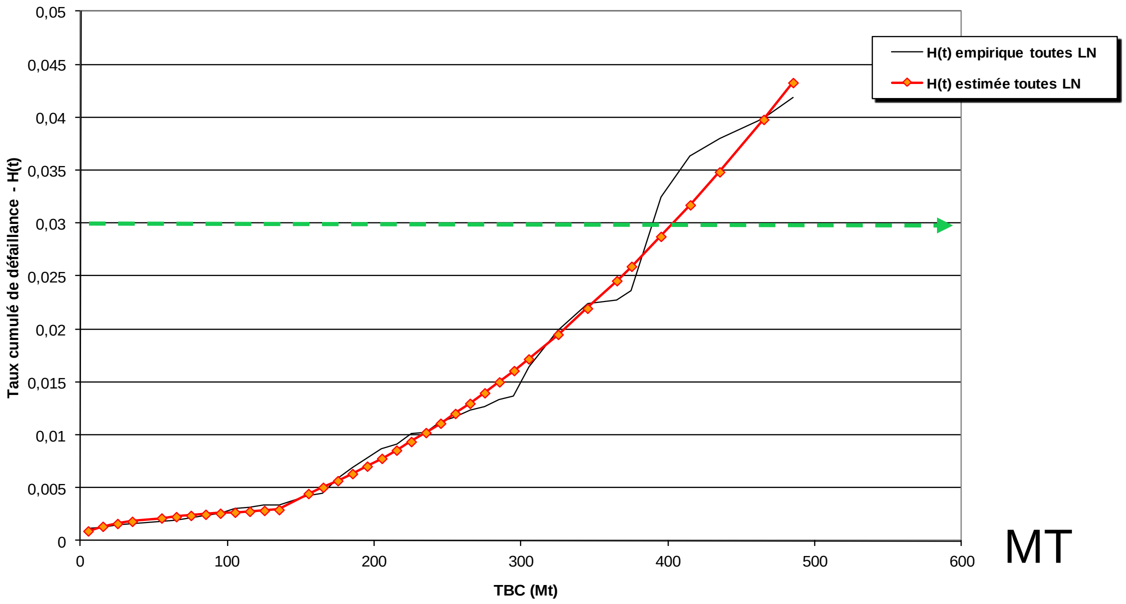
The failure rate can grow more quickly if the rolling stock has an important rate of "slippage" (20% for some materials)

2 - Modelling for Infrastructure Management after conception engineering

Step 1: Lifespan of the components (ballasted HSL)

- **Failure laws of aluminothermy welding**:

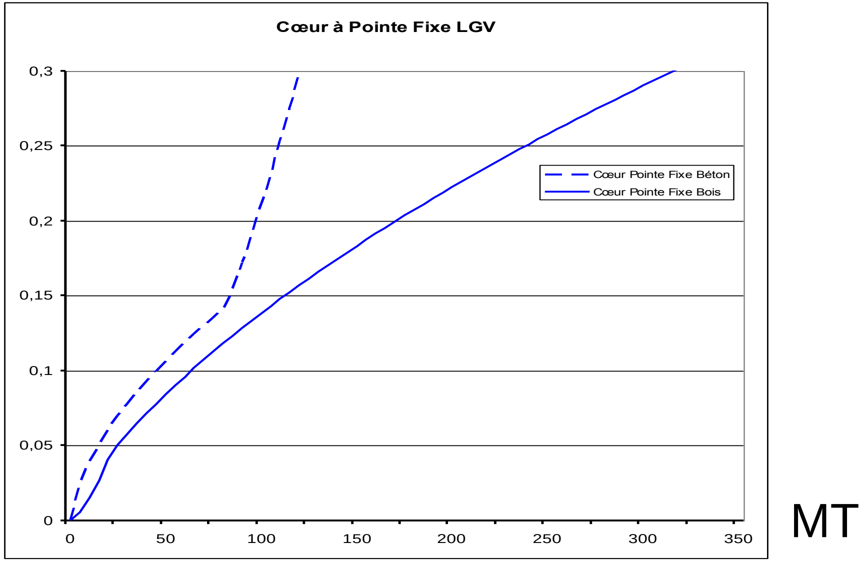
  - lifespan of a weld on ballasted HSL is about 400MT with 3% of cumulative defects
  [even without preventive grinding]



2 - Modelling for Infrastructure Management after conception engineering

Step 1: Lifespan of the components (ballasted HSL)

- **Failure laws of manganese or movable frogs**:
  - lifespan of these components is longer on wooden sleepers then on concrete ones
  - the parameters of these laws are sensitive to the aggressiveness of the rolling stock



2 - Modelling for Infrastructure Management <u>after</u> conception engineering

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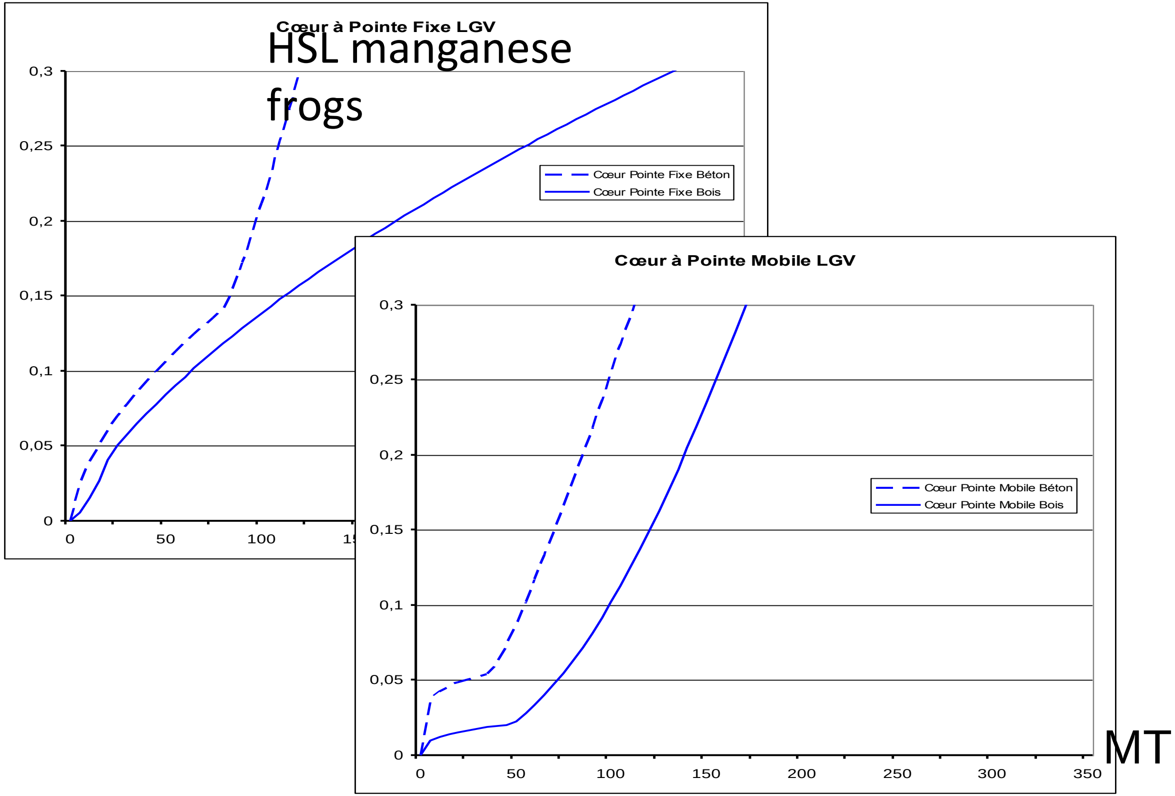
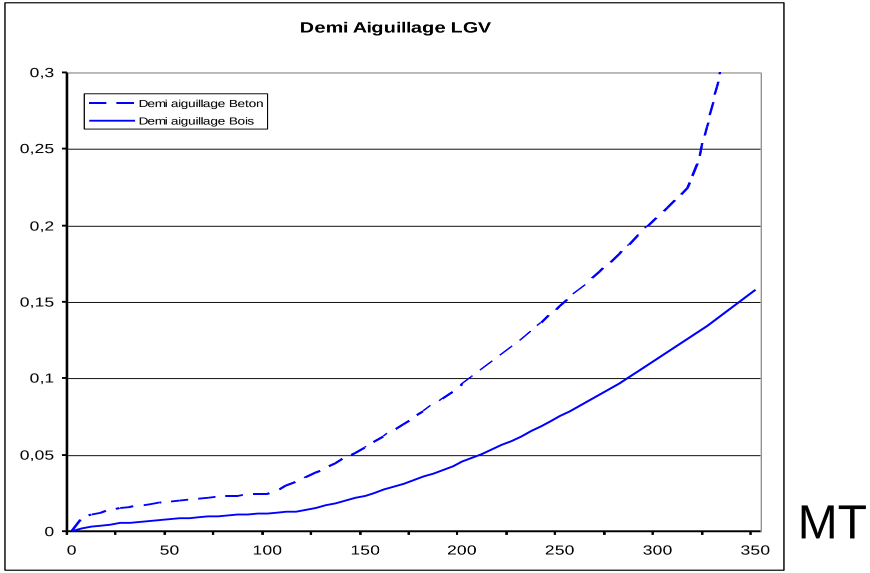


2 - Modelling for Infrastructure Management <u>after</u> conception engineering

Step 1: Lifespan of the components (ballasted HSL)

- **Failure laws of switch half switch set**:
  - lifespan of these components is longer on wood sleepers then on concrete ones
  - the parameters of these laws are sensitive to the aggressiveness of the rolling stock and the hardness of the track

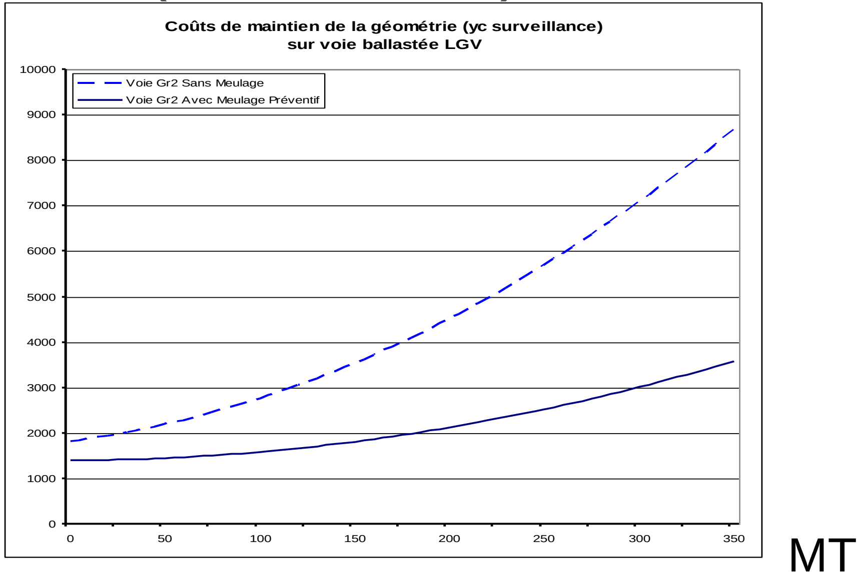


2 - Modelling for Infrastructure Management after conception engineering

Step 1: Lifespan of the components (ballasted HSL)

- **Geometry degradation laws**:
  - lifespan of the ballast, without sand-gravel mix bitumen or PAD, is approximately 25 years on HSL (>300)
  - this lifespan will be much higher with sand-gravel mix bitumen and/or PAD
  - maintenance needs follow Cochet-Maumy laws

$$\mathrm{Im}(N) = k \times 0{,}8 \times \delta \times \left(a + b \times \left(2^{\frac{N}{5}} - 1 \right) \right)$$

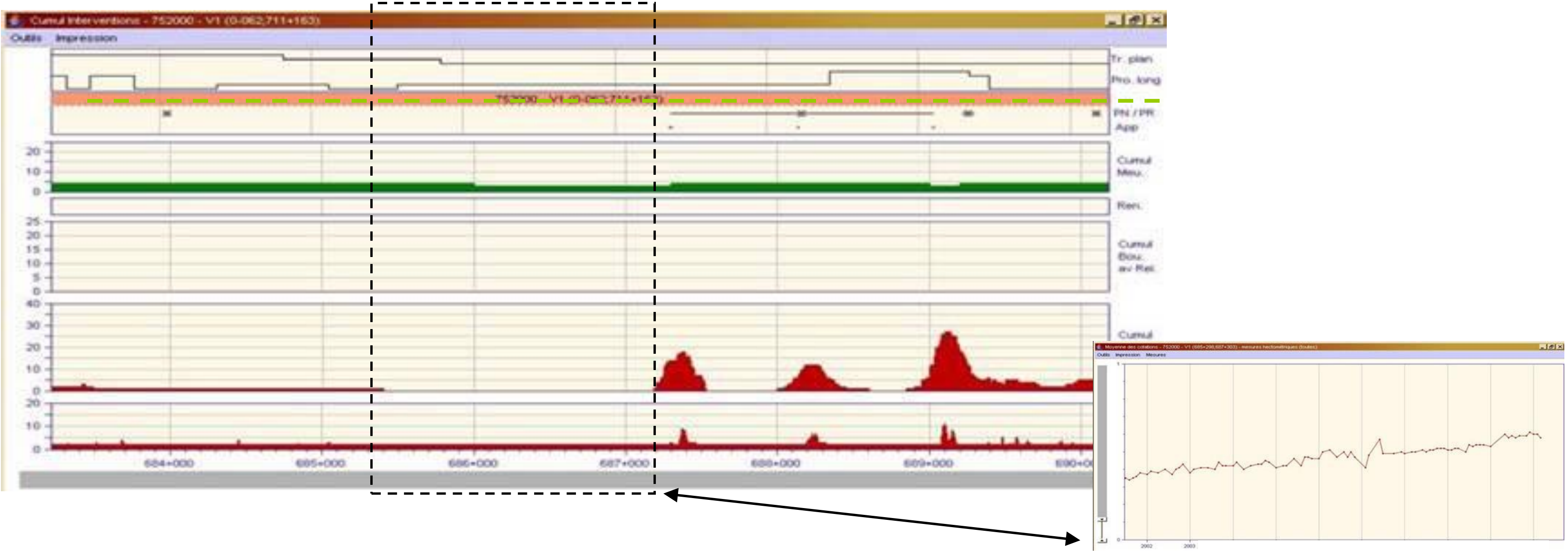


The parameters of these laws depend on grinding, the type of **rolling stock**, etc.

2 - Modelling for Infrastructure Management after conception engineering

Step 1: Lifespan of the components (ballasted HSL)

Some USP could have an influence on track lifespan and HSL geometry ⇒ specific Cochet-Maumy parameters



Average of longitudinal levelling

2 - Modelling for Infrastructure Management after conception engineering

Step 2: Estimation of maintenance needs (ballasted HSL)

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:

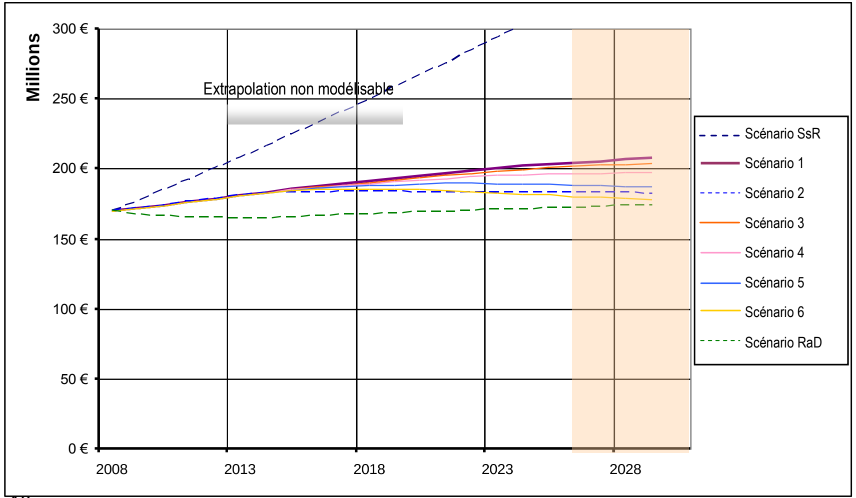
- Levelling maintenance charges: Interventions conditioned by the information coming from track surveillance. Probabilistic estimation of the intervention needs for a specific route, for a UIC group of routes…
- Asset replacement charges: Interventions conditioned by asset defect detection… Probabilistic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

2 - Modelling for Infrastructure Management <u>after</u> conception engineering

Step 2: Estimation of maintenance needs (ballasted HSL)

Example of estimation of maintenance needs for the French network

Switches & Crossing UIC 1 to 6



2 - Modelling for Infrastructure Management after conception engineering

Step 2: Estimation of maintenance needs (ballasted HSL)

Example of estimation of maintenance needs for the French network

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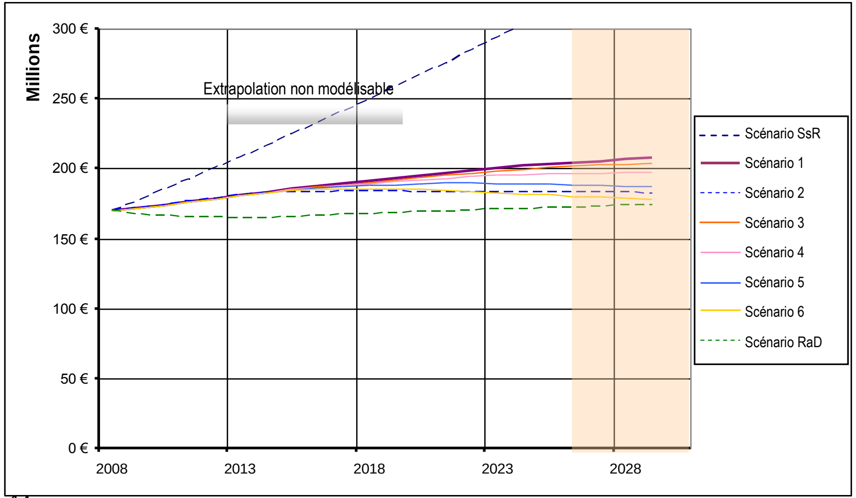
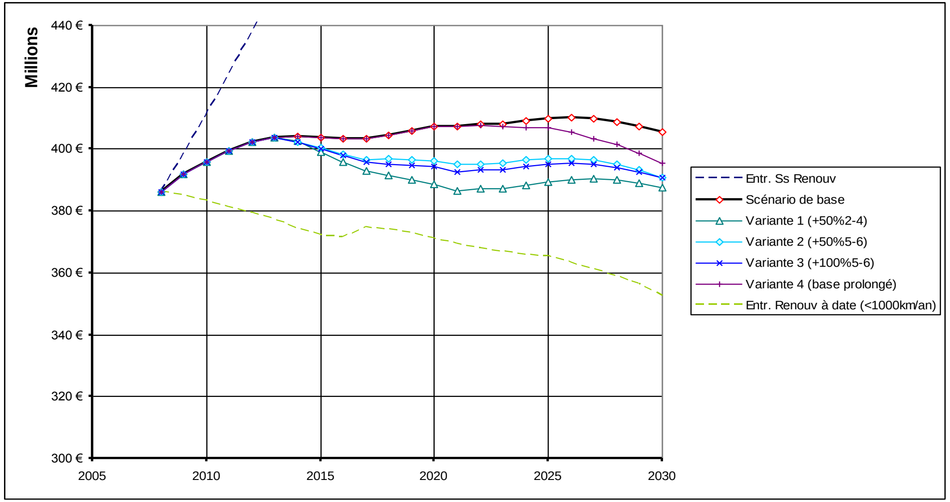


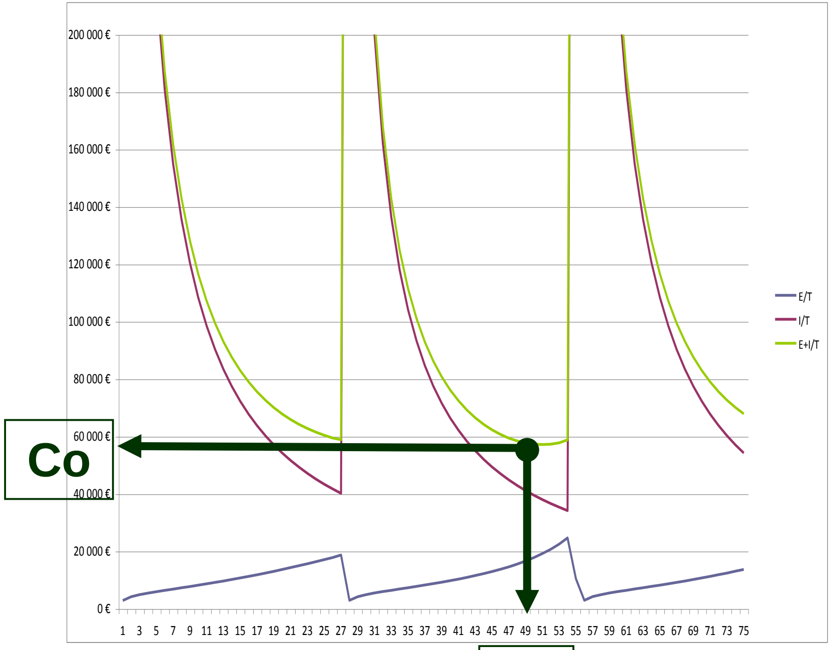
Normal Track UIC 1 to 6

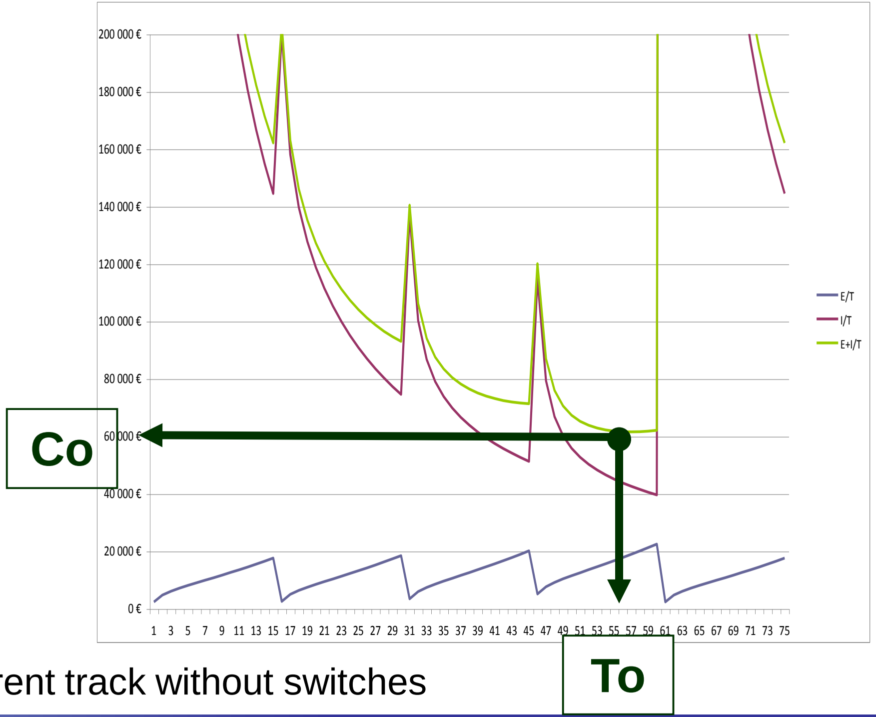


2 - Modelling for Infrastructure Management after conception engineering

Step 3: LCC calculations (ballasted and unballasted HSL)

HSL ballasted track and slab track (UIC gr3)





L300 - UIC - current track without switches

3 - Modelling for Infrastructure management before conception engineering

Thanks to its experience of component and sub-system behaviour a Infra Manager can:

→ 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.

The following examples come from signalling:

- choice of failure laws,
- architecture choice for critical computerised system.

3 - Modelling for Infrastructure management before conception engineering

Modeling methods: renewal density for successive replaced components

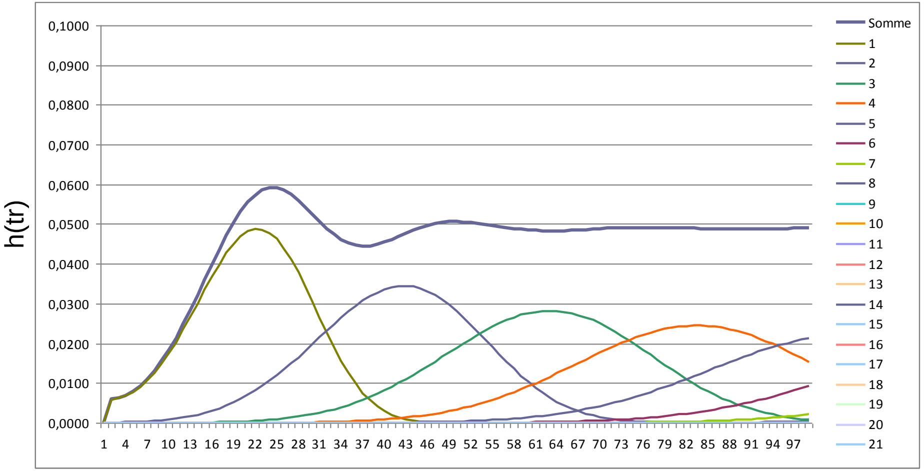
Without system ageing

- The renewal density gives the replacements due to failure at time t :

$$h(t) = \sum_{n=1}^{\infty} -[(1-F(t))']^{*n}$$

where * denotes the convolution.

- The integral of this function gives the number of expected replacements before time t .



Reduced time tr beta = 3,4

3 - Modelling for Infrastructure management before conception engineering

Modeling methods: renewal density for successive replaced components

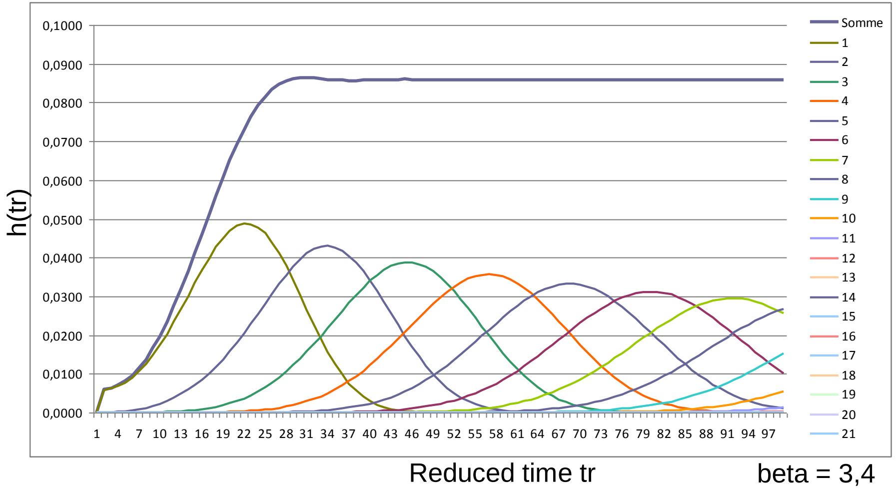
With system aging

- We can include the ageing of the system (or effects of repairs) by using a factor *K*

$$\eta_n = \eta_0 \cdot K$$

at the n^{th} replacement.

- This translates the fact that even a new component has a reduced lifetime if it is introduced into an ageing system.



beta = 3,4
K = 0,75

3 - Modelling for Infrastructure management before conception engineering

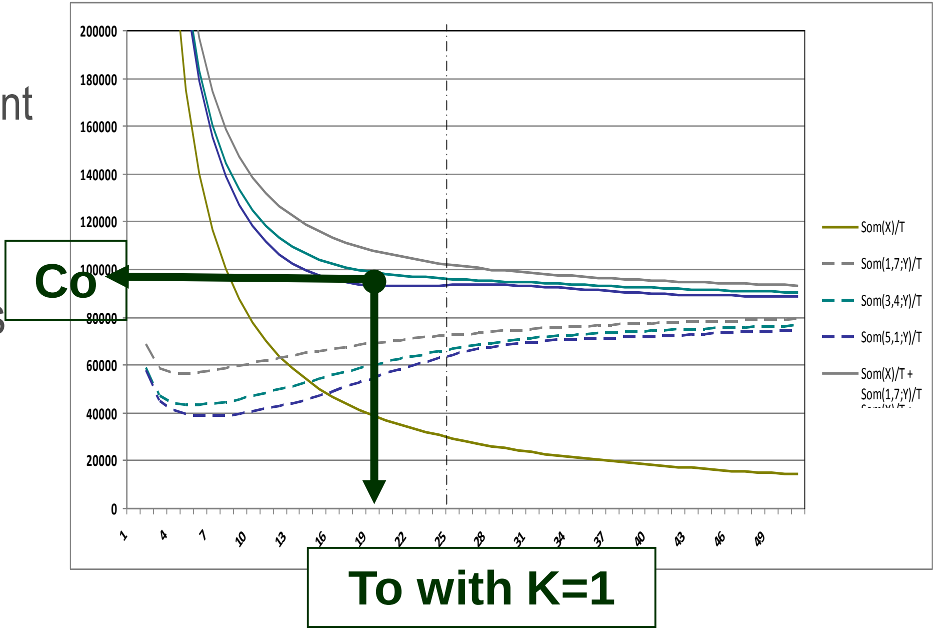
Modeling methods: renewal density for successive replaced components

- **Maintenance expenses: $Y(t) = c_i(t) + c_u \cdot n \cdot h(t)$**
  - c_i: current costs
  - c_u: replacement costs for one component
  - n: number of components
  - $h(t)$: renewal density
- Expected global maintenance expenses (including renewal) per year:

$$C(T)/T = [X + \sum_{t=0}^{T-1} \int_{t}^{t+1} Y(t)]/T$$

$E(T)$

With X: renewal costs



3 - Modelling for Infrastructure management before conception engineering

Modeling methods: renewal density for successive replaced components

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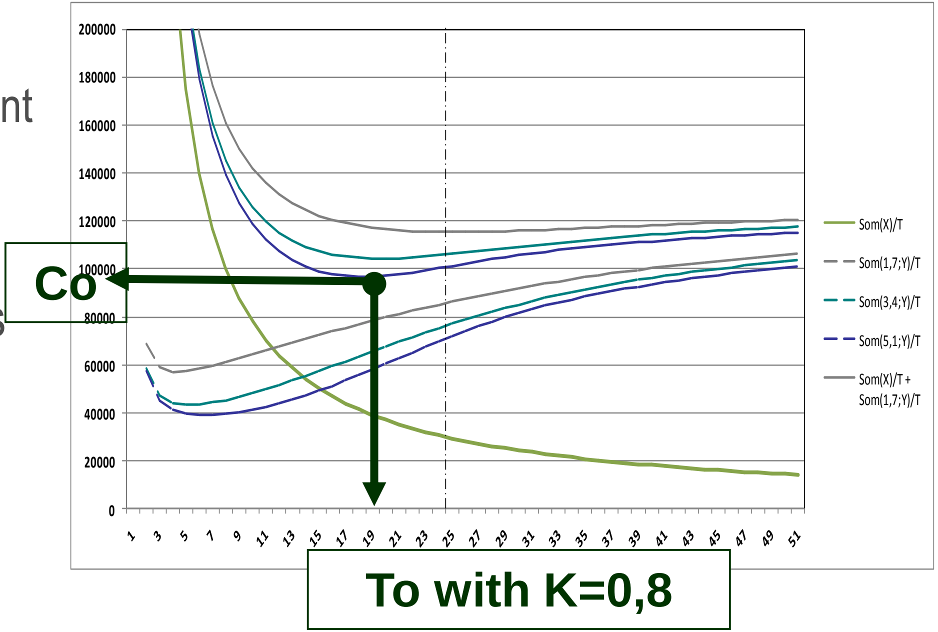


3 - Modelling for Infrastructure management before conception engineering

Modeling methods: renewal density for successive replaced components

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

3 - Modelling for Infrastructure management before conception engineering

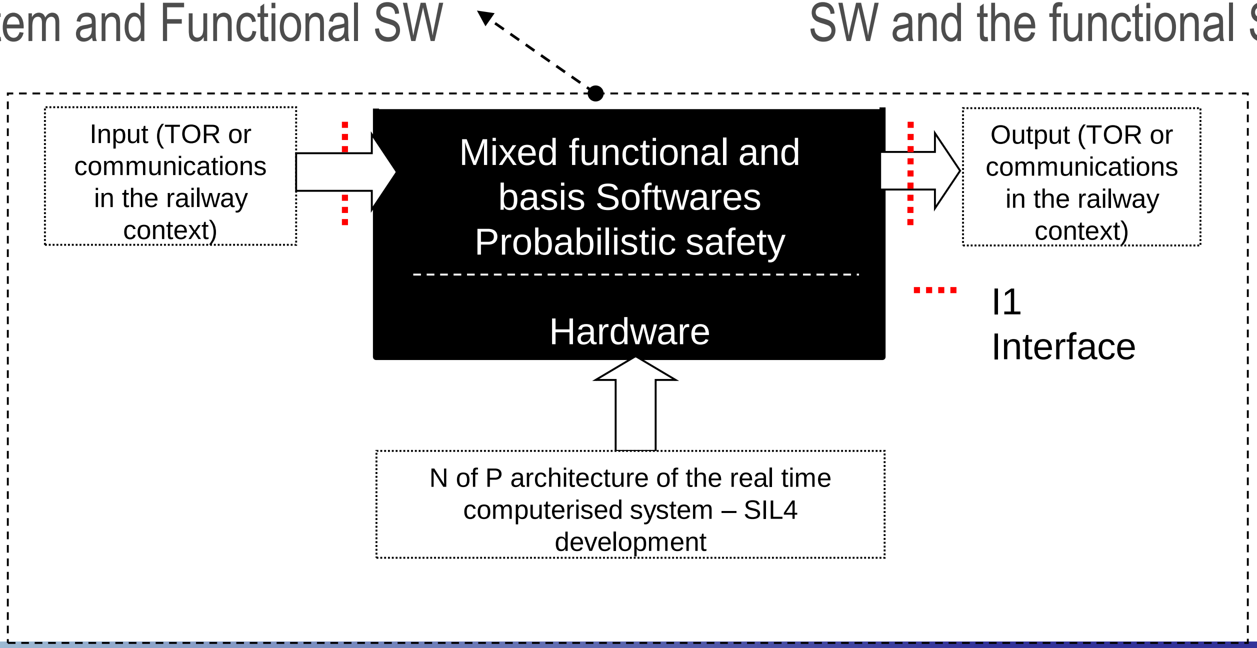
Architecture choice for a critical computerised system

Classical architecture

- Without independence between System and Functional SW

Proposed architecture

- With distinction between HW&System SW and the functional SW



3 - Modelling for Infrastructure management before conception engineering

Architecture choice for a critical computerized system

Classical architecture

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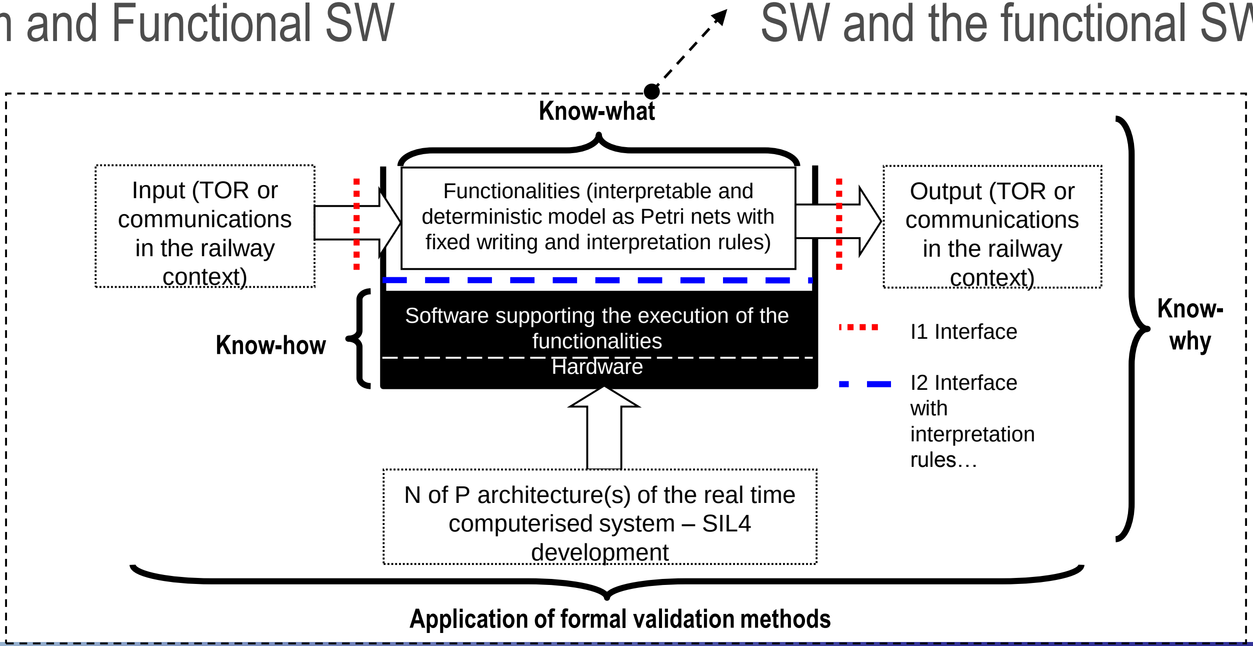
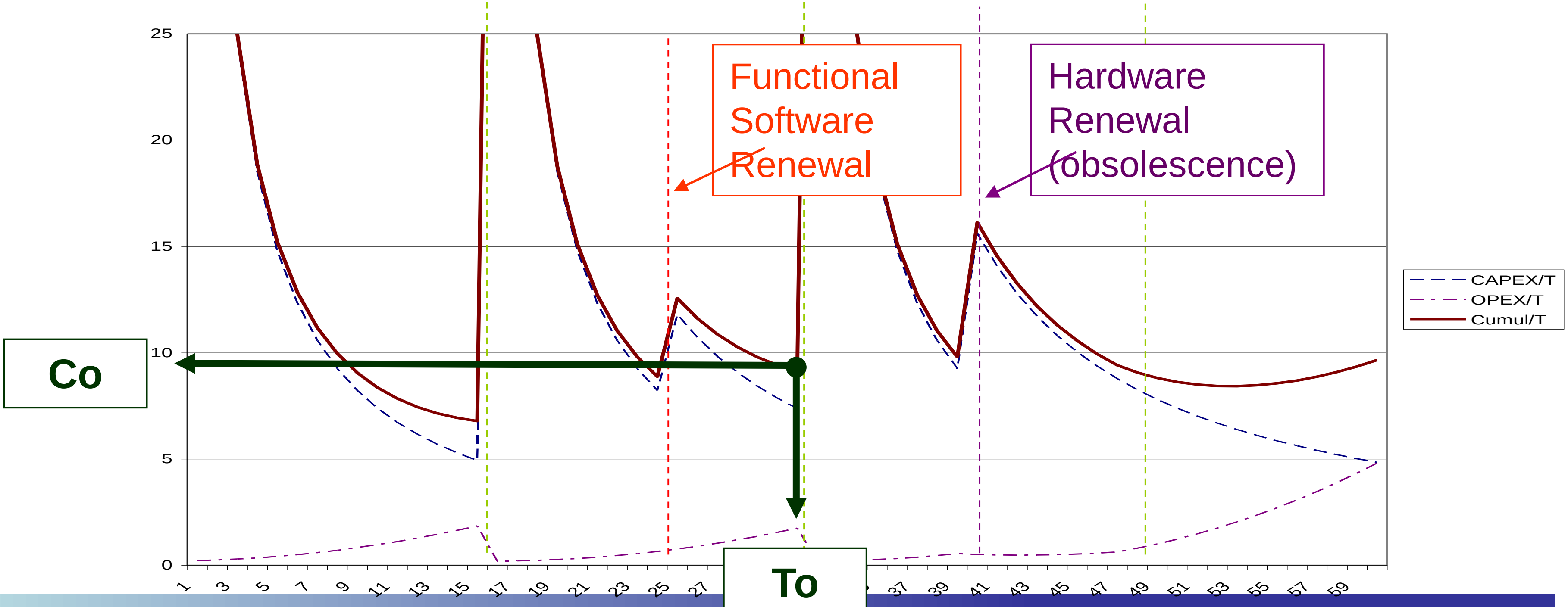


3 - Modelling for Infrastructure Management after conception engineering

Step 3: LCC calculations

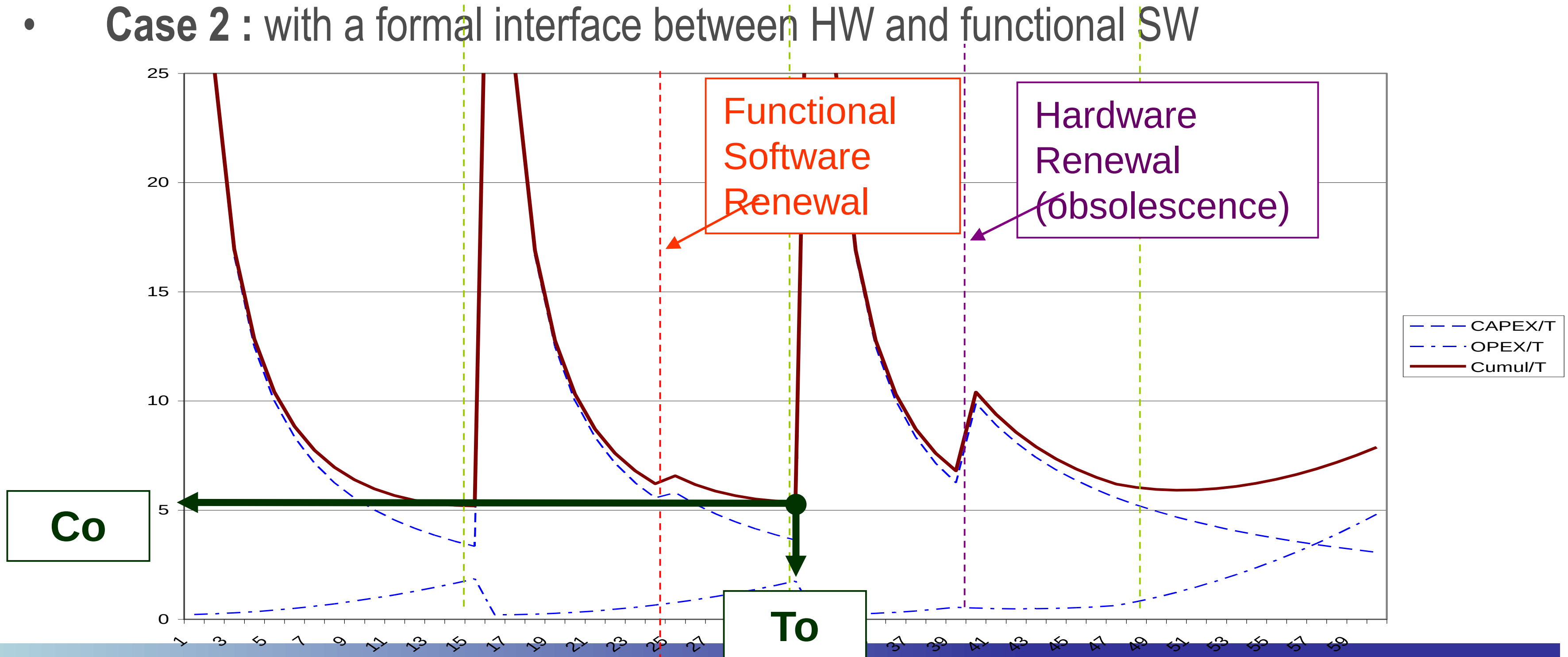
- **Case 1 :** without formal interface between HW and functional SW



3 - Modelling for Infrastructure Management after conception engineering

Step 3: LCC calculations

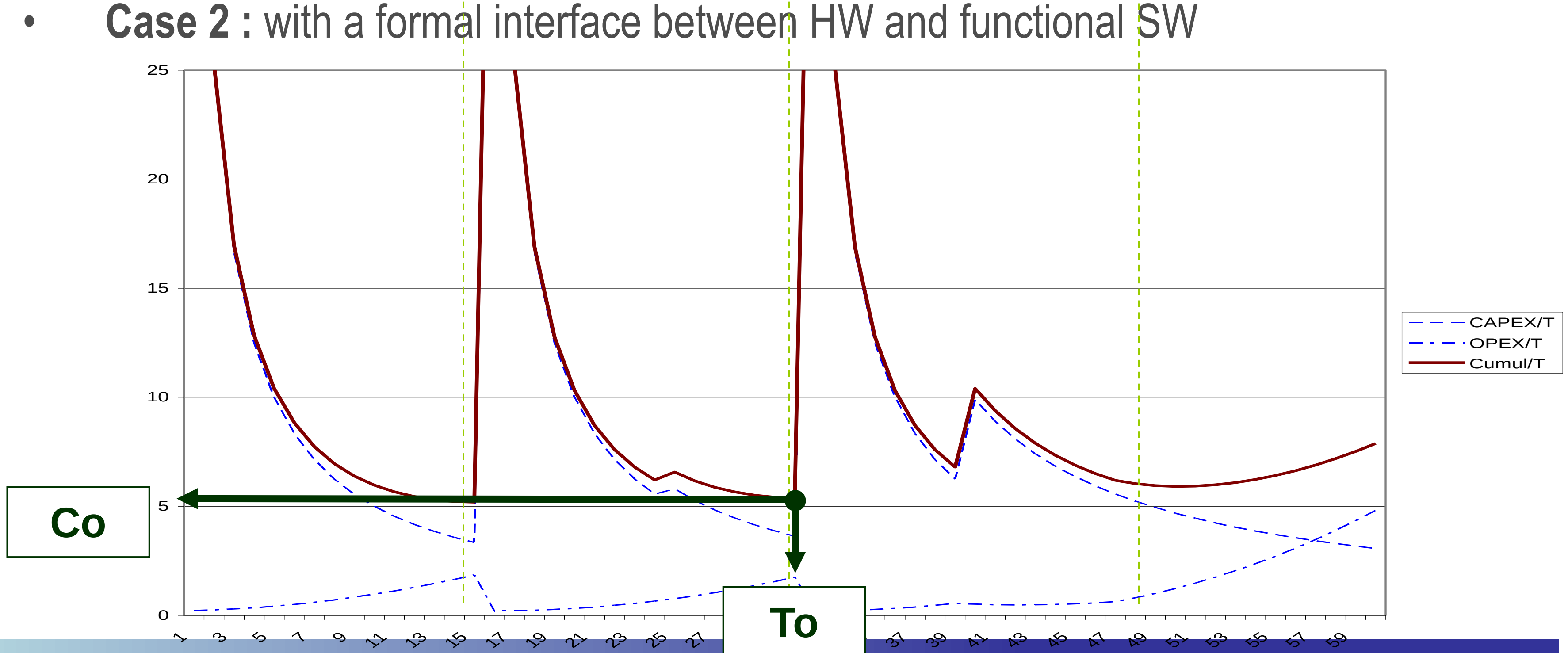
- **Case 2 :** with a formal interface between HW and functional SW



Modelisation for Infrastructure Management <u>after</u> conception engineering

Step 3: LCC calculations (Critical IT system with and without formal interface between HW and functional SW)

- **Case 2 :** with a formal interface between HW and functional SW



4 - Summary

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

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

General approach → the application range is very wide. All replaceable infrastructure equipment can be used for such a study.

4 - Summary

- Modelling is necessary to estimate “value” and “risk” of and from our infrastructures, in different scenarios
- The battle for maintenance is won or lost at the system definition & design stage.
- It is essential to consider the industrial balance of the trio made up of “Maintenance costs – Network Performances regarding the business – Quality&Safety”… including security

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Thank you for your kind attention!