Improved management of drinking water networks: the long-term OPTIMEAU model for forecasting renewal, application on the Water Services of Paris Area (SEDIF) and on Lausanne

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Session III: Data, tools and models
I. Main issues of the 3 water utilities

II. Main issues of long-term planning models

III. Past decision-making process in Lausanne

IV. Overview of OPTIMEAU model

V. Focus on indicators
   1. “I1R”: length to be renewed
   2. “I1P”: number of leaks
   3. “I3P”: risk of traffic disruption

VI. Conclusion
I. Main issues of the 3 water utilities

- Different histories (materials, installation years)
- Different practices
- High cost of pipes $530 \, \text{€} / \text{m}

The renewal of a fraction of the network is needed, each year, because of poor condition, but also for coordination.

- How much length should be replaced each year?
- Balance between cost and performance?
II. Main issues with long-term planning models
Main issues with models at 3 planning scales

1. Optimization of water utility objectives
2. Budget consistent with the chosen strategy
3. Optimization of work

Short-term: < 5 years
Mid-term: 5 to 20 years
Long-term: > 20 years
Example of issues of long-term planning models

- **Steering strategy:** Threshold renewal age by material

<table>
<thead>
<tr>
<th>Material</th>
<th>Renewal Age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>60</td>
</tr>
<tr>
<td>Concrete</td>
<td>120</td>
</tr>
<tr>
<td>Ductile Cast Iron</td>
<td>120</td>
</tr>
<tr>
<td>Gray Cast Iron</td>
<td>70</td>
</tr>
<tr>
<td>PEHD</td>
<td>100</td>
</tr>
</tbody>
</table>

- **Action:** Only renewal
Example of issues of long-term planning models

- Representing the strategy in a survival curve
- Long-term planning:

The Cador method, widely used (biblio and case studies), is not satisfactory!
Objective of OPTIMEAU project:

Build a long-term planning model to help water managers optimize their future objectives by taking into account the past decision-making process.
III. Past decision making process in Lausanne
Output of decision model (M4)

ARP map

Source: eauservice

Renewal site selection: coordination + ARP
Other arbitration criteria

- Coordination
  - Gray cast Iron (not resistant) 20%
  - Advance age 10%
  - Firefighting 5%
  - independent of pipe sections 5%

- Sites around de 30% red & 15% orange 45%

- M4 decision ARP
  - Sites around red (C33) 15%

 Nb pipe sections renewed or improved
IV. Overview of OPTIMEAU model
Water utilities approach

Action cycle

Issues: Territory problems and needs

Goals

Means (financial, human)

Results: On the territory

Concrete Realizations

Effects
11 indicators in OPTIMEAU model

- **I1P**: Number of leaks
- **I2P**: Water cut risk
- **I3P**: Traffic disruption risk
- **I4P**: Flooding risk
- **I5P**: Soil collapse risk
- **I6P**: Leakage volume due to breaks

**Issues**: Territory problems and needs

**Goals**: (financial, human)

**Means**: Concrete Realizations

**Results**: On the territory

**Action cycle**

- **I1F**: Renewal cost
- **I2F**: Repair cost
- **I1R**: Length to be renewed
- **I2R**: Renewal rate
- **I3R**: Network average age
11 indicators in OPTIMEAU model

- I1F: Renewal cost
- I2F: Repair cost
- I1P: Number of leaks
- I2P: Water cut risk
- I3P: Traffic disruption risk
- I4P: Flooding risk
- I5P: Soil collapse risk
- I6P: Leakage volume due to breaks
- I1R: Length to be renewed
- I2R: Renewal rate
- I3R: Network average age
T : Decommissioning age

Survival function connects all the indicators
Example of *survival function* for human beings

Survivors for 100,000 birth

Source: Jacques Vallin, 2005
Observation period of “decommissioning years” for the statistical model [1995, 2012]
Past real survival curves, in linear 

T : decommissioning age
V. Focus on indicator \( I_{1R} \): length to be renewed
Scenario 1: Status quo

Length in service, end 2012

Construction year
Scenario 1: Status quo

- Prediction until end 2013

In the graph:
- Red: Decommissioned in 2013
- Green: In service

The output indicates construction years from 1870 to 2013.
Scenario 1: Status quo

- Prediction until 2025

Output

km

- D. between 2013 & 2025
- In service

Construction year

km
Scenario 1: Status quo

- Prediction until 2050

km

- D. between 2013 & 2050
- In service

Output

km

Construction year


25 50 100 150 200 250
V.2 Focus on indicator (‘I1P’): number of breaks
I1P: Number of future leaks

Scenario A: Status quo

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of leaks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>100</td>
</tr>
<tr>
<td>2004</td>
<td>150</td>
</tr>
<tr>
<td>2007</td>
<td>100</td>
</tr>
<tr>
<td>2010</td>
<td>50</td>
</tr>
<tr>
<td>2013</td>
<td>25</td>
</tr>
<tr>
<td>2016</td>
<td>10</td>
</tr>
<tr>
<td>2019</td>
<td>5</td>
</tr>
<tr>
<td>2022</td>
<td>2</td>
</tr>
<tr>
<td>2025</td>
<td>1</td>
</tr>
<tr>
<td>2028</td>
<td>0</td>
</tr>
<tr>
<td>2031</td>
<td>0</td>
</tr>
<tr>
<td>2034</td>
<td>0</td>
</tr>
<tr>
<td>2037</td>
<td>0</td>
</tr>
<tr>
<td>2040</td>
<td>0</td>
</tr>
<tr>
<td>2043</td>
<td>0</td>
</tr>
<tr>
<td>2046</td>
<td>0</td>
</tr>
<tr>
<td>2049</td>
<td>0</td>
</tr>
</tbody>
</table>
Scenario B: More drastic around vulnerable clients

- Medium vulnerability
- Low vulnerability
- High vulnerability

Number of leaks

Year

2014 2017 2020 2023 2026 2029 2032 2035 2038 2041 2044 2047 2050
V.3 Focus on I3P: Risk of traffic disruption induced by a leak
I3P: Risk of traffic disruption induced by a leak

\[ \text{Hazard} \times \text{Vulnerable element} \times S = \text{Damage} \]

\[ Nb \text{ leaks} \times Rt \times S = \text{traffic risk} \]

**Rt (repair time)**

<table>
<thead>
<tr>
<th>Rt (hours)</th>
<th>Materials</th>
<th>Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Ductile cast iron, Plastic</td>
<td>( \phi &lt; 250 )</td>
</tr>
<tr>
<td>4</td>
<td>Ductile cast iron, Plastic</td>
<td>( \phi \geq 250 )</td>
</tr>
<tr>
<td>6</td>
<td>Grey cast iron, Asbestos</td>
<td>( \phi &lt; 250 )</td>
</tr>
<tr>
<td>8</td>
<td>Grey cast iron, Asbestos</td>
<td>( \phi \geq 250 )</td>
</tr>
</tbody>
</table>
Scenario 1: We stop renewing the network

Scenario 2: We renew grey cast iron earlier in the future than in the past

Stratification of the network by materials

All network, no stratification
VI. Conclusion
Conclusion

• Advantages and innovations in the OPTIMEAOU model
  – Using the survival curve, long-term planning indicators can be linked together and connected to past decisions.
  – Performance indicators (risk, failures) are based on reliable statistico-probabilistic models

• Perspectives
  – Currently in the scenario with changes: empirical “trial and error” method => future mathematical optimization
Thank you for your attention!