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A MULTI-NETS APPROACH FOR MODELING AND EVALUATING RAIL MAINTENANCE STRATEGIES.

O.C.H. FRANÇOIS, L. BOUILLAUT, S. DUBOIS, IFSTTAR-GRETTIA & RATP.

INTRODUCTION

The theory of **Dynamic Bayesian Networks (DBN)** offers an interesting frame to solve **maintenance optimisation** problems as it allows to use

- probability distributions to represent **degradation process** together with
- stochastic representation of maintenance agents

Based on the **VirMaLab** (*Virtual Maintenance Laboratory*) formalism, the **StatAvaries** modelling is a **modular** modeling of the current rails' diagnosis. It allows to simulate the rail degradation and the whole maintenance process.

CONTEXT

The rising needs for public transportation in the Paris metro network (current traffic: **1.5 billion trips** per year) and obsolescence of equipment make RATP renew its systems.

For instance, to allow a significant headway reduction for its most congested lines (interval between two trains close to 90 seconds, roughly 20% traffic increasing), **RATP** has to **modernize the train command control** with a continuous train speed control (CBTC like) replacing the current one based on train positioning (using track circuits). Such system is deployed on steel wheel metro lines.

To be able to take into account the impact of various factors (notably on the ability to prevent and detect broken rails), RATP engages a research project, **StatAvaries**, that consists in the implementation of a **decision support software** that models the entire diagnosis and maintenance actors together with the rail degradation depending on some operating rules.

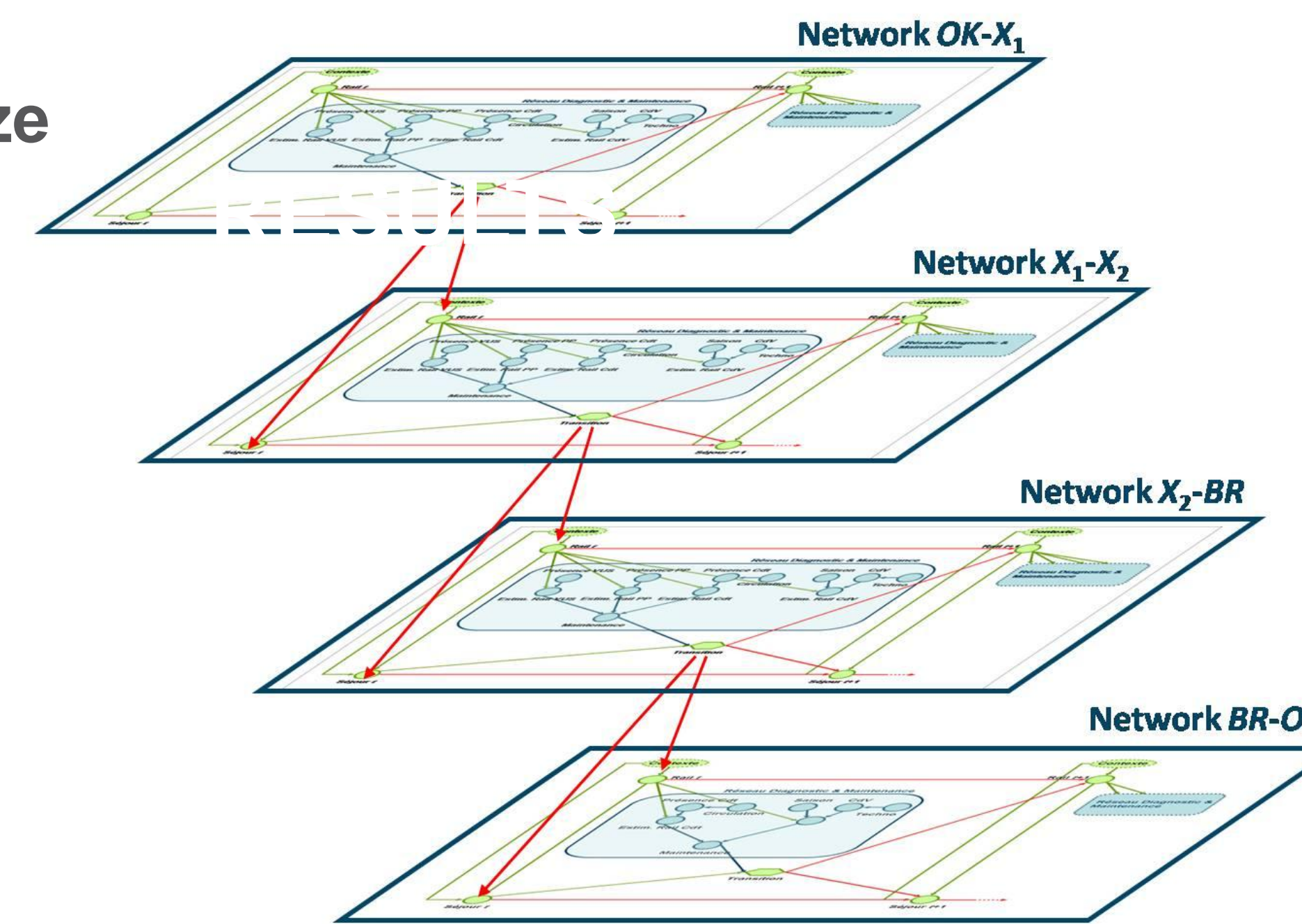
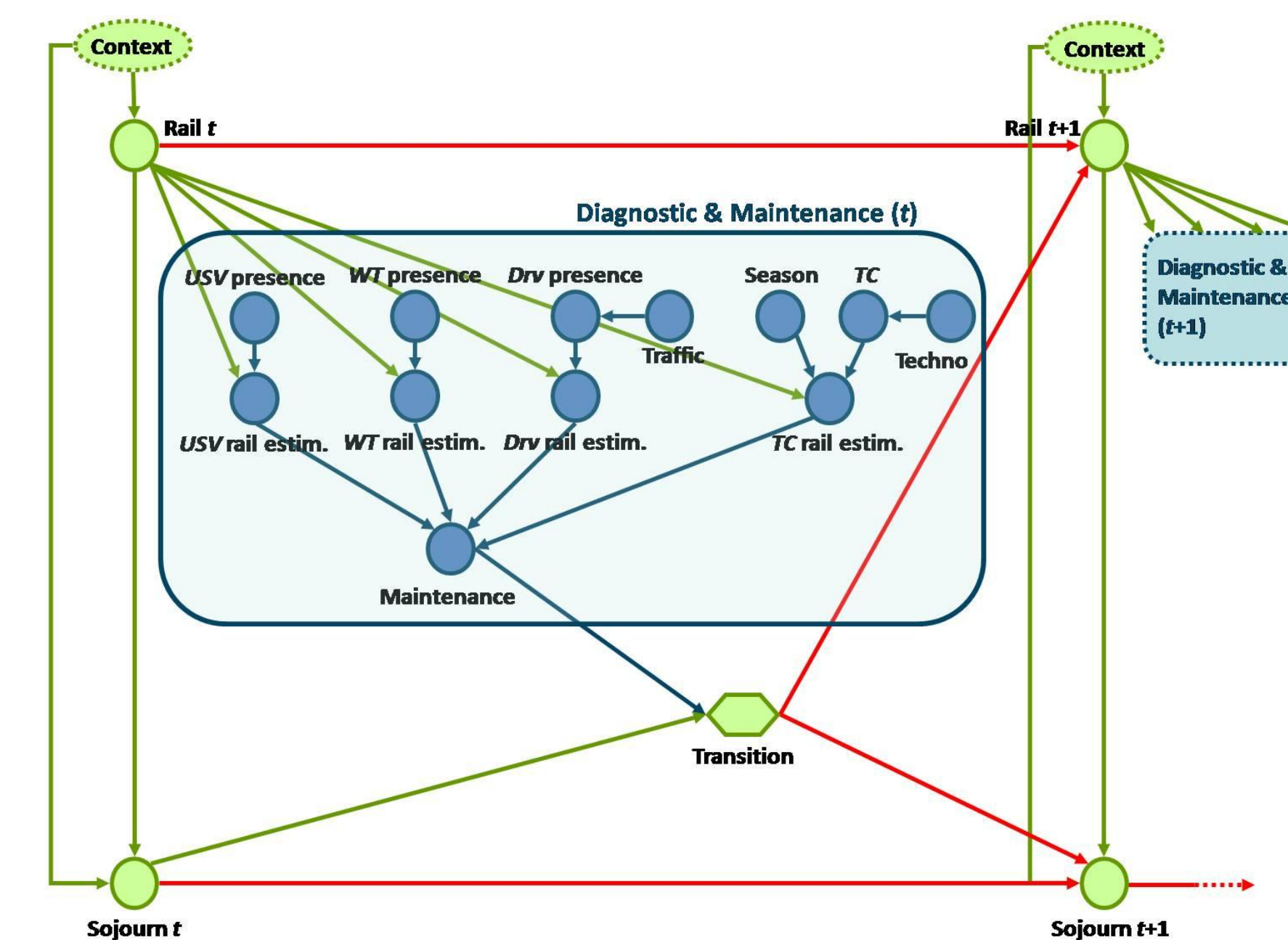
VirMaLab

VirMaLab (*Virtual Maintenance Laboratory*) is a modular generic approach based on the DBN theory, with 3 interconnected layers:

- The first one consists in the **mathematical modeling of the physical state** of the system. The degradation process can be modeled by various approaches (stochastic processes, Markov chains, semi-Markovian modeling...).
- The second one deals with both the **diagnosis actors** (periodical auscultations, good detection and false alarms rates...) and the **maintenance strategy** (all kind of maintenance can be modeled, from corrective to systematic, conditional or predictive actions).
- Finally, each module of a **VirMaLab** model can be characterized by **costs** (financial, human ...). The last phase consists in determining an **economical model** of the system

A **VirMaLab** modeling offers therefore a **decision support tool** for **quantifying and optimizing a maintenance policy**

STATAVARIES

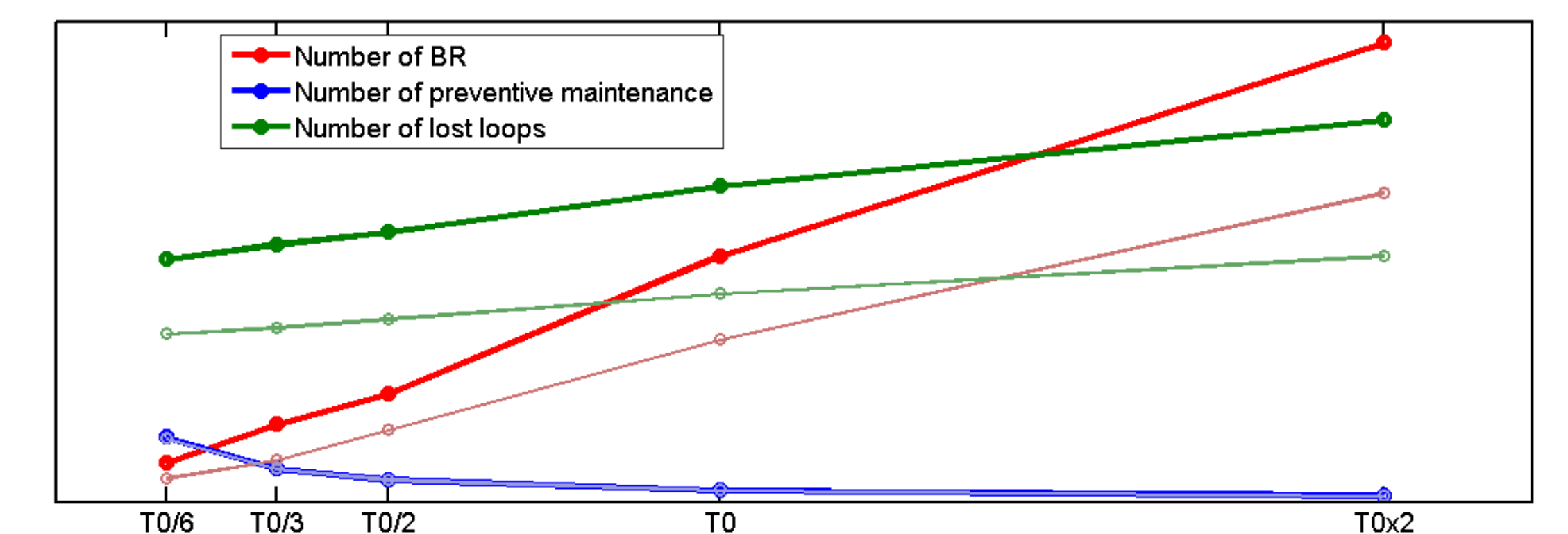


Main assumptions and needs of the model:

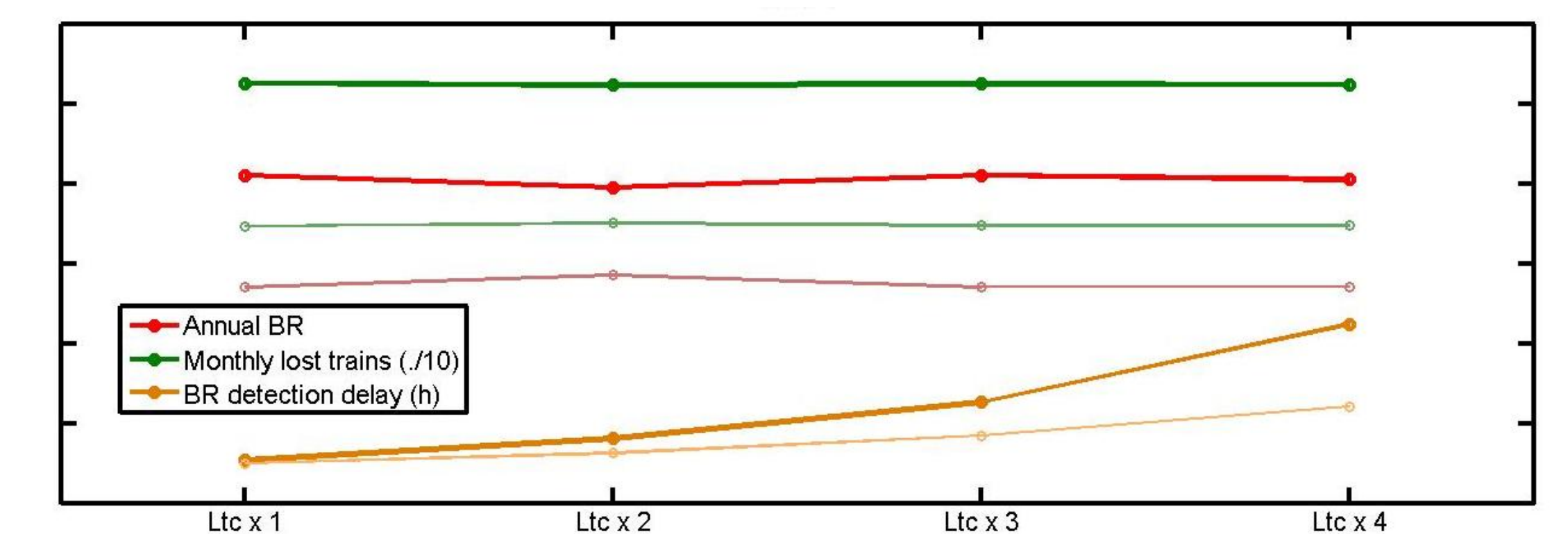
- 1 elementary rail section.
- semi-Markovian modeling of rail degradation process
- 4 diagnosis actors (2 preventive and 2 corrective)
- adaptative temporal granularity (1 month to 1 hour)
- many indicators on broken rails, maintenance actions, network availability (lost loops), detection delays...
- no cost modeling
- user friendly interface
- 1 reference scenario and 7 *prospective* scenarios

Impact of USV period on corrective and preventive maintenances and on availability.

Current and increased intervals (light and bold curves) for M7 steel wheel Paris metro .



Impact of mean TC length on BR, availability and BR detection delays (2 intervals values).



CONCLUSIONS

StatAvaries is an original maintenance strategy modeling dedicated for the **prevention and detection of broken rails**.

The proposed modeling can be divided in sub networks, eventually interconnected, describing the rail **degradation process**, the different **diagnosis actors** and the **maintenance actions**.

The **multi-nets** extension allows introducing an **adaptative temporal granularity** (in respect of both the **degradation dynamic** and the required accuracy for **indicators estimation**)

The **StatAvaries** decision support tool is currently **used by two RATP departments**.

