



HAL
open science

Stochastic optimization of predictive maintenance under uncertainty

Wenbo Wu, Sihem Tebbani, Rim Kaddah, Miguel Anjos

► **To cite this version:**

Wenbo Wu, Sihem Tebbani, Rim Kaddah, Miguel Anjos. Stochastic optimization of predictive maintenance under uncertainty. DTD&O, Nov 2024, Paris, France. 2024. hal-04774549

HAL Id: hal-04774549

<https://hal.science/hal-04774549v1>

Submitted on 8 Nov 2024

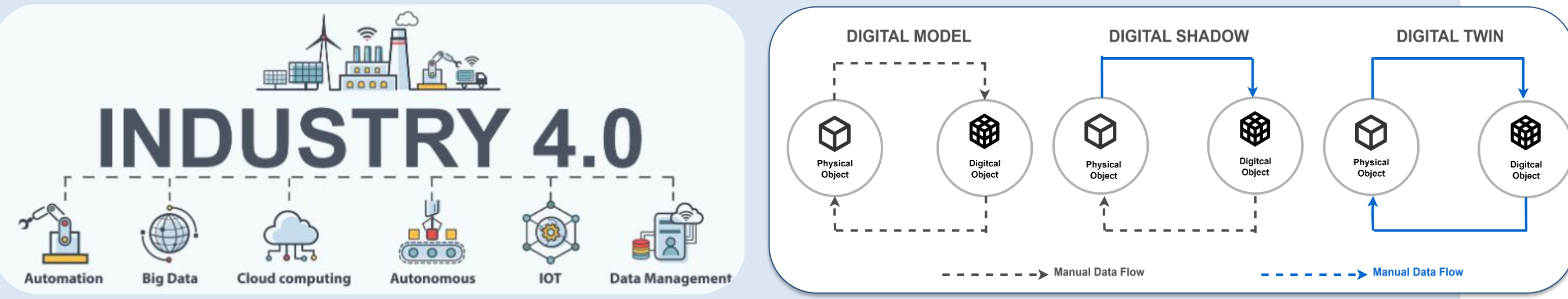
HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

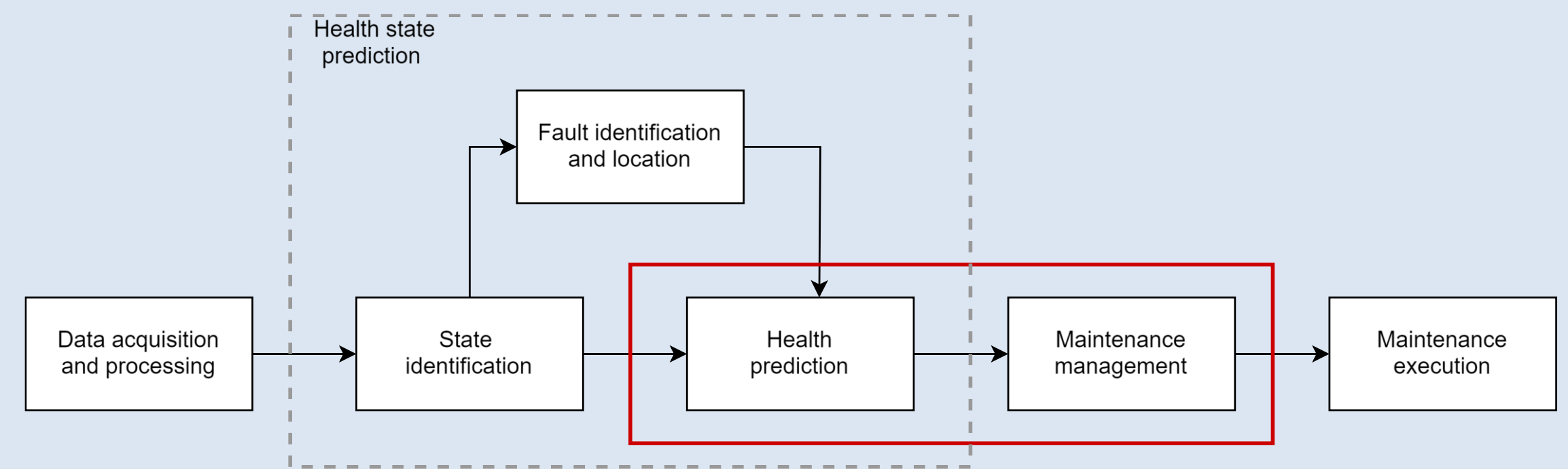


Distributed under a Creative Commons Attribution - NonCommercial - NoDerivatives 4.0 International License

- Industry 4.0:**
 - Heightened complexity in industrial systems
 - Need for real-time decision-making
 - Investigate data-driven optimizations



- Predictive maintenance in the era of digital twins (DT)**



Context 1

2 Objectives & Scientific Challenges

- Uncertainty handling:**



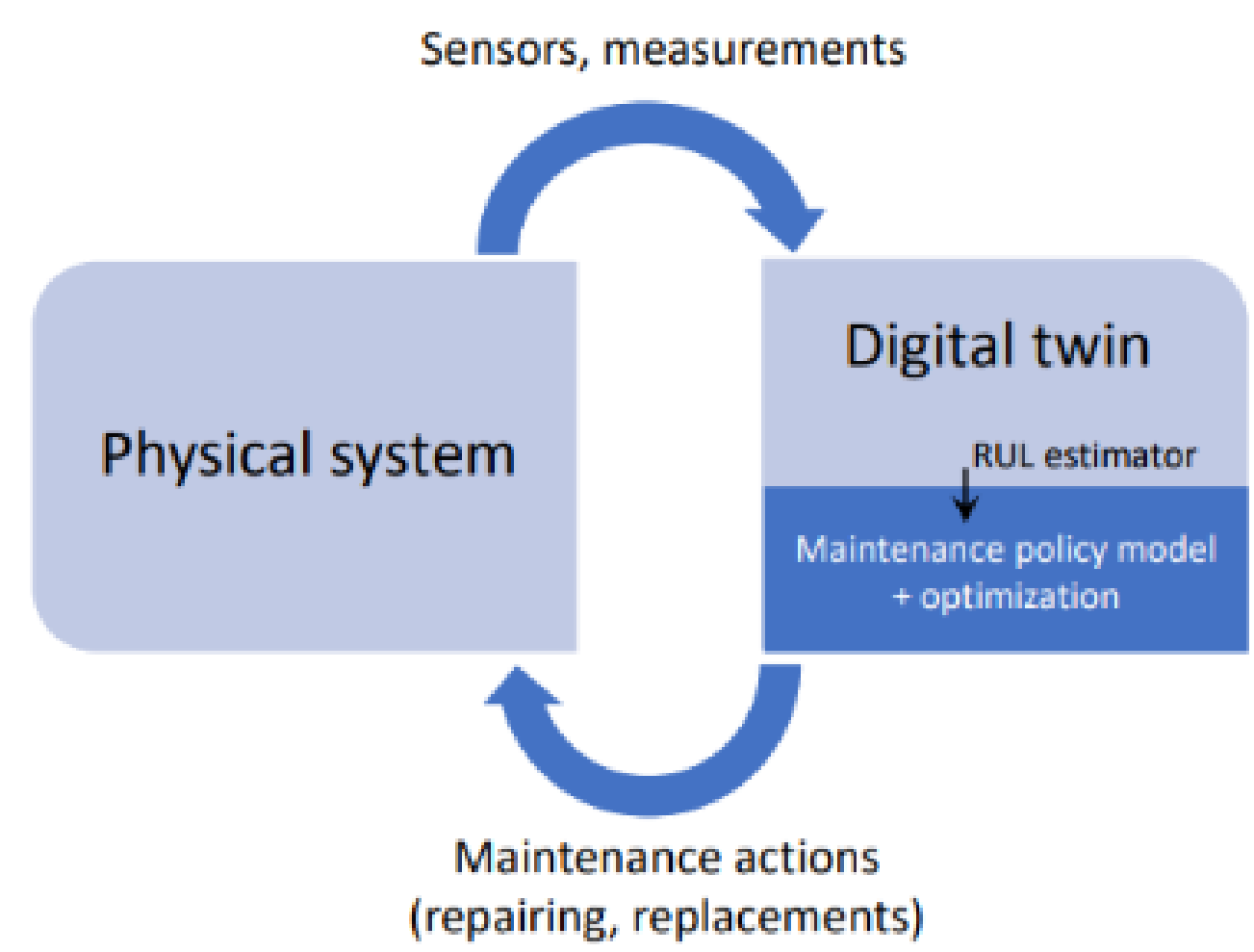
Data Uncertainty
 Missing data
 Unstable sensors
 Data error

Environment Uncertainty
 Operating conditions
 External environment

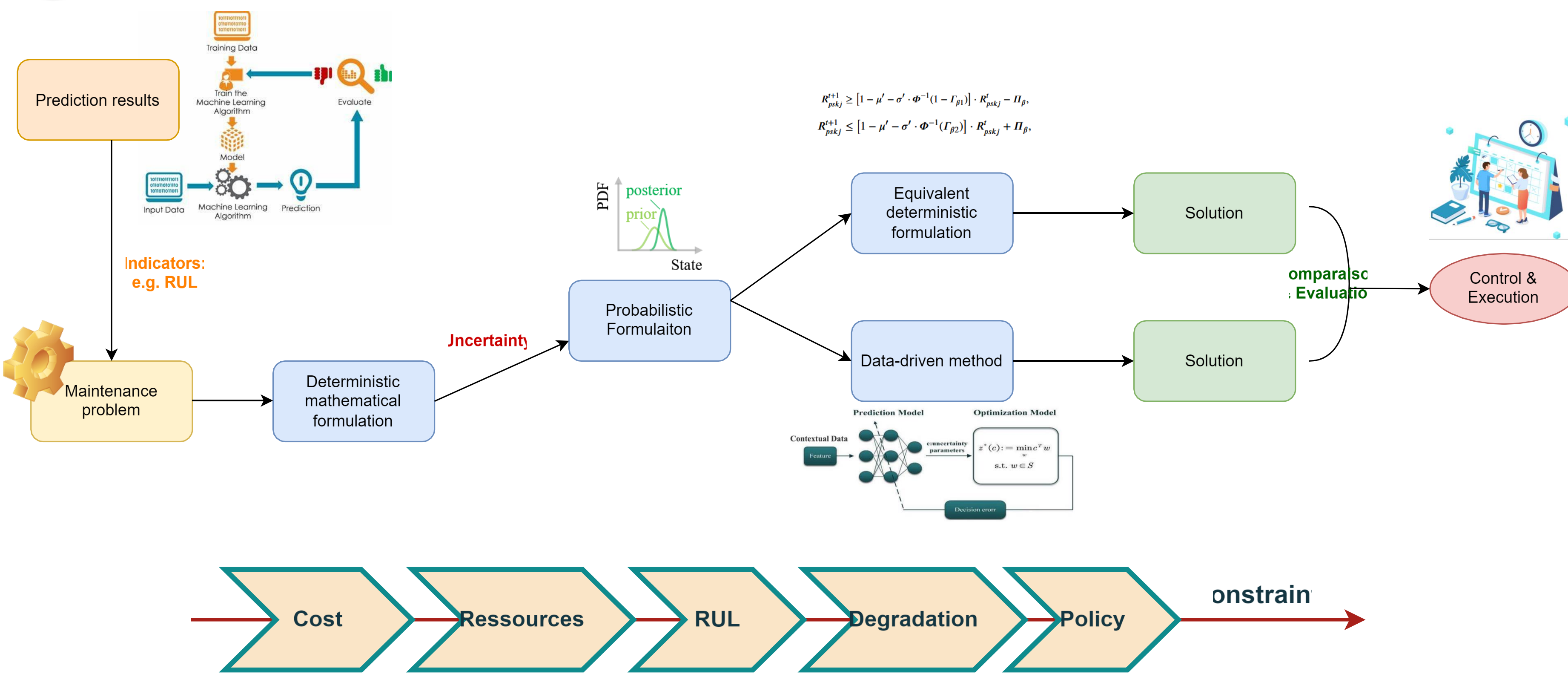
Performance & Deterioration
 Deterioration process
 Failure modes

- Data-driven Optimization:**

Using the results of the optimization solutions as feedbacks to reconfigure, actuate or modify the maintenance planning accordingly.



3 Methodology



4 Expected Results

- State of the art research :** Comprehensive overview of current advancements, industry applications, research gaps, and future directions.
- Decision Support System:** Dynamic Maintenance Plan: A dynamic maintenance plan based on the uncertainty of the real-time status of the equipment. Trade-off between cost and parameter of interest.
- Improved System Availability and Stability:** Notable improvement in system availability, stability and performance resulting from the comprehensive integration of approaches above mentioned.

- Explore exact mathematical models through a probabilistic optimization approach, focusing on small and medium problem instances.
- Explore new data-driven optimization approaches (e.g. Predict-then-optimize, Reinforcement learning etc.) to improve considerably the accuracy of the decision.

6 References

[1] Rasheed et al.(2020) Rasheed, San, and Kvamsdal] Adil Rasheed, Omer San, and Trond Kvamsdal. Digital twin:Values, challenges and enablers from a modeling perspective. IEEE Access, 8:21980–22012, 2020. doi: 10.1109/ACCESS.2020.2970143.

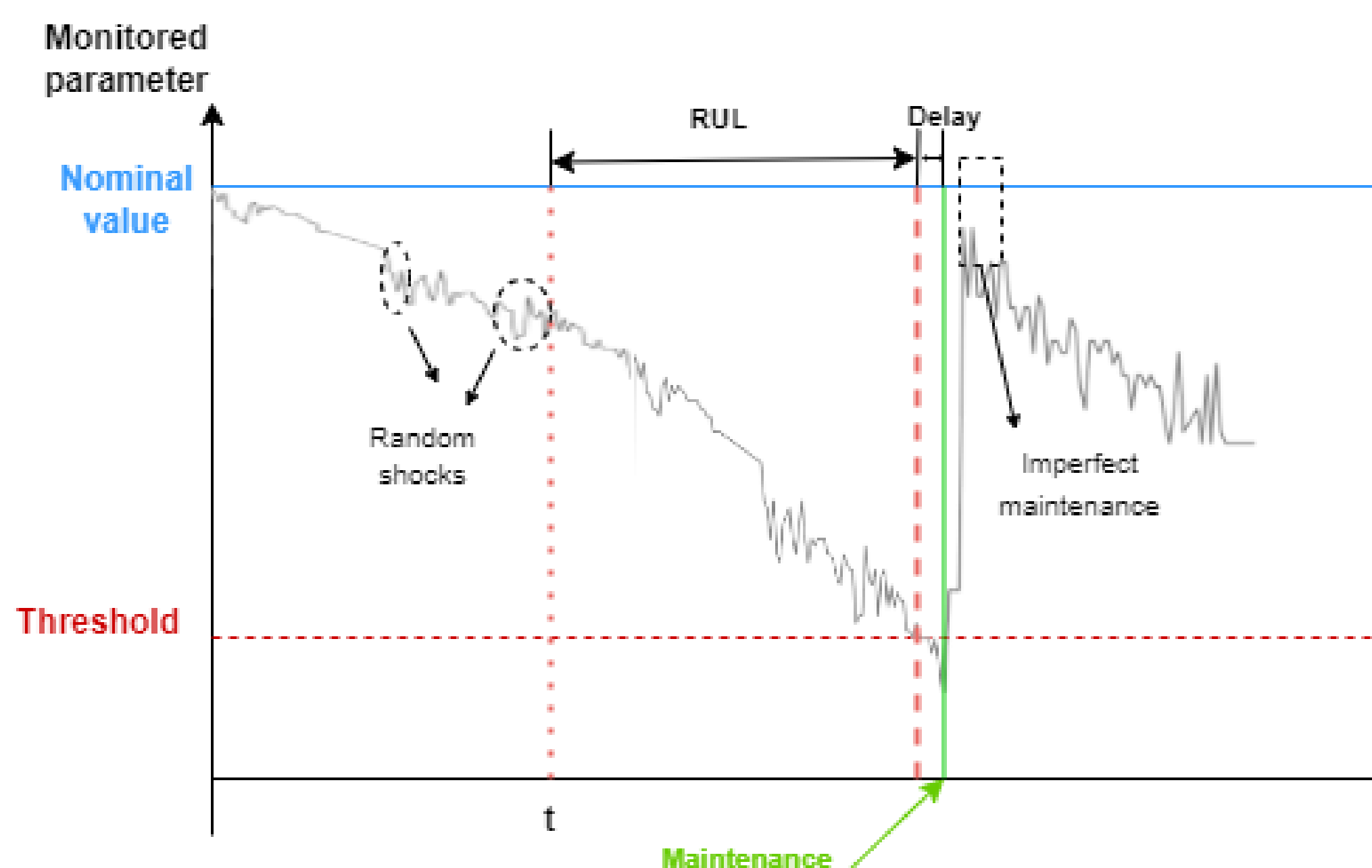
[2] A.N., Elmachtoub et al, Smart “Predict, then Optimize”, Management Science Volume 68 Issue 101, January 2022, pp 9–26

[3] S. Khebbache, M. Hadji and M. Batteux, "Stochastic Maintenance Optimization of Complex Industrial Systems under Uncertainty of Repair Time and Resources,"2022 6th International Conference on System Reliability and Safety (ICRSRS), Venice, Italy, 2022, pp. 512-518, doi: 10.1109/ICRSRS56243.2022.10067835.

[4] Zhang, Beikun et al. "Remaining Useful Life Based Maintenance Policy for Deteriorating Systems Subject to Continuous Degradation and Shock." Procedia CIRP 72 (2018): 1311-1315.

Acknowledgement:
 This work has been supported by the French government under the "France 2030" program, as part of the SystemX Technological Research Institute within the JN13 project.

5 Use Case Study



- Validation of the effectiveness through a electricity network.
- Handling real-world complexity
- Identifying and addressing sources of uncertainty.
- Performance analysis and improvement.

