Trustworthy Predictive Maintenance (TPdM)

Coordinator organization: Chalmers University of Technology, Department of Industrial and Materials Science

Start 2022 September 30
End 2025 September 29

Mohan Rajashekarappa
Ph.D. Student in Production Systems Division,
Department of Industrial and Materials Science,
Chalmers University of Technology
Email: rmohan@chalmers.se

VINNOVA
Sweden's Innovation Agency

Advanced and innovative digitalization 2022

Agenda

- Industrial challenge
- The scope of the TPdM
- TPdM concept
- Vision and the goals of TPdM
- Collaboration in TPdM
- TPdM implementation
- Dissemination plan

Industrial challenge

Source: https://data.europa.eu/doi/10.2777/308407.

Emphasis is put on dynamic human-in-the-loop scenarios, where ethical, transparent, and trusted AI systems co-exist with human workers!

Source: https://library.oapen.org/handle/20.500.12657/52612

Industrial data reliability

Responsible and transparent artificial intelligence systems

Reliable AI deployments in production lines

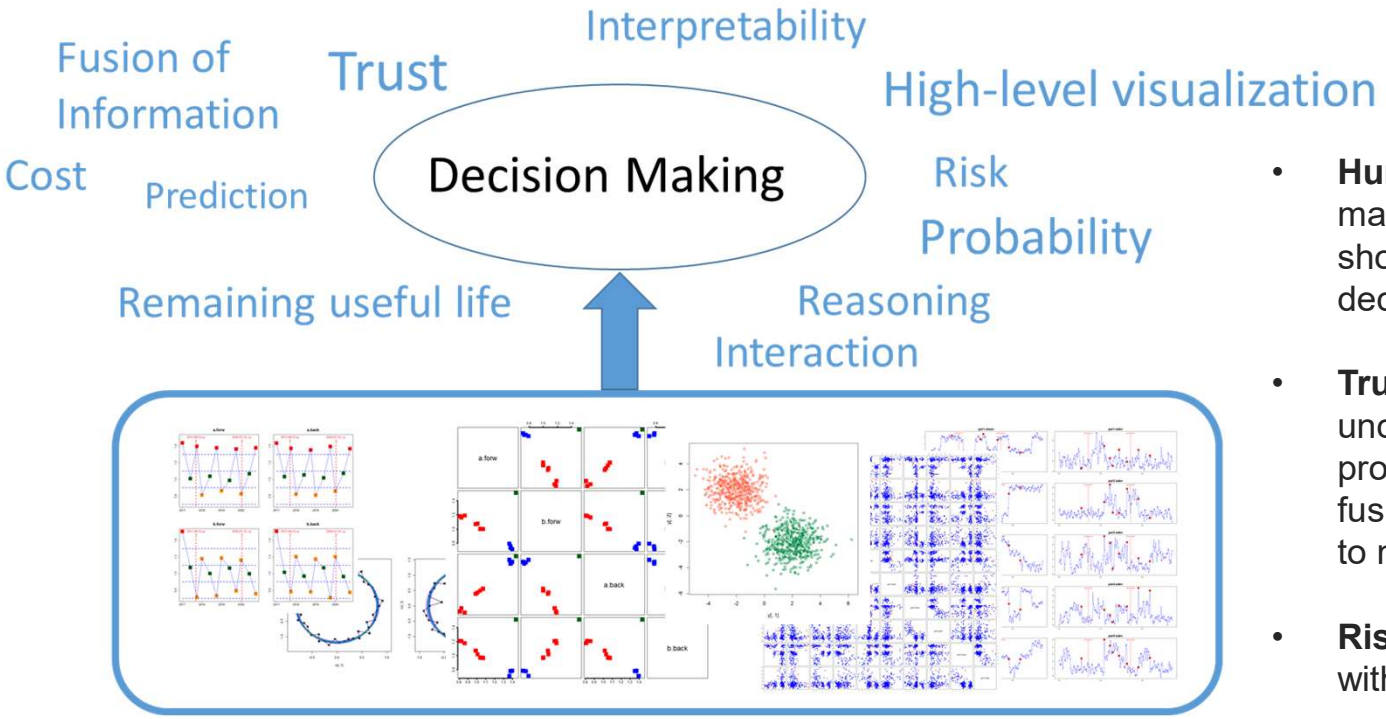
Industrial challenge

As also identified from the state-of-the-art*, there are still some challenges in Predictive Maintenance (PdM) solutions:

- *“PdM solutions need to provide clear, actionable, and comprehensible maintenance decisions”.*
- *“The output of PdM systems must be actionable decisions and solutions on the asset” .*

*Al-Najjar, B., Alexopoulos, K., Hribrenik, K., Surico, M., Nikolakis, N., Keraron, Y., ... & Makris, S. (2021). Predictive maintenance technologies for production systems: A roadmap to development and implementation.

The scope of TPdM

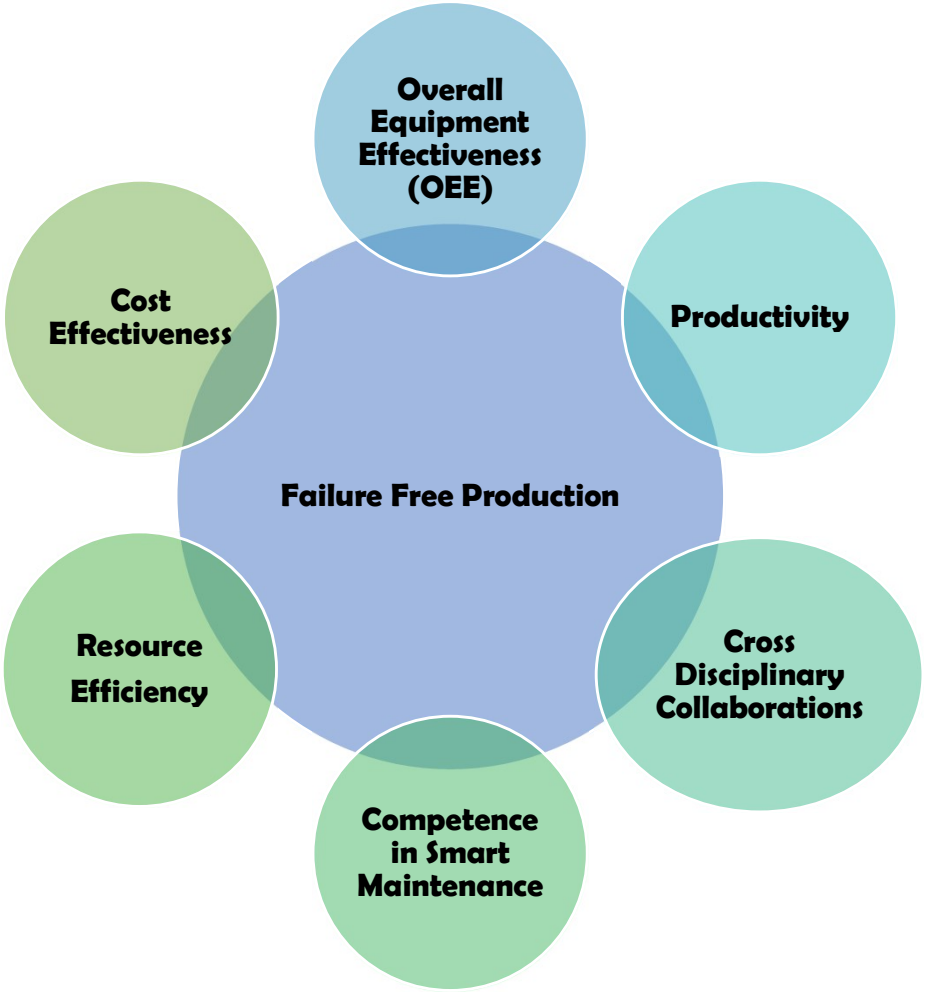


- **Human in the center** of the decision-making – information from the data analysis should be highly supportive of the given decision
- **Trustworthiness** – all involved uncertainties regarding the decision problem should be taken into account and a fusion of data sources should be performed to minimize uncertainty
- **Risk/utility** should be modeled together with the uncertainty in the decision problem

TPdM concept

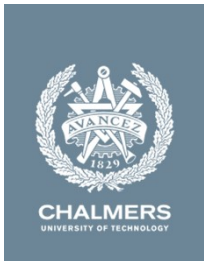
- TPdM project aims to design ***human-centric decision support prototypes*** for PdM to achieve actionable decisions
- ***Iteratively deploying*** working prototypes for on-site and online analysis
- ***Interpretable data analysis*** based on ***multiple information sources*** and ***modeling uncertainties*** (e.g., Bayesian statistical data analysis)
- It contributes to ***technical focus areas***:
  - “Datadriven utveckling och säkert utbyte av data mellan processer och aktörer”
  - “End-to-End AI i utveckling, produktion och tjänster”.

Vision and the goals of TPdM



- PG1. Develop a proof-of-concept implementation that illustrates the predictive performance of the developed algorithms;
- PG2. Identify a requirement specification for prototypes of the TPdM decision support system;
- PG3. Develop a proof-of-concept demonstrator for proactive maintenance recommendations;
- PG4. Develop industrial demonstrators of high-level visualization solutions for PdM decision-making;
- PG5. Develop pedagogical and lifelong learning materials
- PG6. Publish the designed models for the TPdM in high-impact journal articles

Collaboration in TPdM



AB Volvo, AB SKF, and Husqvarna Group

- Industrial use case and domain expertise for PdM development

Siemens AB

- Technical expertise & knowledge in online data collection and connectivity solutions

Capgemini AB

- Extensive expertise & knowledge in digital transformation and data-driven solutions to be operationalized in the industry

University of Skövde

- Research group - Artificial Intelligence Lab (SAIL) - Applied AI/data science in different application areas
- Research group - Intelligent Production Systems - Optimization and data analytics, as well as learnings from an ongoing project in PdM

Chalmers University of Technology

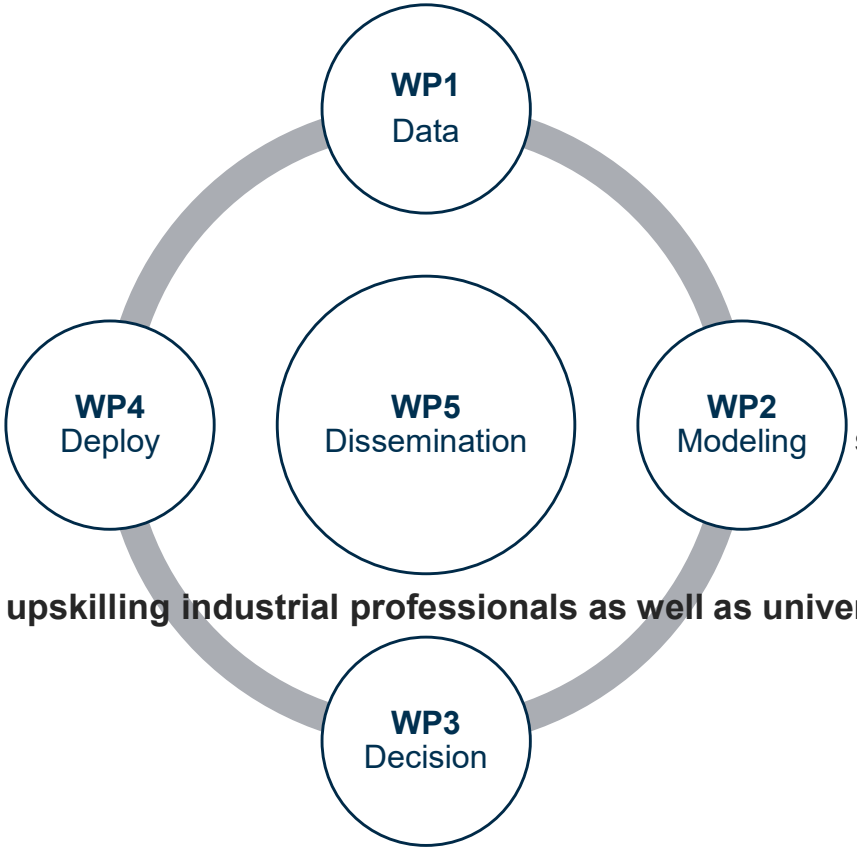
- Research group - Production Services & Maintenance Systems - Smart Maintenance and industrial data analytics/AI

Industrial use cases in brief

- AB Volvo
  - **Analysis of the degradation pattern and fault diagnosis of the ball screw system**
  - **Spindle bearings remaining useful life (RUL) estimation**
- AB SKF
  - **Implement a condition monitoring and predictive maintenance system for machining fluids in the bearing ring production**.
- Husqvarna Group
  - **Implement a condition monitoring and predictive maintenance system for die-casting machine.**

TPdM implementation

Review of data and patterns



Continuous deployment of software prototypes on the shop floor

Model development resulting in several different and refined models

Reskilling and upskilling industrial professionals as well as university students

Design of maintenance decision support system for achieving TPdM

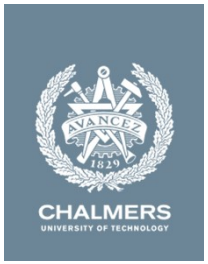
Expected results

- Identified model road maps
- Models and methods for trustworthiness in PdM
- Designed software prototype for TPdM
- Deployed TPdM prototype
- Dissemination materials (e.g., pedagogical and life-long learning materials)

Dissemination plan

- Regular collaborative meetings
- Technology workshops (open to the Swedish industry)
- External dissemination through Sustainability Circle business networks, Swedish Maintenance Community, and the Swedish Maintenance Fair
- Scientific dissemination in the form of publications
- The project results will be incorporated into master's level course materials
- Additional funding for education and life-long learning materials ("nuggets")
- General public dissemination
- Create dissemination packages (slide shows) for consultancy costumers

Thank you!



- VINNOVA Avancerad och innovative digitalisering for their research grant!
- All our valued partners in TPdM project!
- All for your listening!

Contact information:

Project leader: Ebru Turanoglu Bekar

Email: ebrut@chalmers.se

Telephone: +46 709 49 23 38

Project webpage:
https://research.chalmers.se/en/project/10948

CHALMERS

UNIVERSITY OF TECHNOLOGY