# Towards predictive maintenance via digital twinning: Bridging data-driven and model-based fault detection and isolation

DSPE YOUR PRECISION PORTAL
2020 CONFERENCE ON PRECISION MECHATRONICS
8 & 9 September - De Ruwenberg Sint Michielsgestel
www.dspe-conference.nl

# Towards predictive maintenance via digital twinning: Bridging data-driven and model-based fault detection and isolation*

Koen Classens[1], Tom Oomen[1], Maurice Heemels[1], Jeroen van de Wijdeven[2], Marc van de Wal[2], Wouter Aangenent[2]

[1] Eindhoven University of Technology, Eindhoven, The Netherlands
[2] ASML Research Mechatronics, Veldhoven, The Netherlands

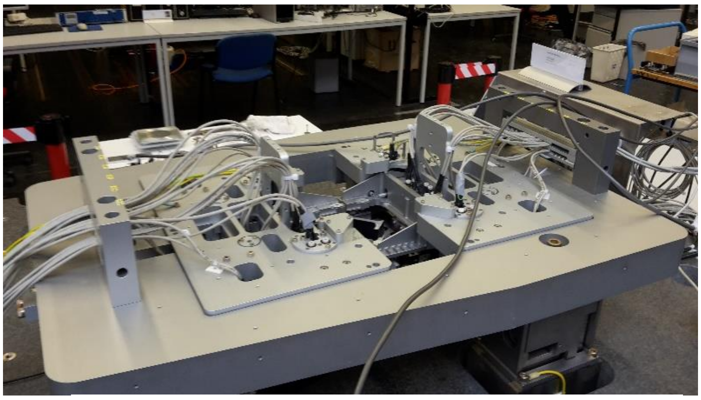
k.h.j.classens@tue.nl

**Abstract**

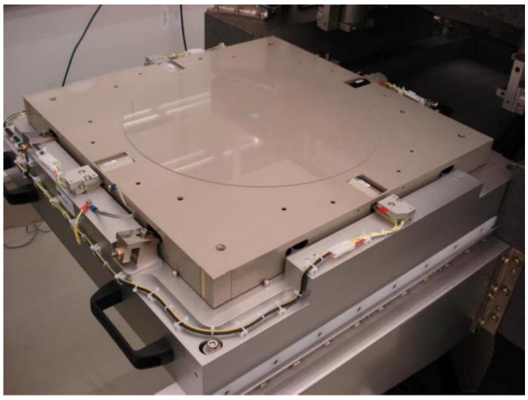
The economic value of high-tech production equipment is to a large extent determined by its productivity. Unexpected faults may result in downtime leading to a loss of productivity. Such unexpected faults arise from defects, ageing and wear of system components. Ideally, critical faults are detected in an early stage and handled such that downtime is minimized. Equipment downtime can be minimized by means of predictive maintenance, which can be pursued via the process of predicting and detecting faults in equipment and pinpointing its origin, which is called Fault Detection and Isolation (FDI).

Typically, models of the system are available prior to commissioning a machine, for instance, through Finite Element Modeling or identified models during system integration. After system integration and control design, the model is generally left unused. Evidently, this model is extremely valuable and can be exploited in the form of a digital twin that is informed with real-time data through a large number of sensors and actuators [1]. A physics-based model is envisaged that is learned from data to improve the predictive capability of this digital counterpart. The underlying physical model enables to isolate the origin of anomalous behaviour, which in turn allows for effective self-healing or specific hardware maintenance.

The envisioned approach involving data-enriched physics-based digital twins is general in nature and therefore likely to be applicable to a large range of systems, including production machines and scientific instruments. The proof-of concept will demonstrate that the envisioned approach can be applied to a broad industrial range of mechatronic systems far beyond wafer scanners. In this way, the present research project (2020-2024) focuses on bridging the gap between data-based approaches and model-based approaches, which are currently largely separated.



(a) Free floating reticle stage.



(b) Overactuated test rig.

Figure 1: Two experimental setups.

[1] T. Oomen, "Advanced Motion Control for Precision Mechatronics: Control, Identification, and Learning of Complex Systems," *IEEJ Journal of Industry Applications*, 7(2), 127-140, 2018.

Keywords of the content are: Digital Twinning, Predictive Maintenance, Fault Detection and Isolation, Model Learning

* This work is supported by TKI and ASML Research