

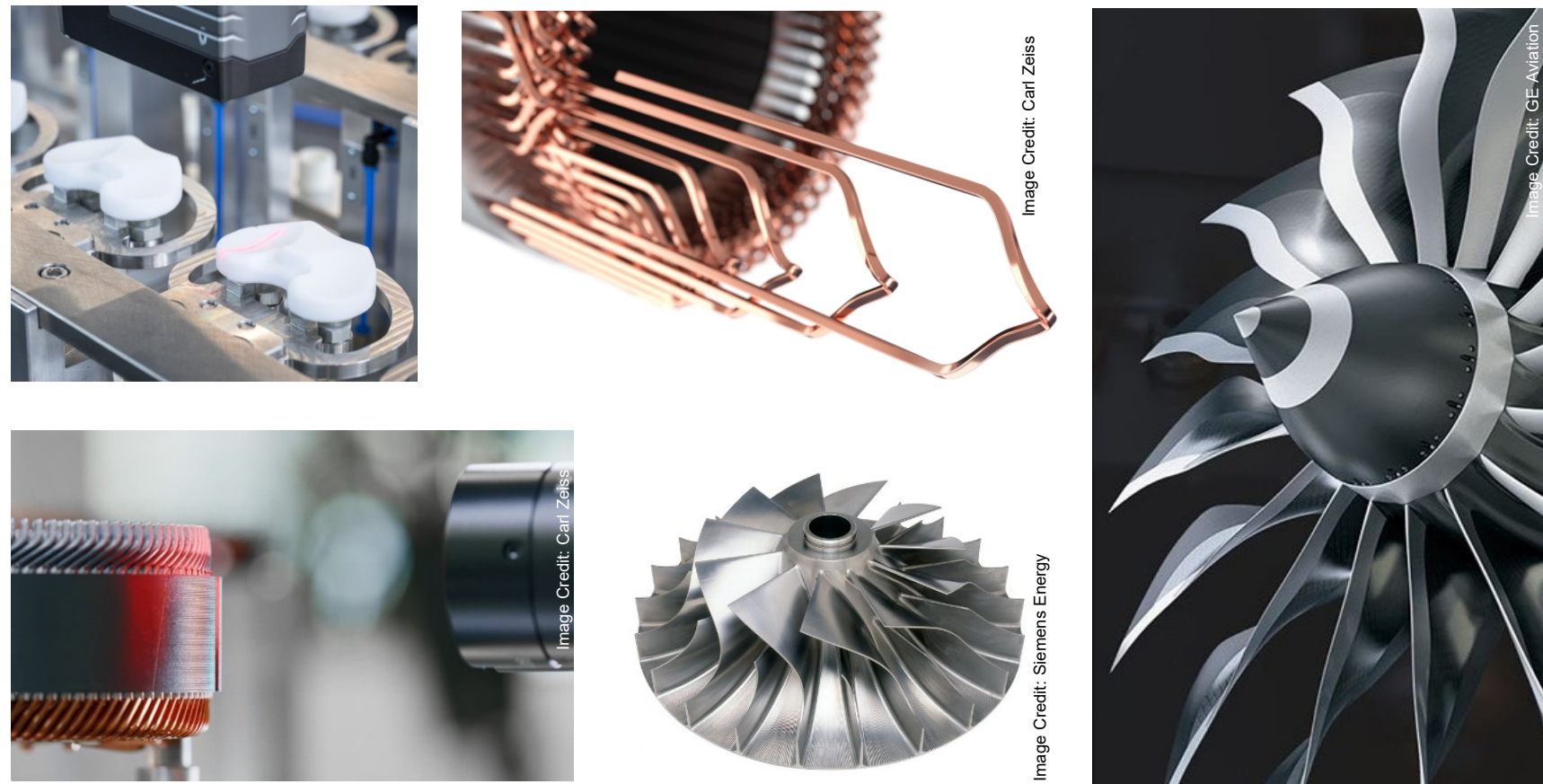
Application of digital-metrological twins for emerging measurement technology in advanced manufacturing



D. HeiBelmann¹, K. Janzen¹, U. Neuschaefer-Rube¹, L.-J. Frömel¹, J. Soukal², I. Linkeova², J. Hynek², J. Cibulka², A. Wojtowicz^{3,11}, D. Czulek³, H. Noura⁴, E. Xhafa⁴, S. Bergstrand⁵, A. Thore⁵, C.-H. Hanquist⁵, W. Knulst⁶, M. van Dijk⁶, D. Nalbantoglu⁶, G. Kok⁶, B. Hemming⁷, V. Heikkinen⁷, A. Lassila⁷, G. Tossello⁸, N. Anwer⁹, P. Puerto¹⁰, A. Garcia Berdote¹⁰, A. Gaska¹¹, W. Harmatys¹¹, G. Maculotti¹², M. Galetto¹², E. Verna¹², G. Genta¹², M. Bodenbenner¹³, Y. Dang¹³, D. Wolfschläger¹³, G. Kortaberria¹⁴, E. Gomez-Acedo¹⁴, U. Mutilba¹⁴, E. Savio¹⁵, S. Catalucci¹⁵, L. Didonè¹⁵, J. Hageney¹⁶, A. Pierro¹⁶, F. Paul¹⁶, T. Maresch¹⁷, M. Abe¹⁸, D. Imkamp¹⁹, O. Sato²⁰

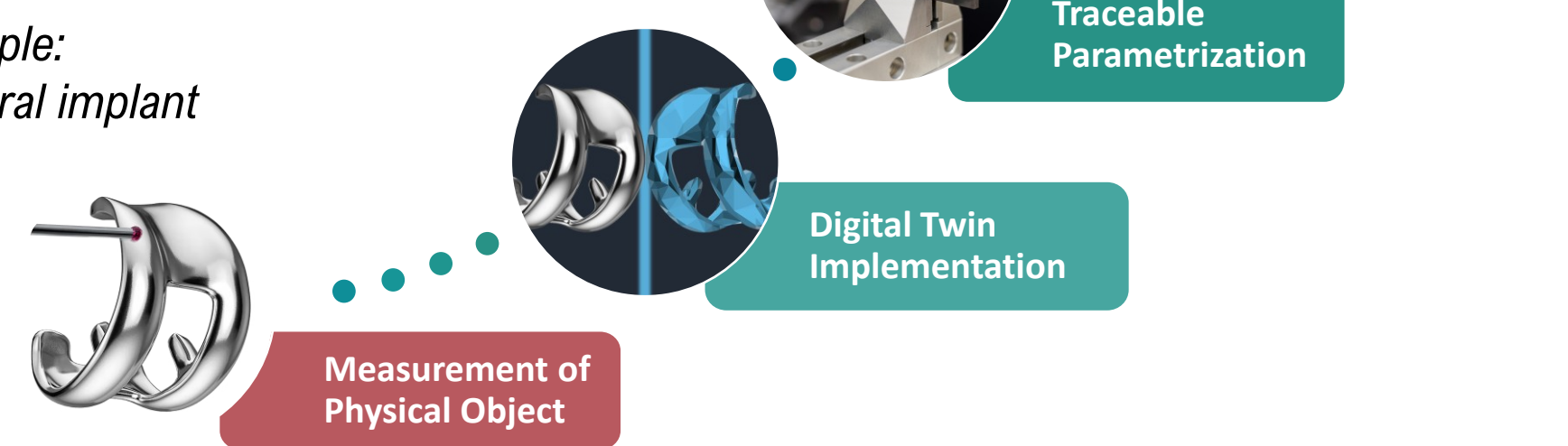
Motivation

Advanced manufacturing methods demand for new technology, assembly concepts and product designs. To adequately measure the products, **methods for the measurement uncertainty evaluation of freeform geometries and using non-contact optical sensors** are of increasing importance.



To enable the **efficient and reliable** use of emerging measurement technologies in industry, **machine-interpretable results** need to be created using **validated digital-metrological twins (D-MTs)**. Operators have to be trained and guided to **determine the influencing parameters by traceable means**.

Example: Femoral implant



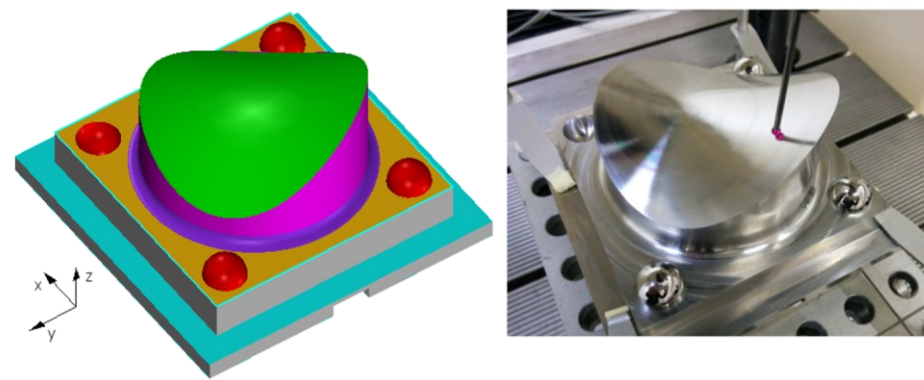
Project goals

- ← D-MTs for freeform geometries and their measurement process
- ← Virtual reference artefacts (softgauges)
- ← Derivation of D-MT models for typical optical sensors
- ← Parametrization strategies and methods (incl. measurement standards)
- ← Performance optimization and validation
- ← Glossary, Guidelines, and Good Practice Guides

Freeform Geometries

D-MT for freeform geometries

- ← Digital representation of freeform geometry measurement standard



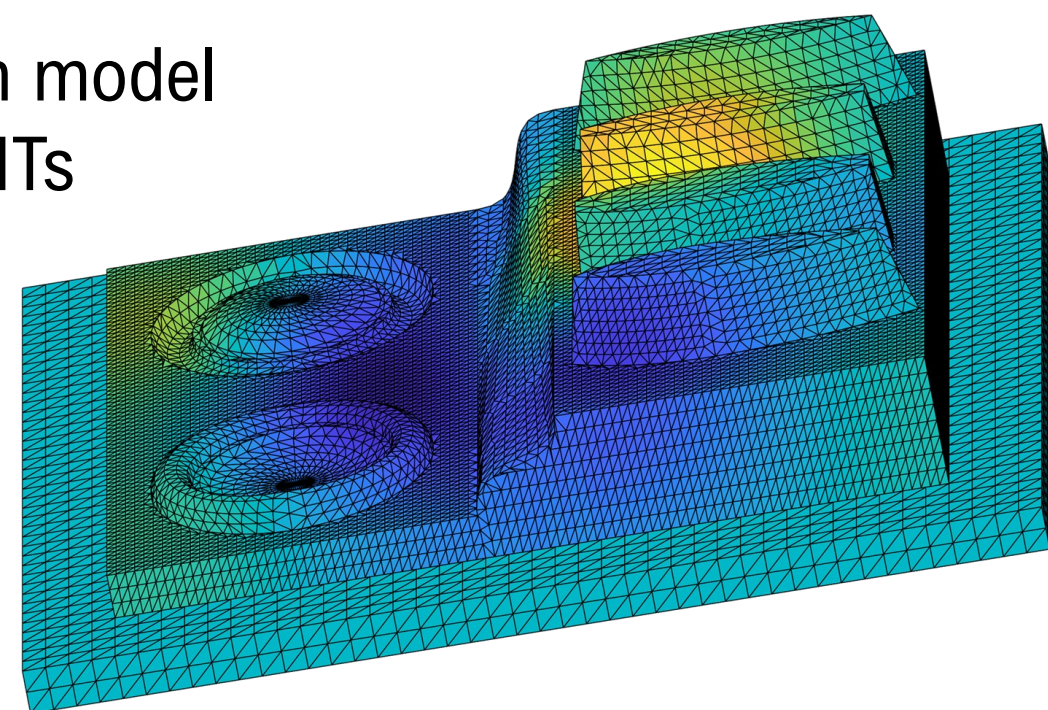
D-MT for freeform measurement process

- ← For tactile and optical probing
- ← Comparison to measurements of prismatic geometries



Softgauge as virtual reference artefact

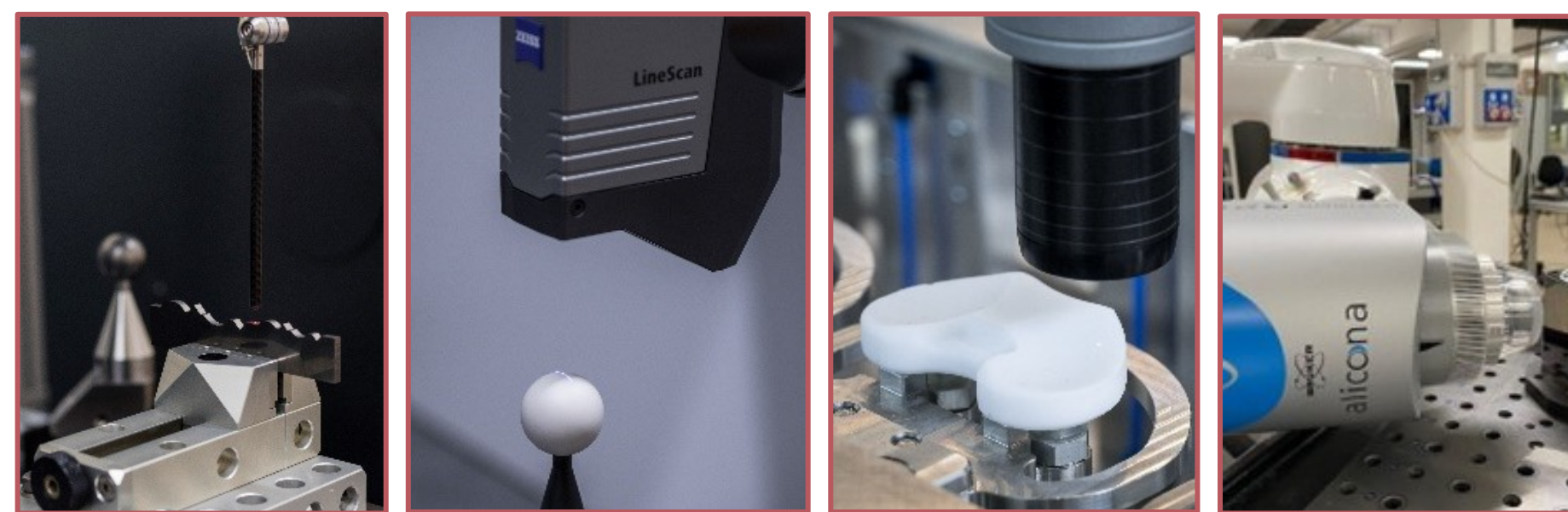
- ← From e. g. skin model
- ← Testing of D-MTs



Optical Sensors

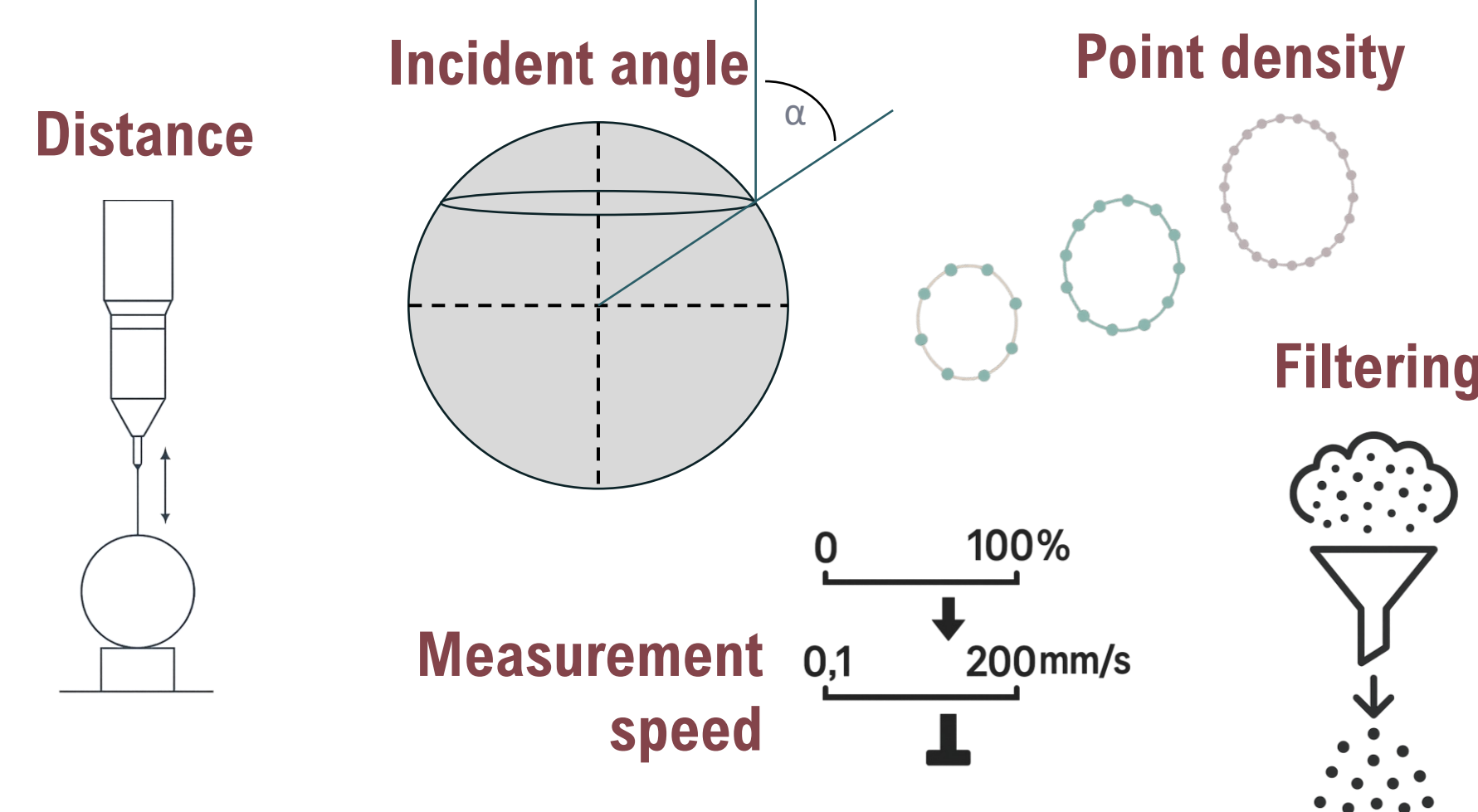
4 typical sensors for CMM and MTs

- ← Interferometric point sensors
- ← Chromatic confocal sensors
- ← Line-scanning sensors
- ← Focus variation sensors



Common investigation strategy

- ← Determination of measurement uncertainty contributions
- ← Different levels of parameter space combinations



Parametrization & Optimization

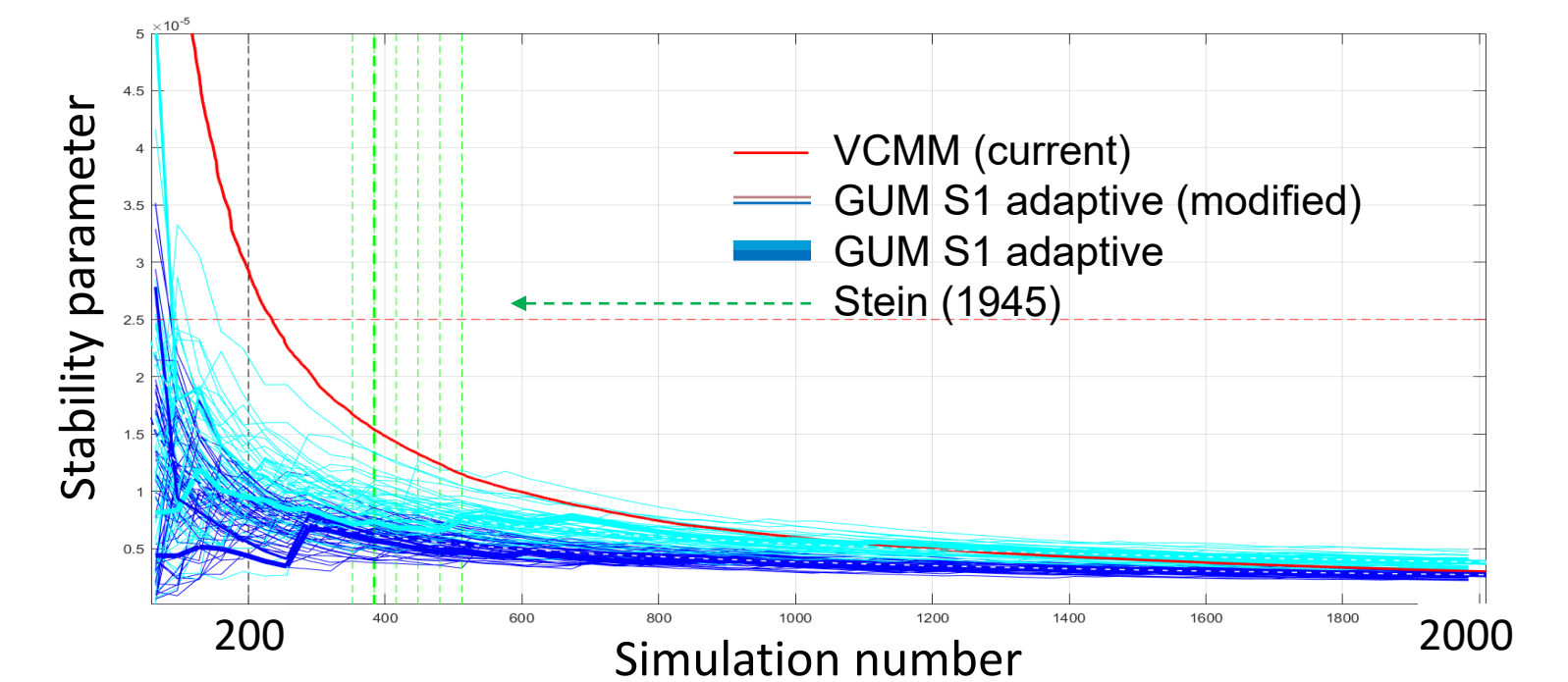
Traceability of parameters

- ← Parametrization using calibrated sensors and measurement standards
- ← Newly designed/manufactured freeform measurement standards to augment characteristics of available objects



Optimization

- ← Study of number of required parameters
- ← Economics: time and cost-efficient parametrization strategies
- ← Evaluation of numerical stability vs. GUM S1 conformity



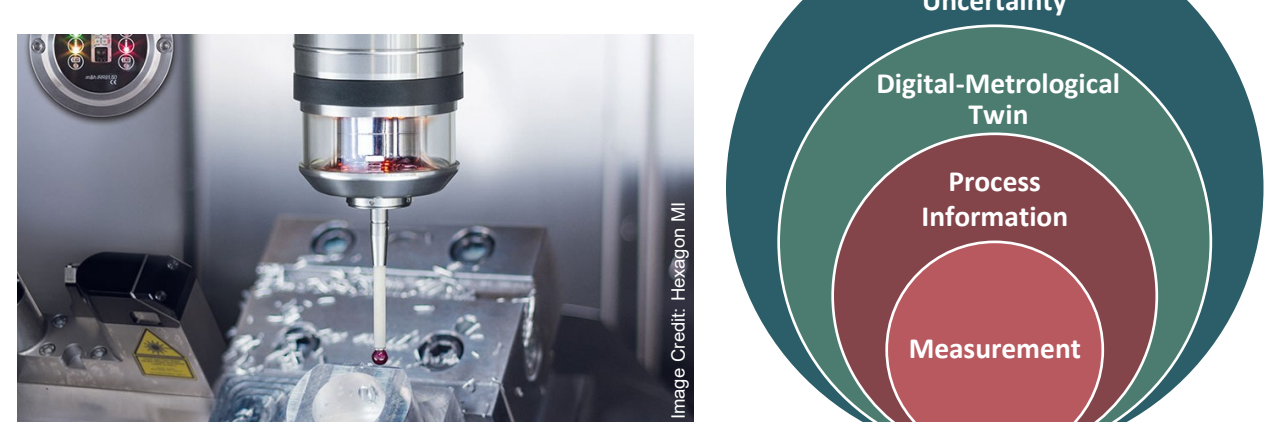
Validation

- ← Validation of achieved measurement uncertainty in industrial use cases

Expected Outcomes

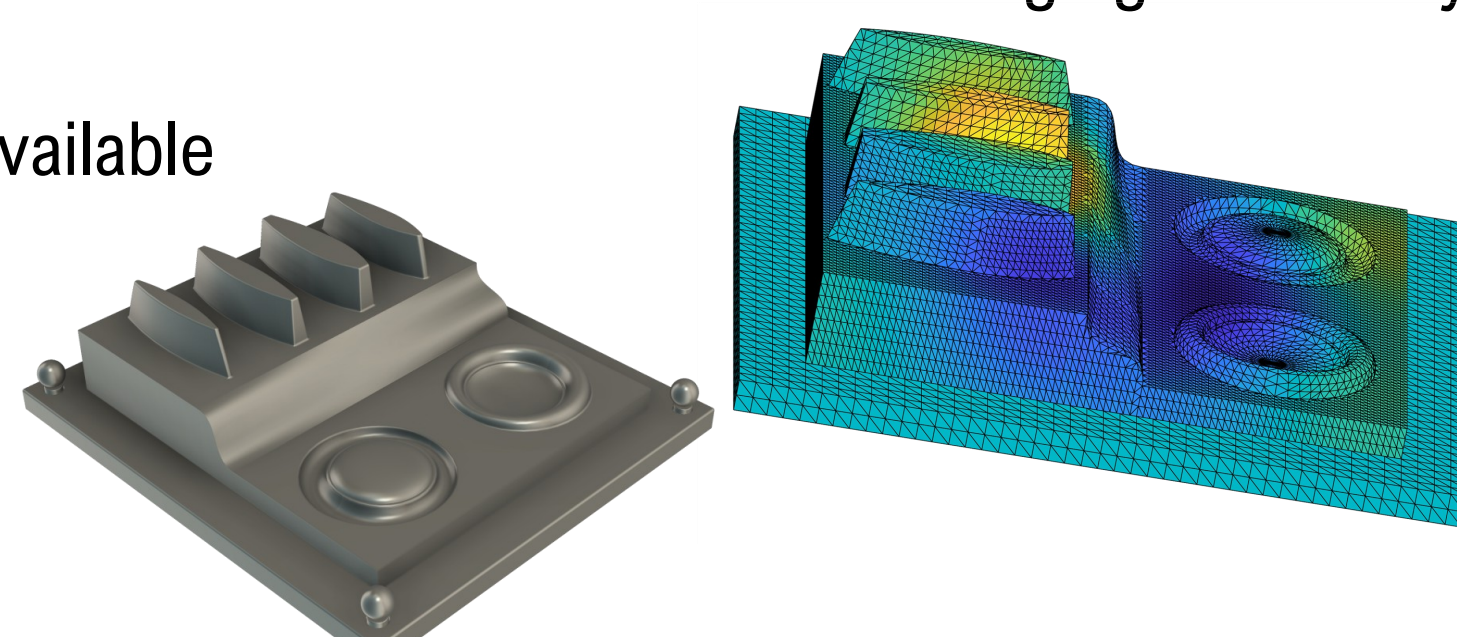
Validated D-MT Models

- ← D-MT models for freeform geometry measurements and use of optical sensors
- ← Validation for industrial use cases of CMMs and MTs



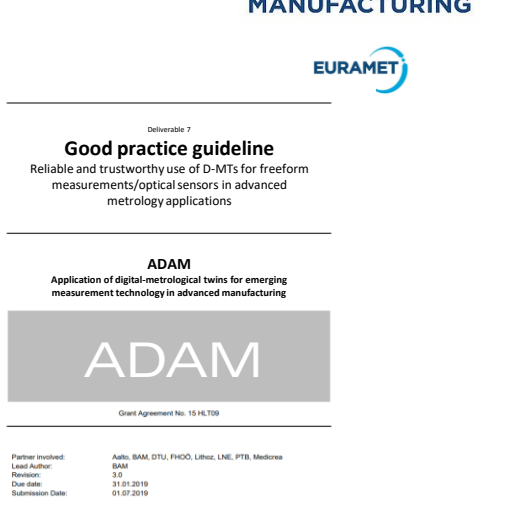
Freeform Measurement Standard(s)

- ← New freeform measurement standards bridging availability gaps
- ← Design available to public



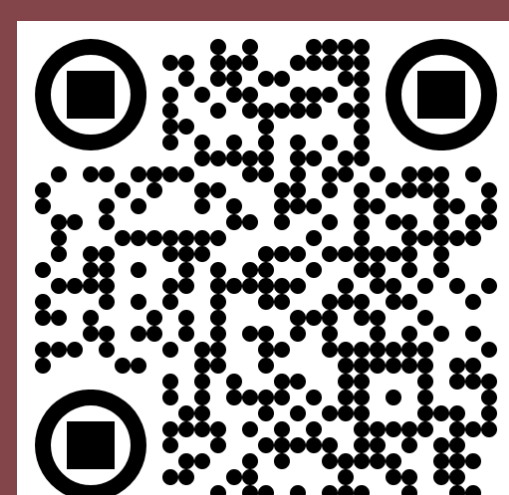
Guidance, Standards, Services

- ← Good Practice Guidelines
- ← Working group in EMN Advanced Manufacturing
- ← Input to ISO/TC 213/WG 10 and AG 12, ISO/TC 39/SC 2, ISO/IEC JTC 1/SC 41, and several national committees

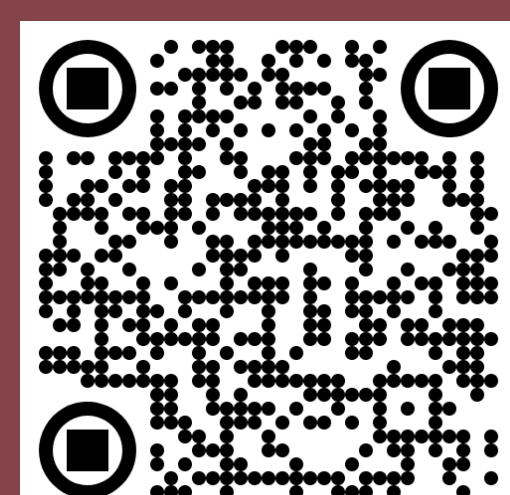


Follow the project

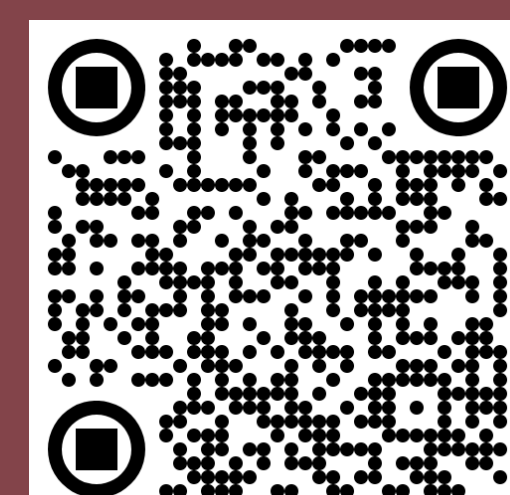
<https://adam.ptb.de>



Website



Zenodo



LinkedIn

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EURAMET. Neither the European Union nor the granting authority can be held responsible for them.

The project has received funding from the European Partnership on Metrology, co-financed from the European Union's Horizon Europe Research and Innovation Programme and by the Participating States.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

METROLOGY PARTNERSHIP

EURAMET

