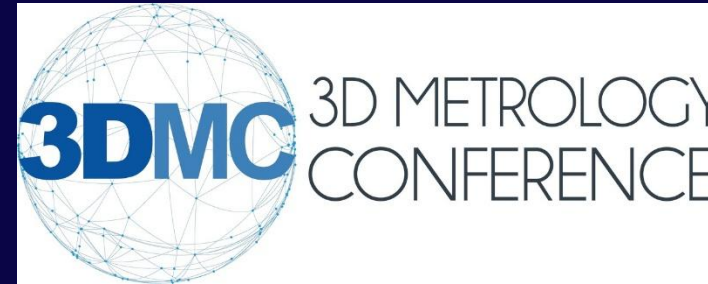


Determination of measurement uncertainties of characteristics for coordinate measuring machines and machine tools

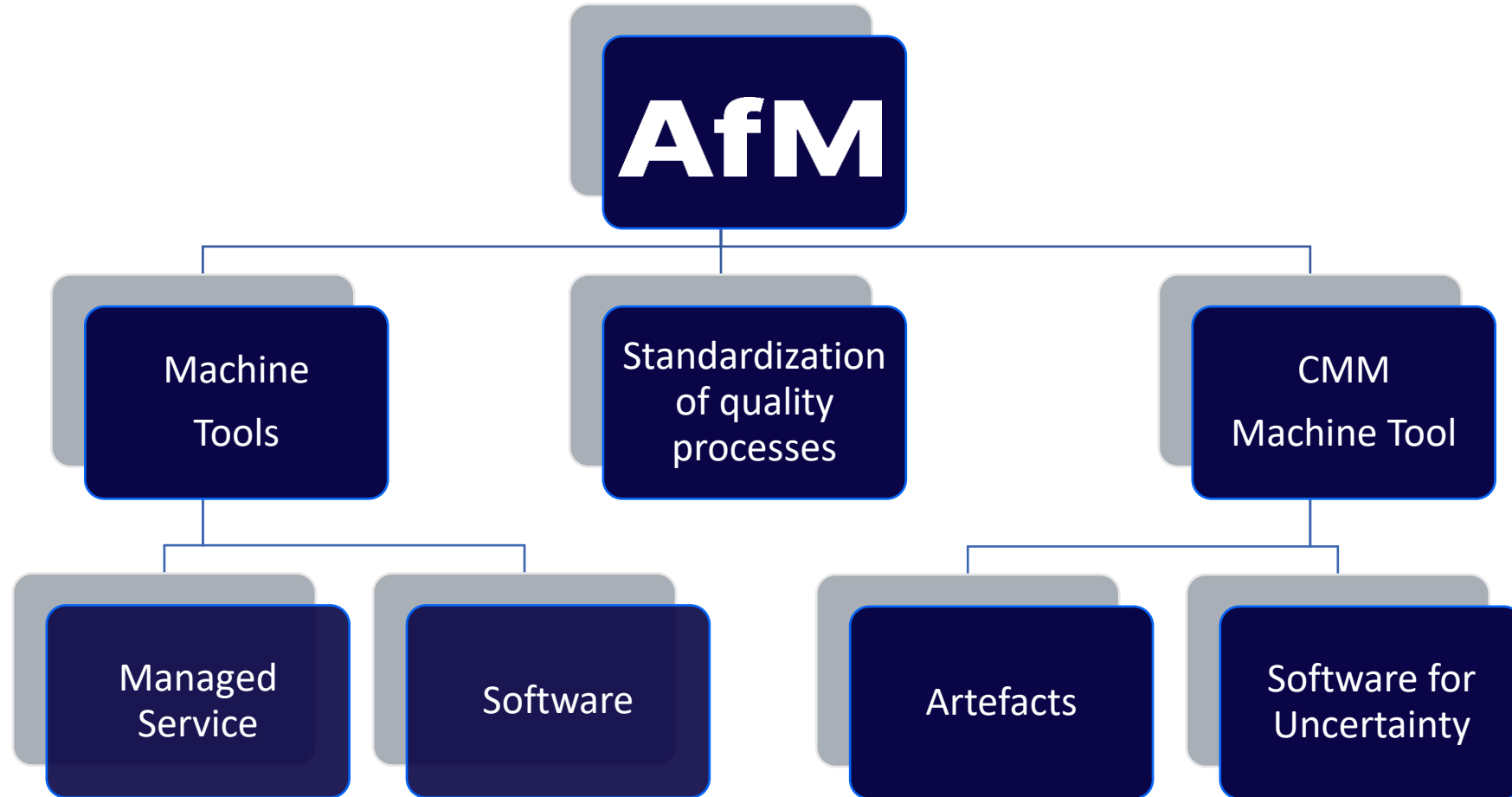


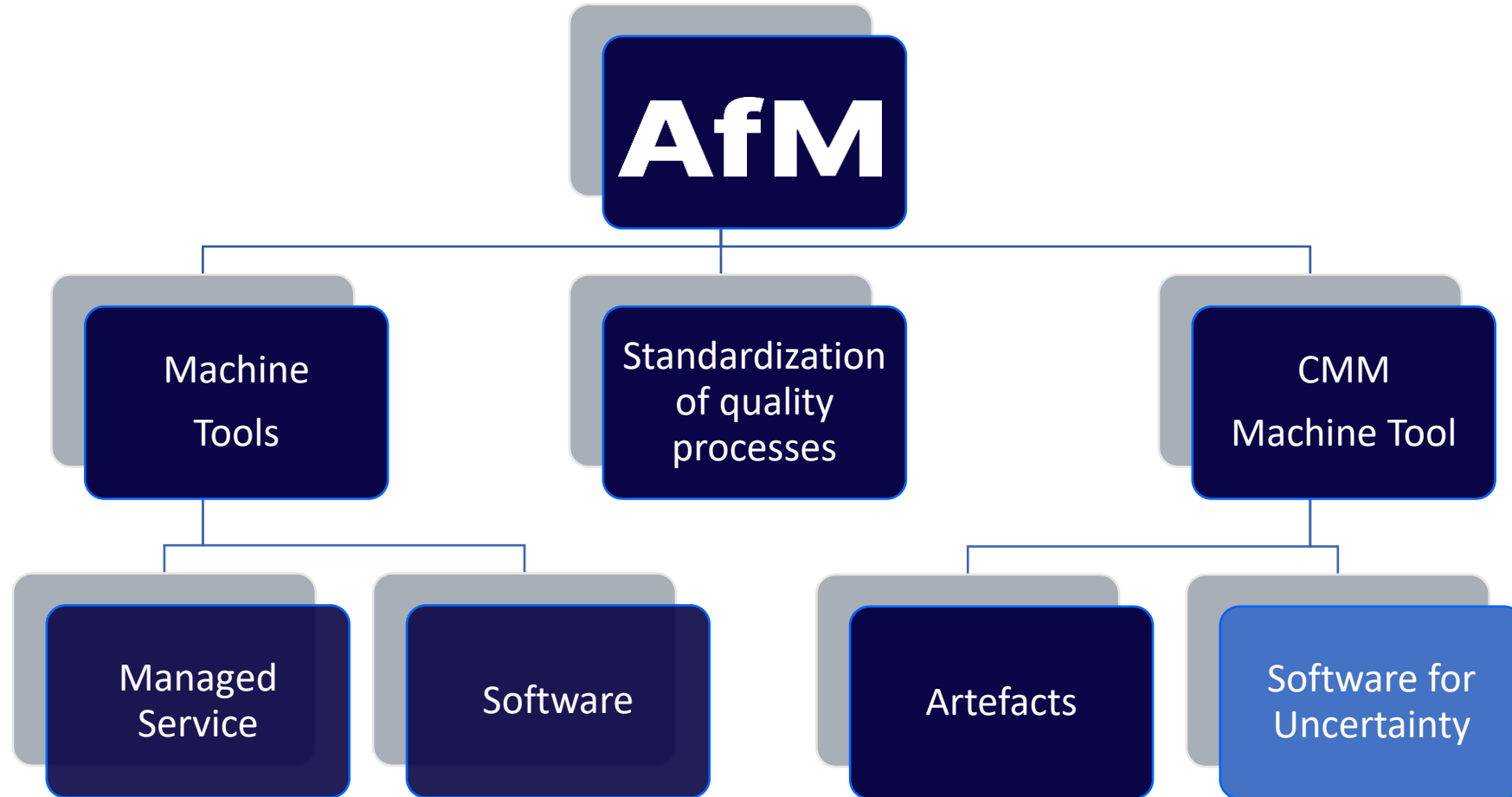
22. September 2025

Klaas Hageney



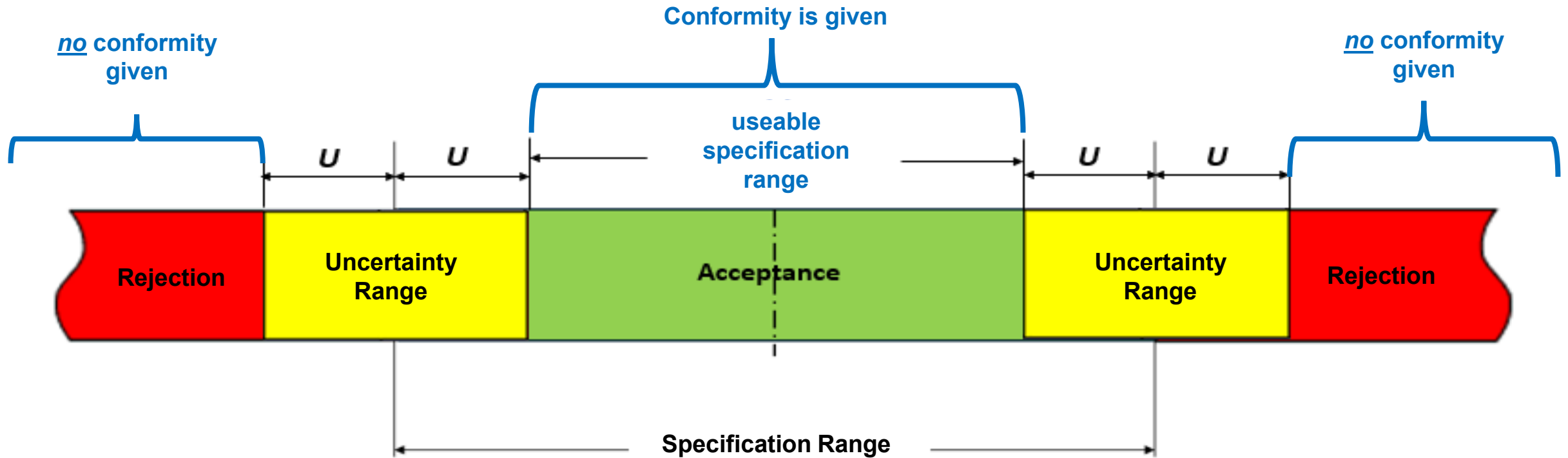
Aachen, 16 – 18 Sep 2025





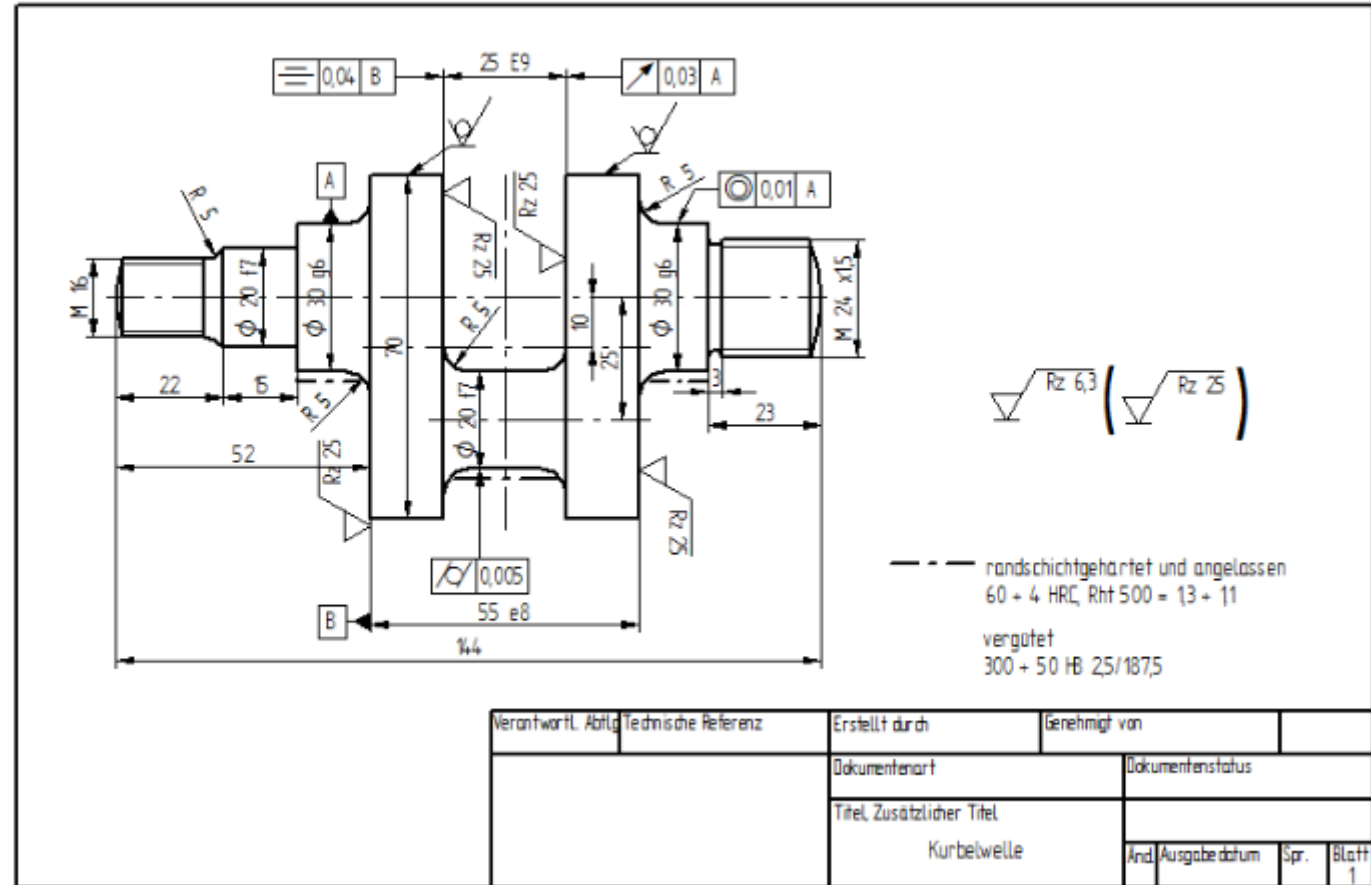
ISO 14253-1: Conformity assessments taking measurement uncertainty into account

Enable a reliable statement regarding compliance and non-compliance with specifications



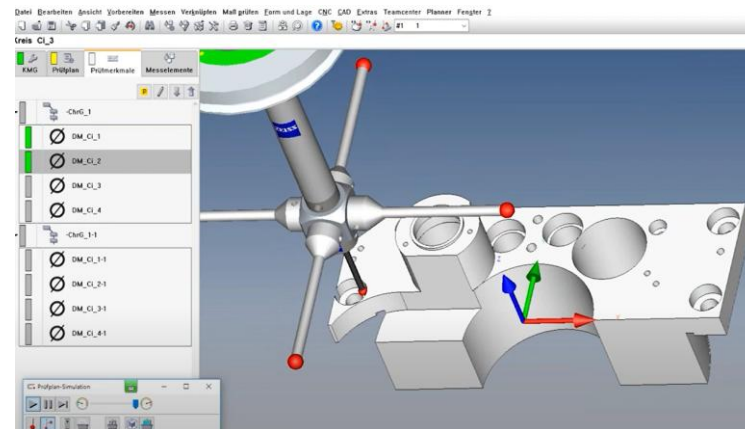
Who is affected by measurement uncertainty and what are the effects of measurement uncertainty?

- Quality
- Determination of tolerances
- Manufacturing costs
- Product quality
- Lifespan



The accuracy of a measured value

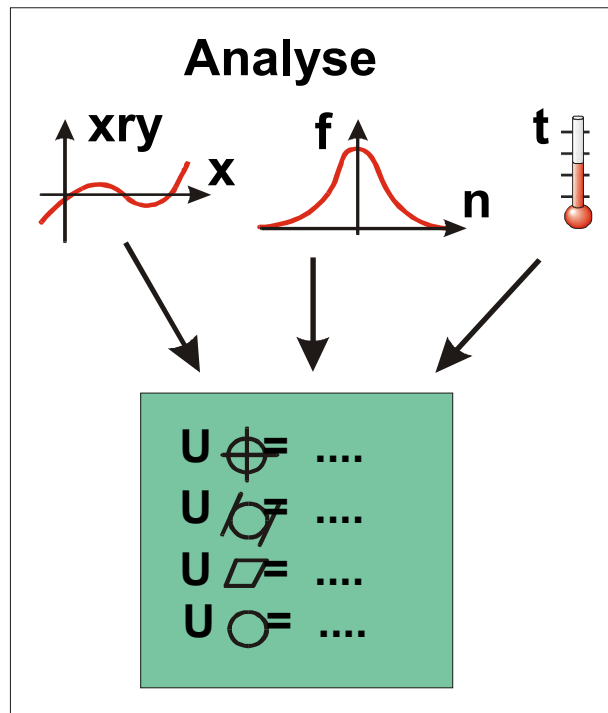
The **measured value** provided by a measuring device is therefore a “random value” that always deviates more or less strongly from the **true value**



? **Measured value:** D = 29,99785 mm ?

Uncertainty budget through analysis

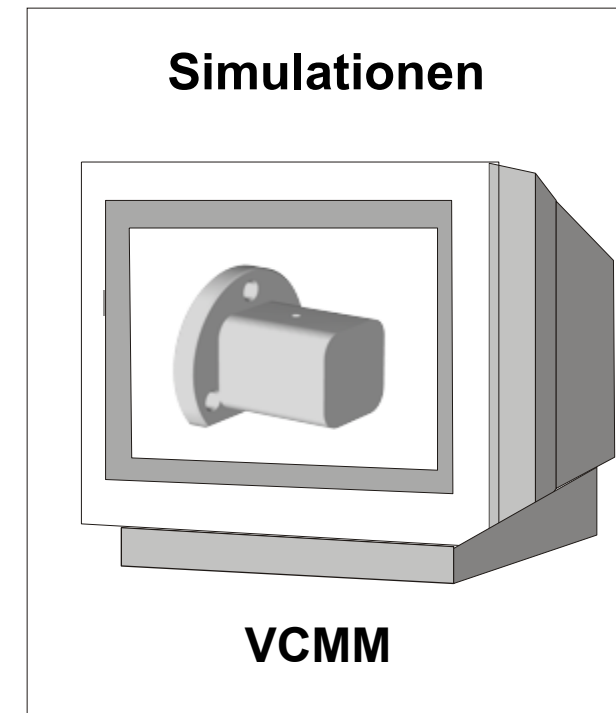
with separate uncertainty amounts (VDI/VDE 2617 Part 11)



Experimental method with the measurement of calibrated workpieces (VDI/VDE 2617 Part 8)



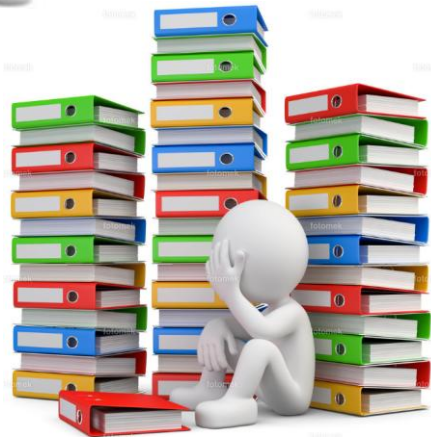
Simulation of the measurement process based on its influencing variables (VDI/VDE 2617 Part 7)



Determination of measurement uncertainty



„until now“

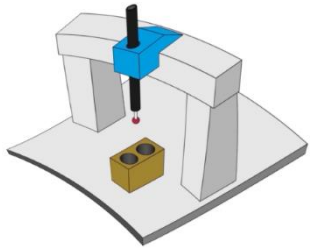
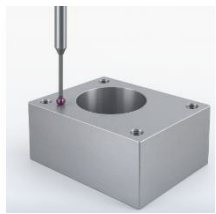


„new“



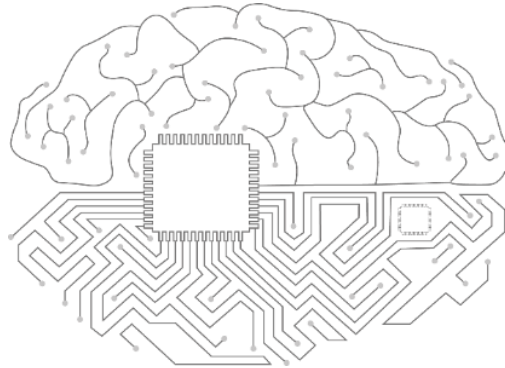
Our new solution from AfM: VCMM – User

Measurement program

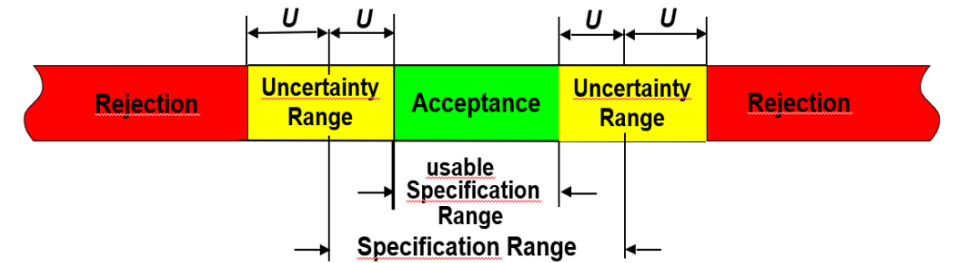


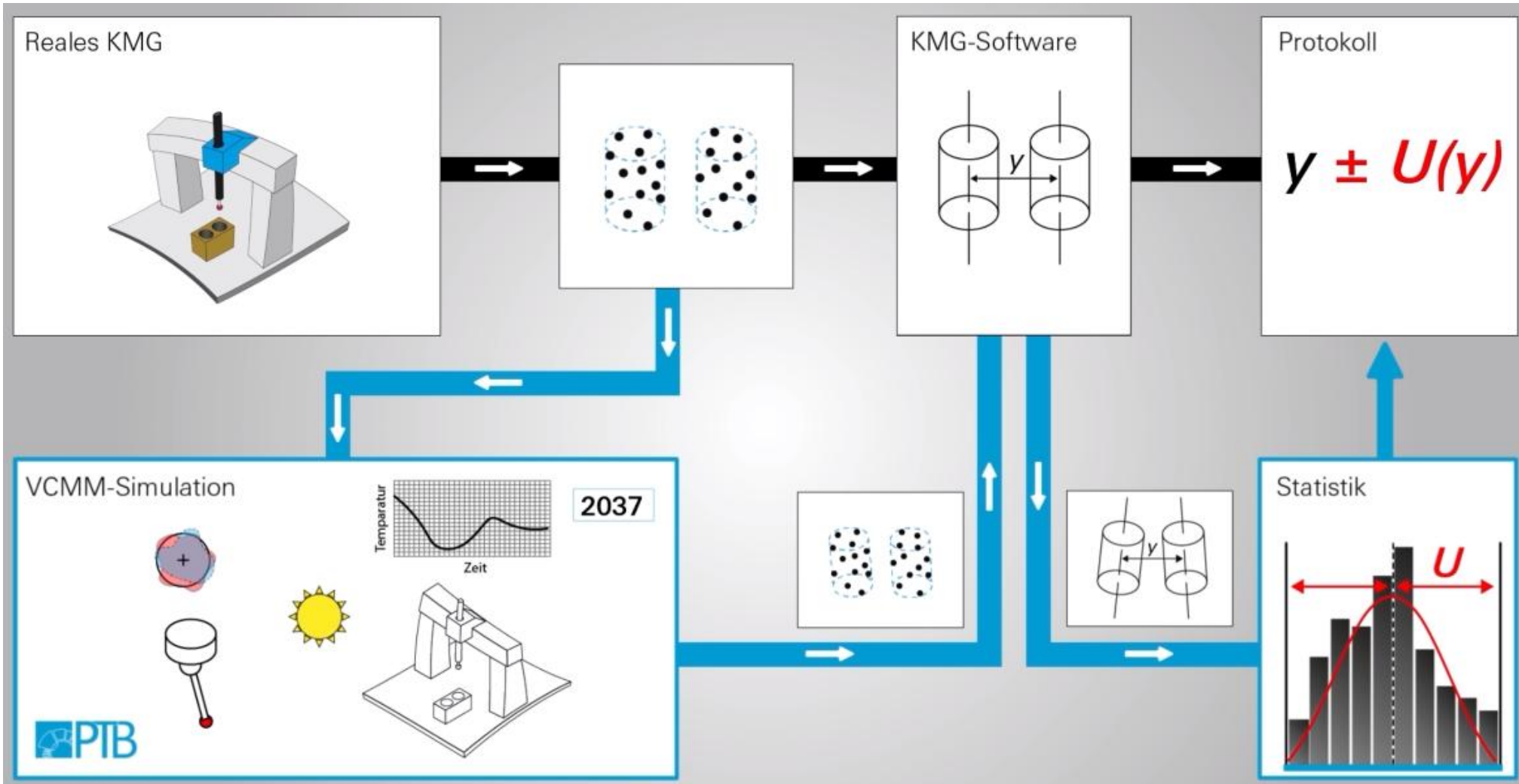
KMG

AfM VCMM (Virtual CMM) – User
(knowledge-based)

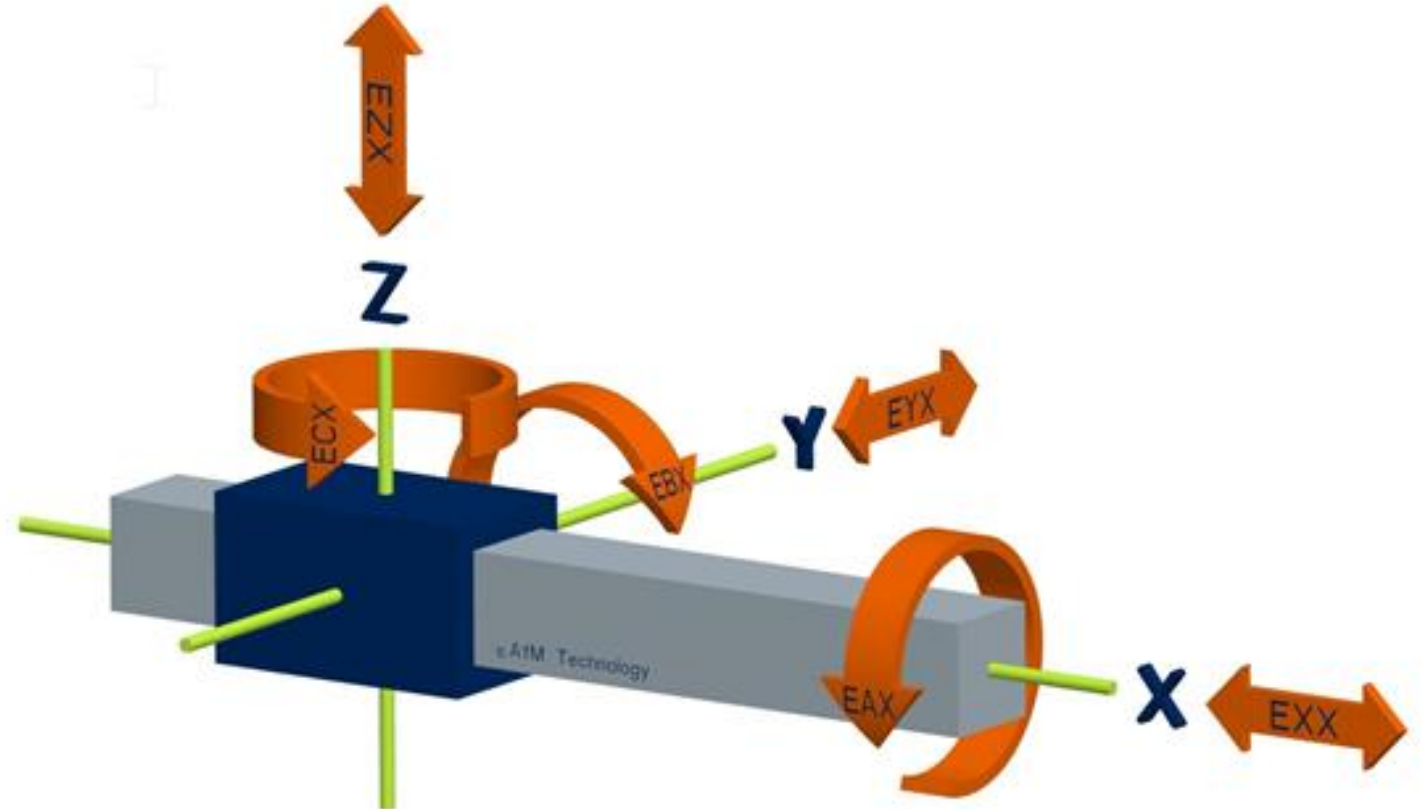


Measurement uncertainties
(test characteristic-related)

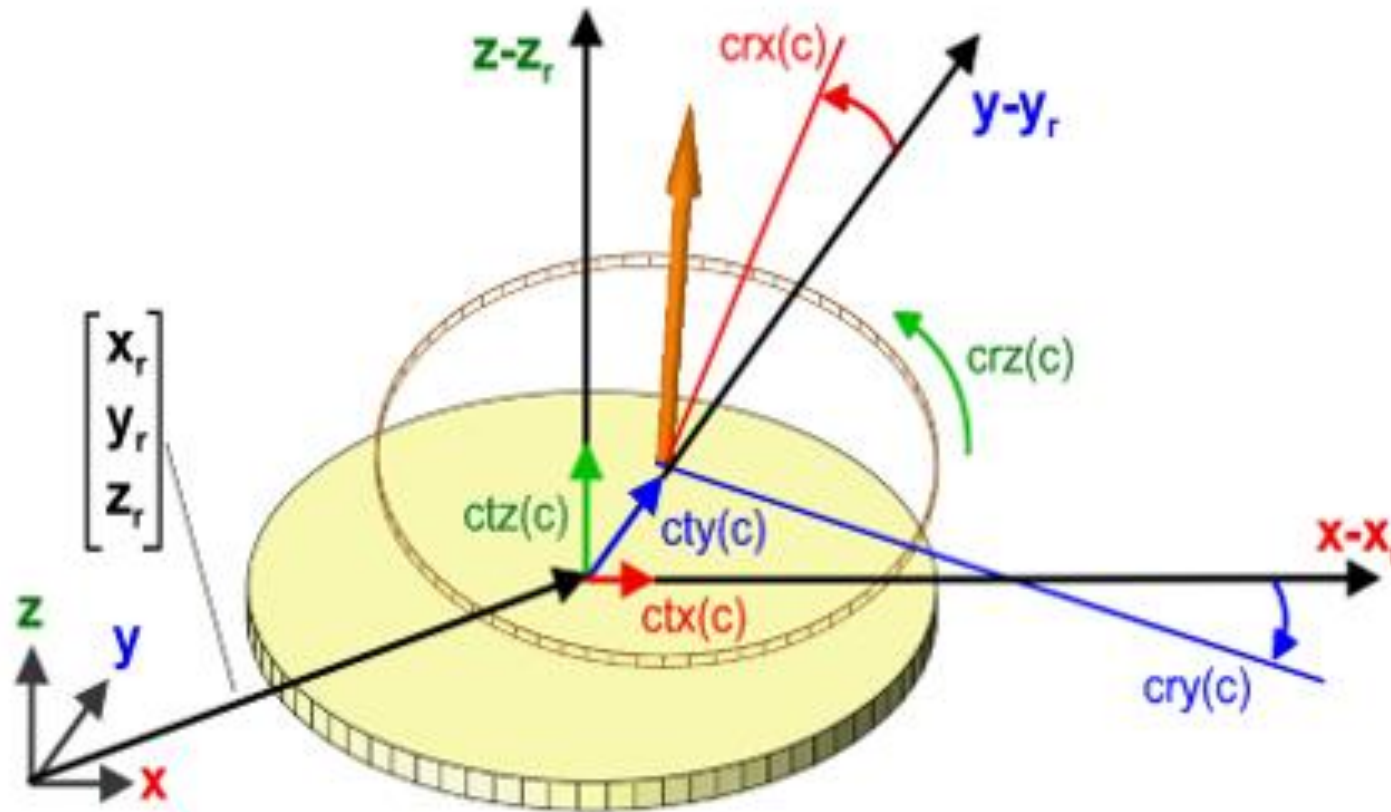




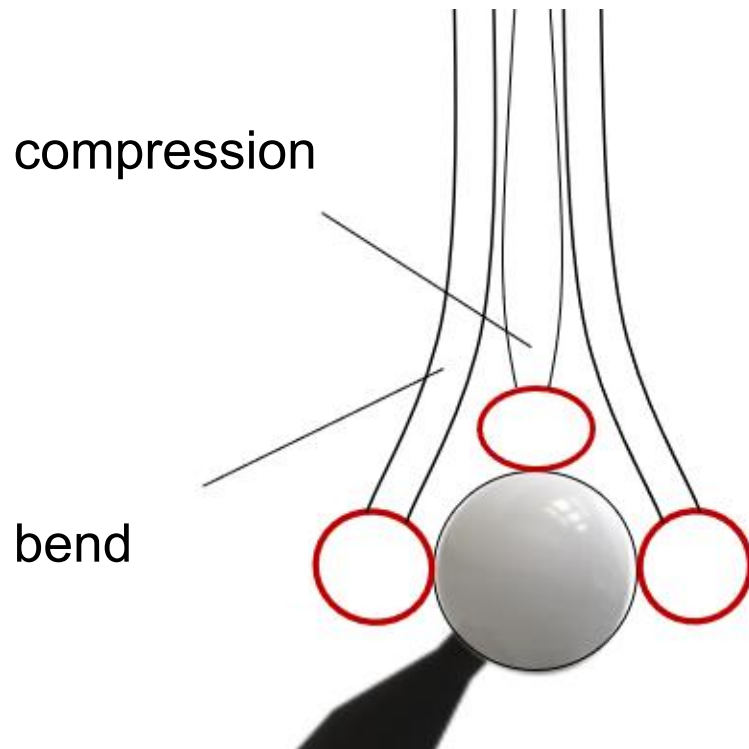
Example of the 6 influences of the guide deviations of an axis



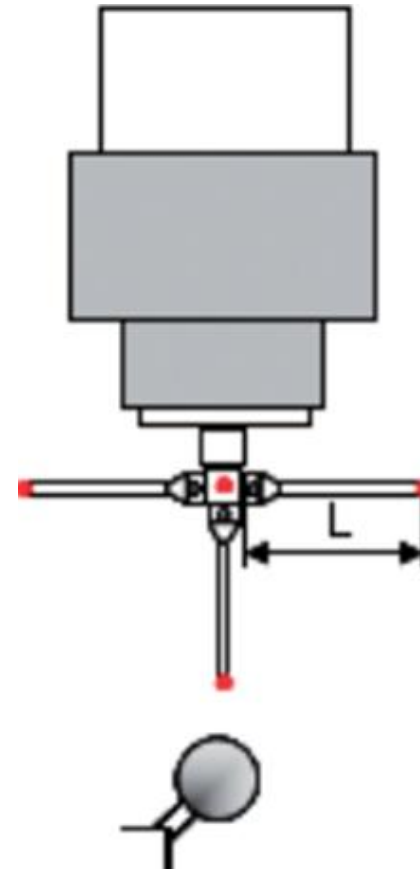
Example: Influence of the rotary table (4th axis)



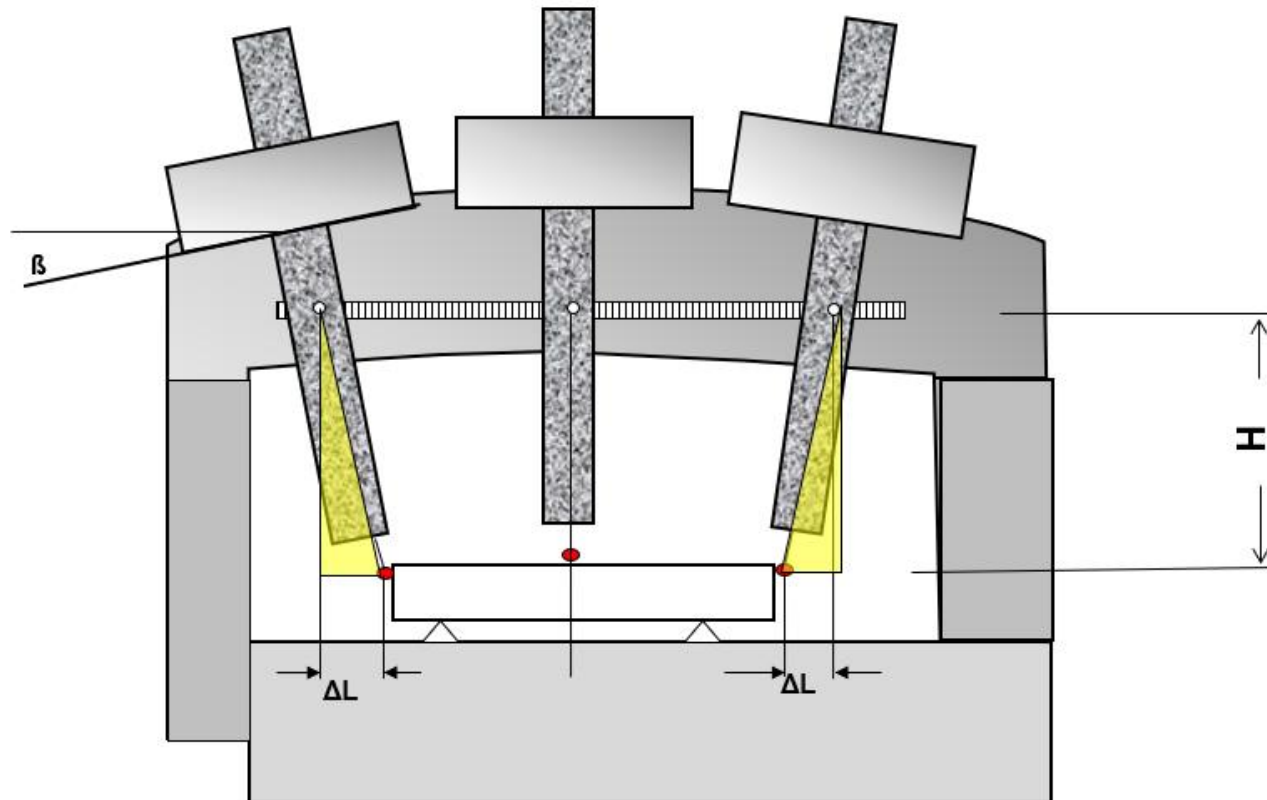
Stiffness of the probe



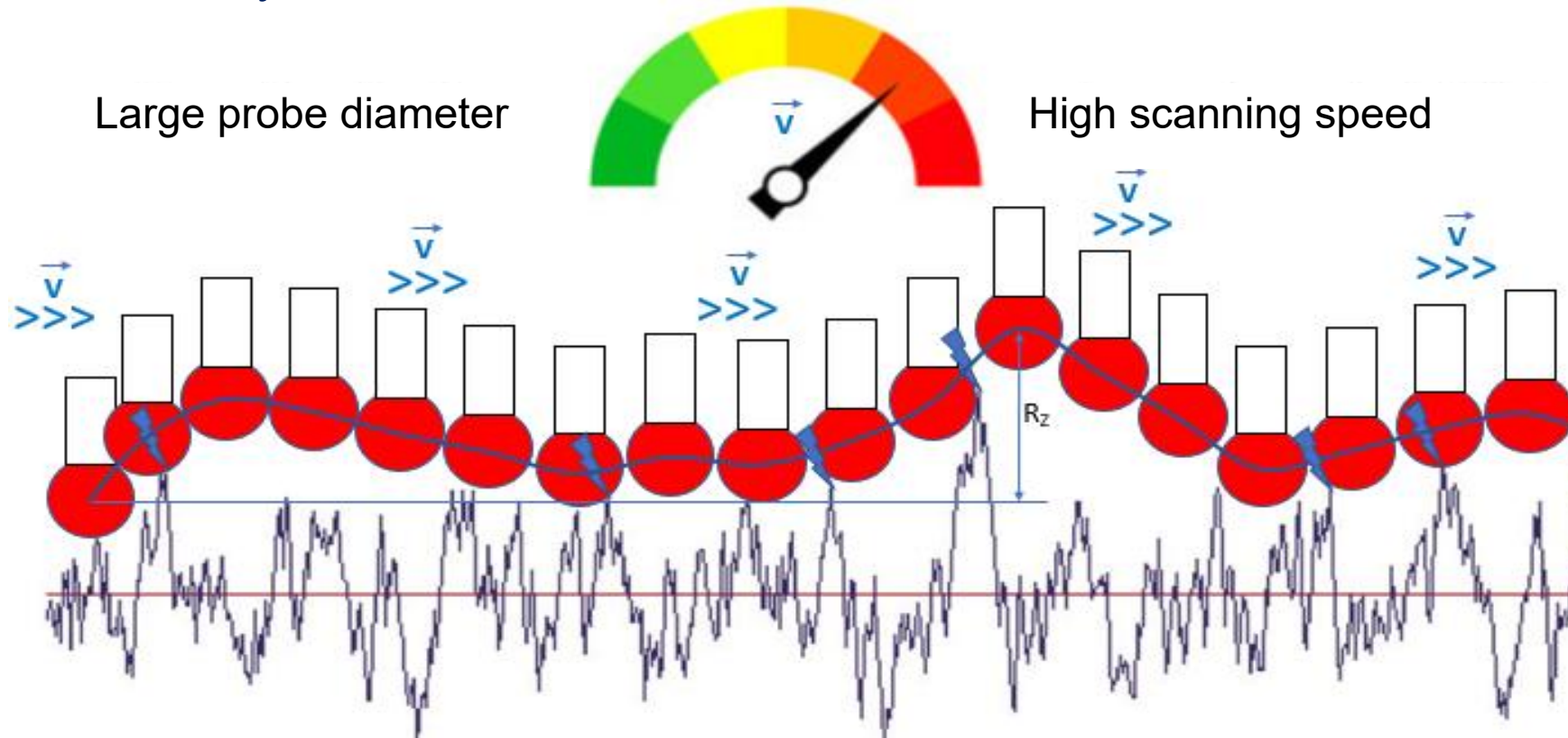
Offset of the probes to each other



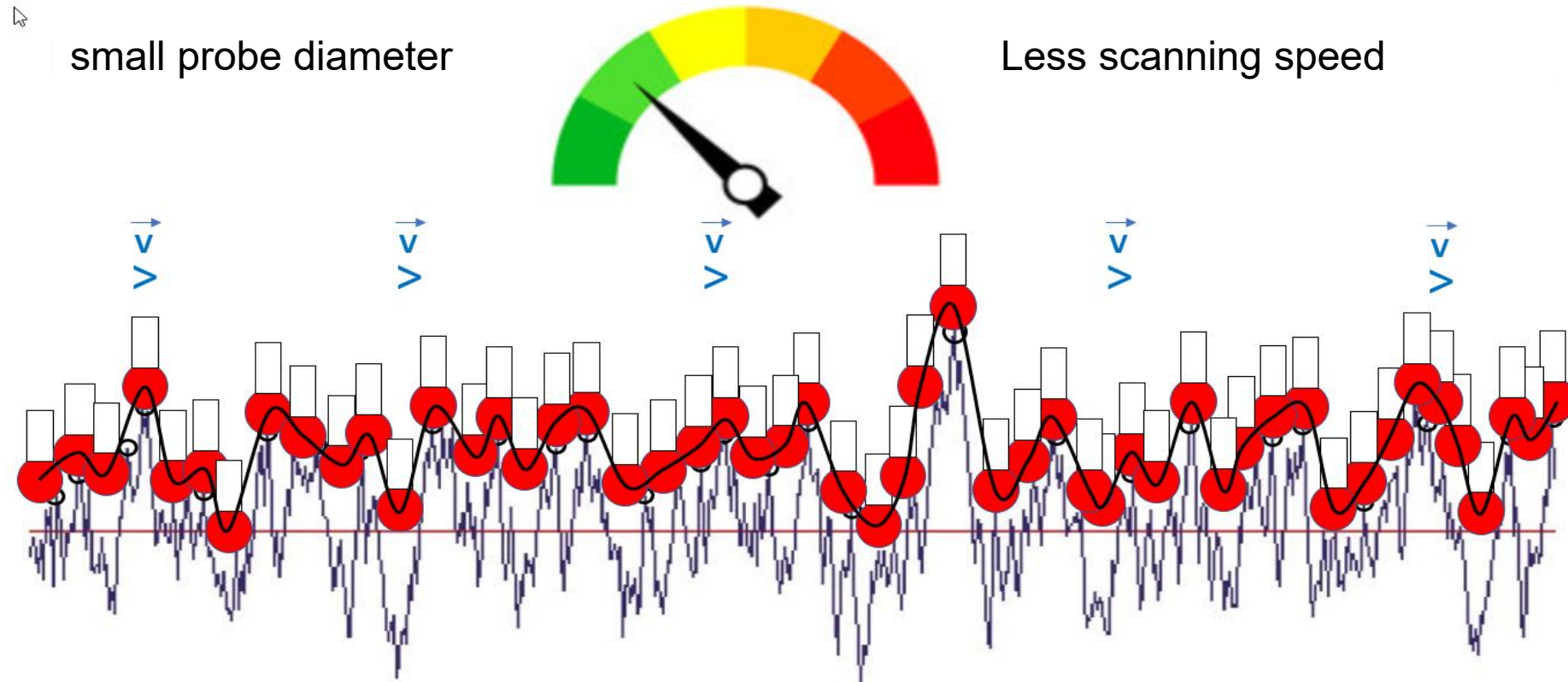
Example: Influence of the temperature gradient in Z-direction on the traverse

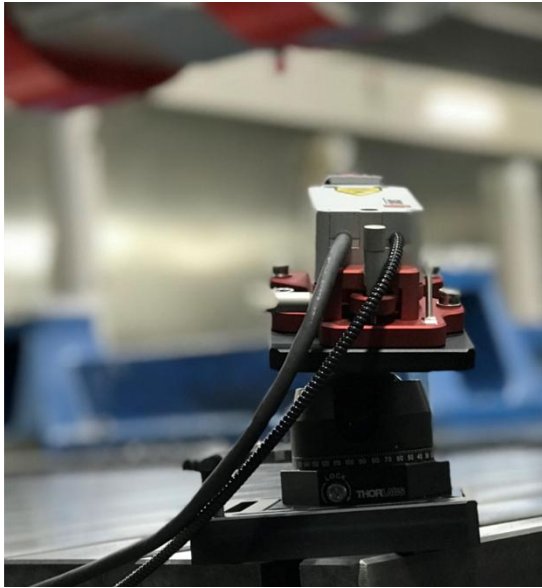


The larger the probe and the higher the scanning speed, the smaller the roughness influence and the greater the uncertainty of the measurement

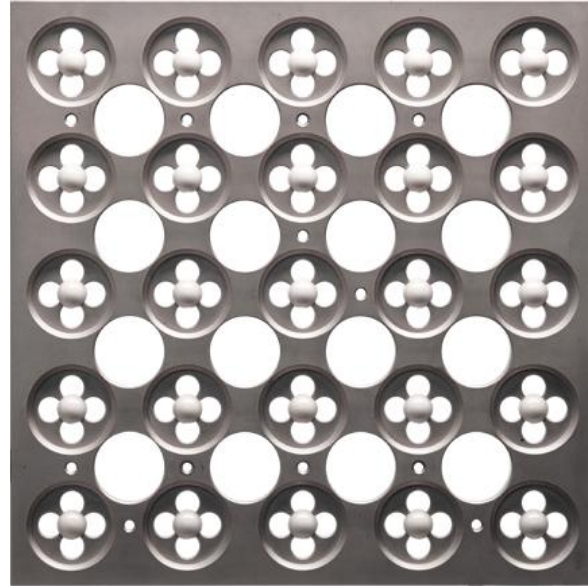


The smaller the probe and the lower the scanning speed, the greater the roughness influence and the smaller the uncertainty of the measurement

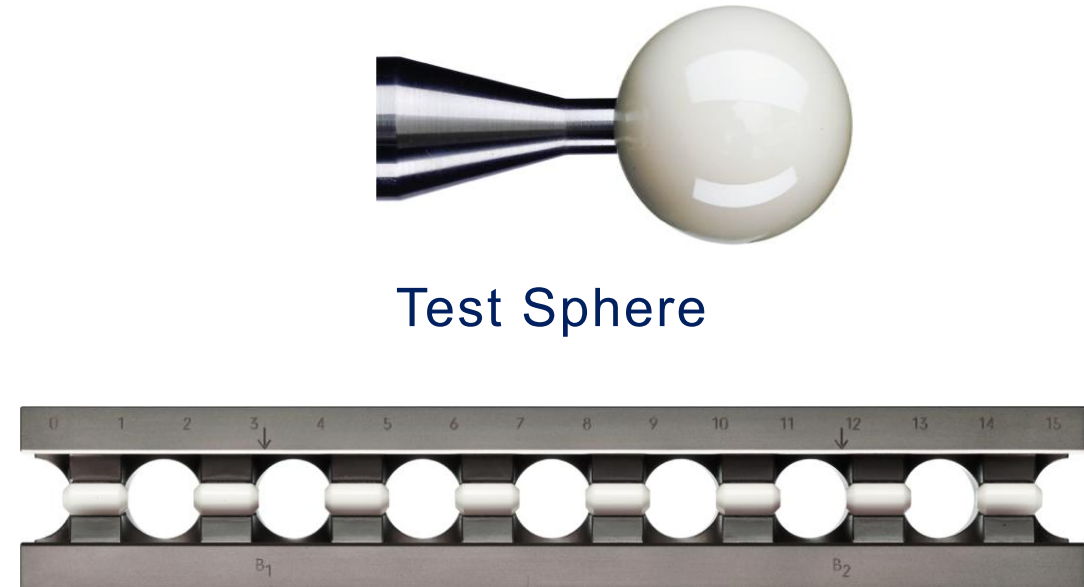




Interferometer



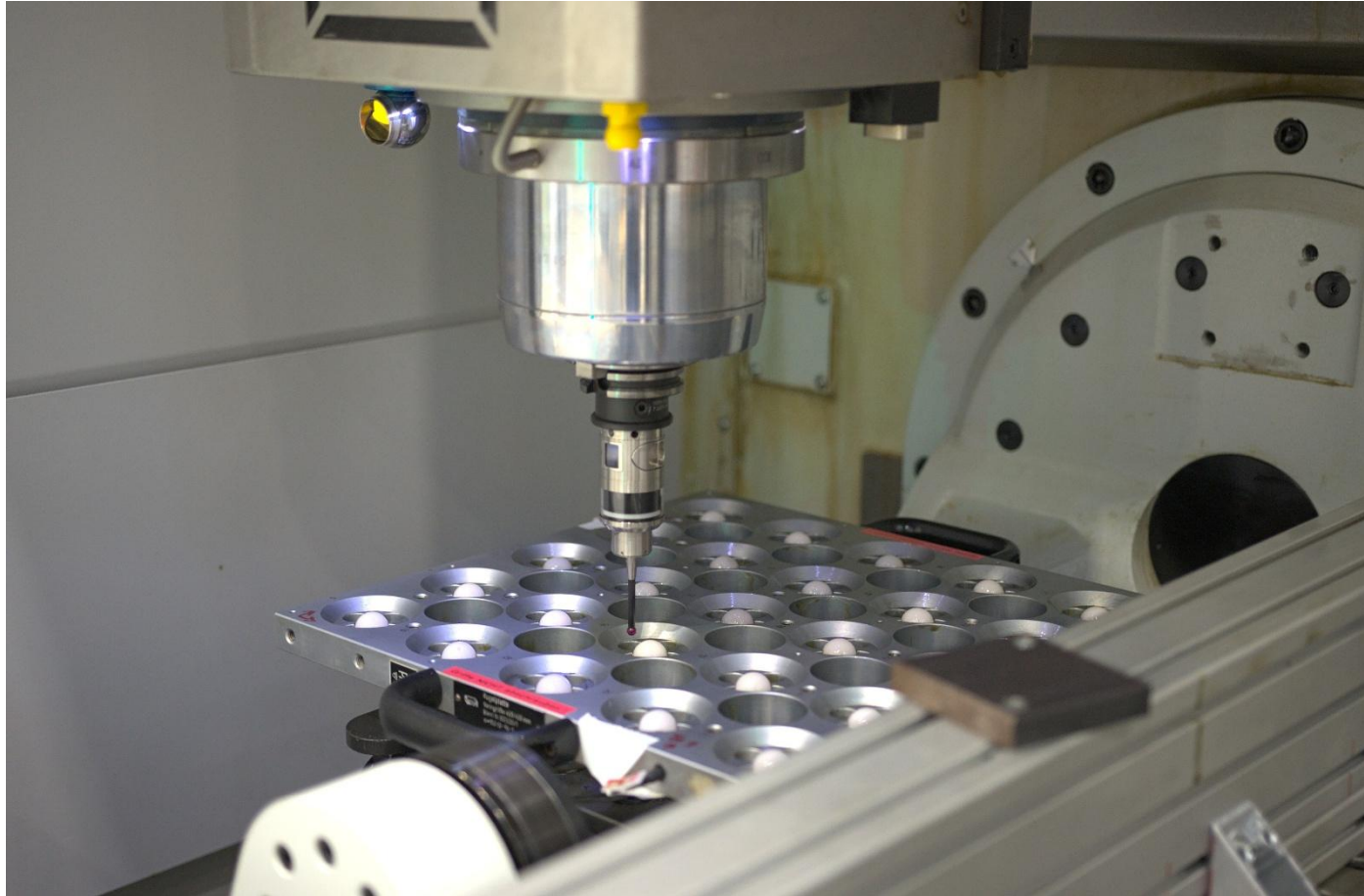
Ball Plate



Test Sphere

Step Gauge

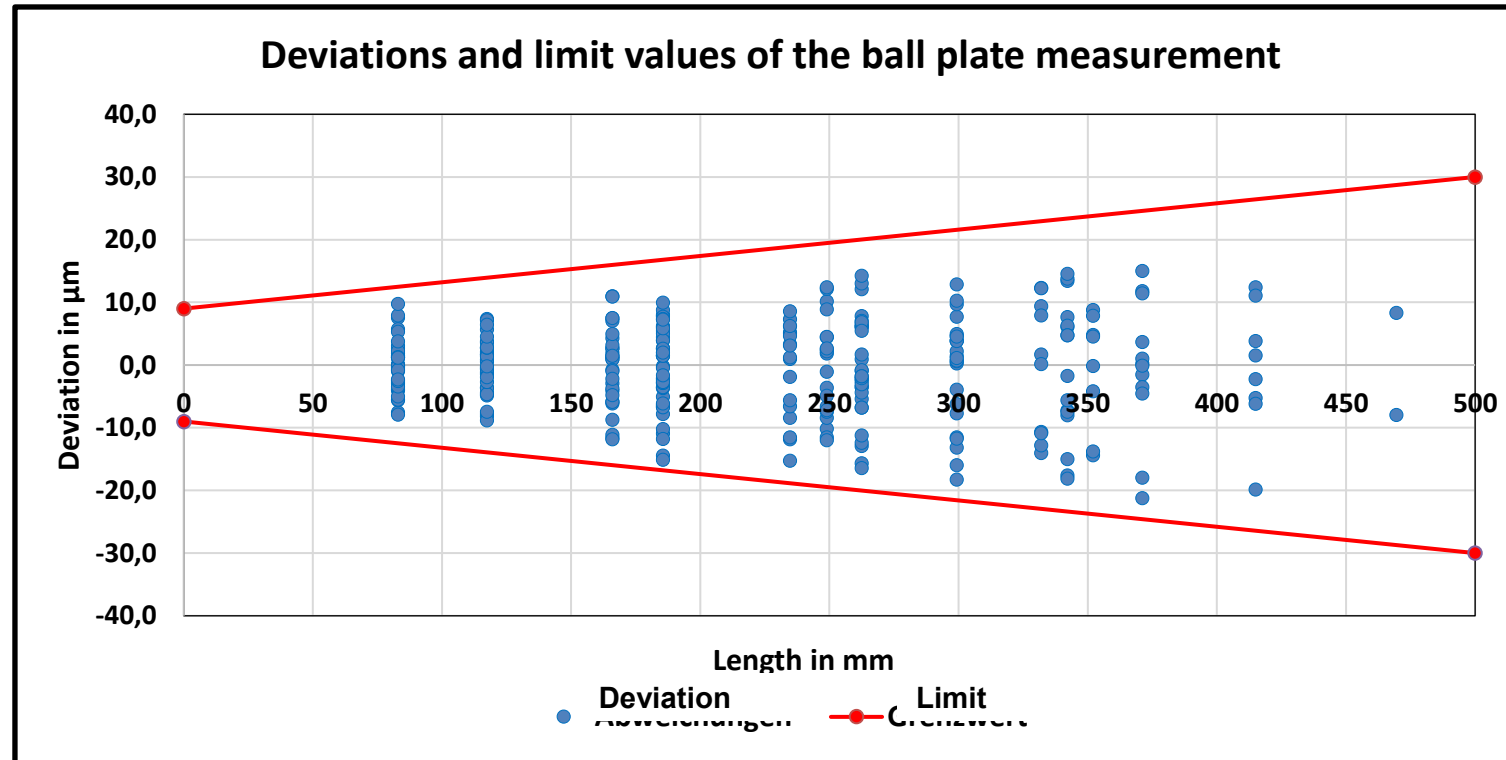
Ball plate, measured on a spinner machine tool



Measurement of the ball plate
in the X/Y plane of a machine
tool

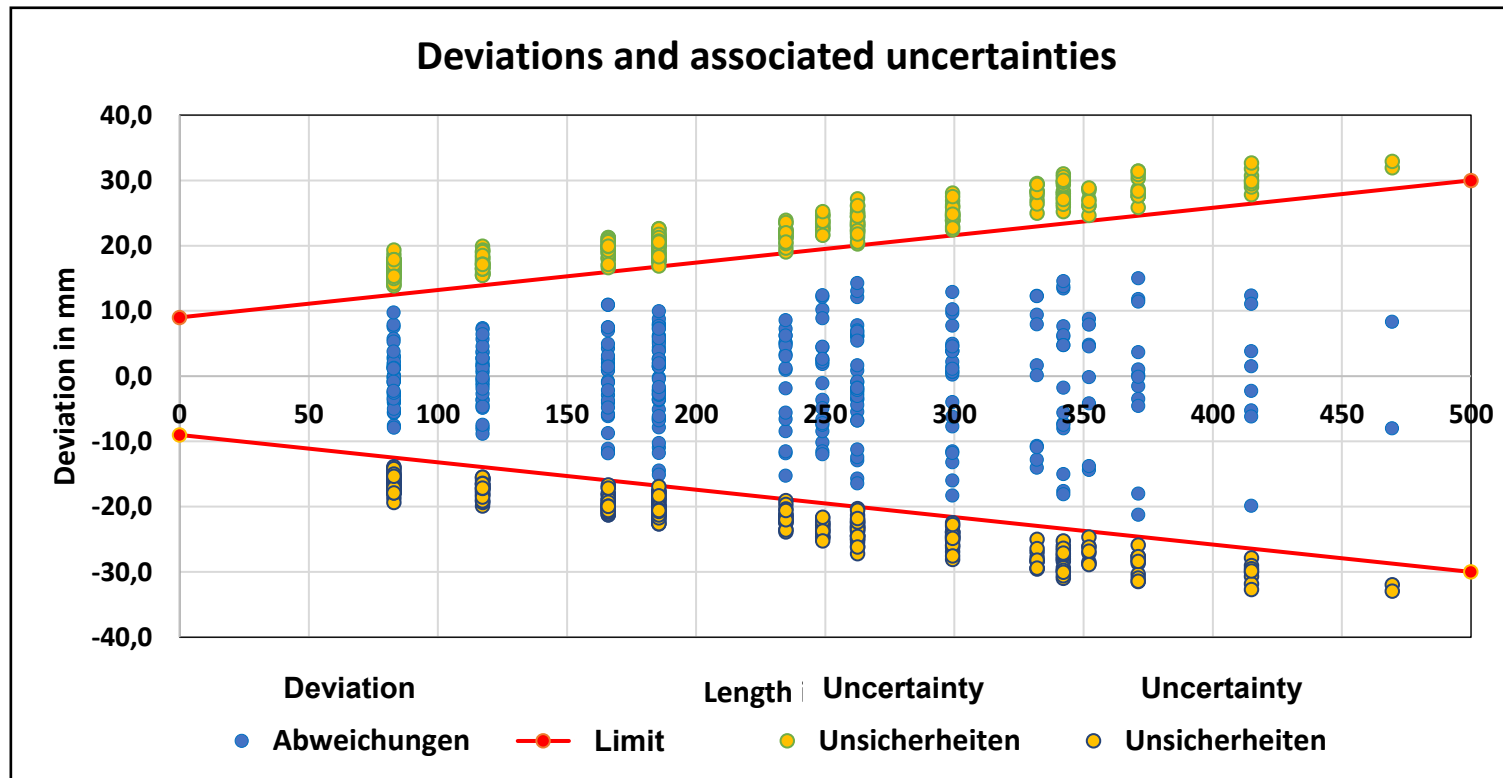
Determination of the limit value of the length measurement deviation for a machine tool

The red „trumpet“ is set in such a way that the deviations of the ball plate measurement are included as best as possible.

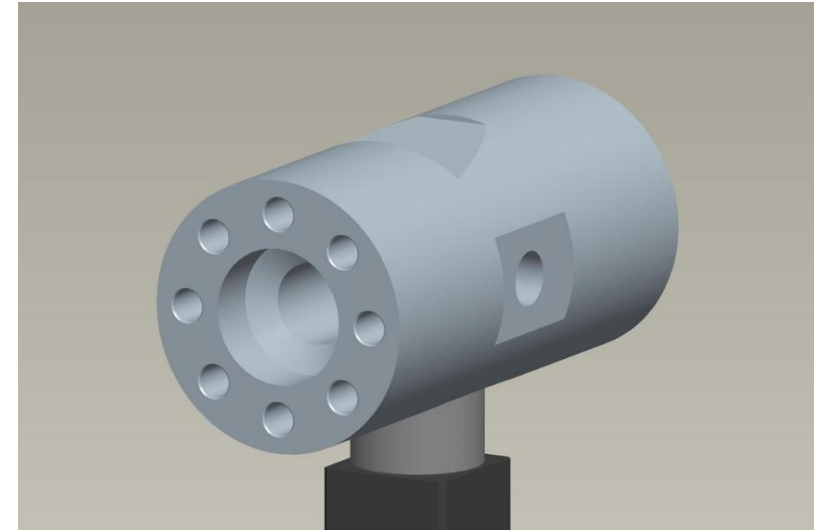
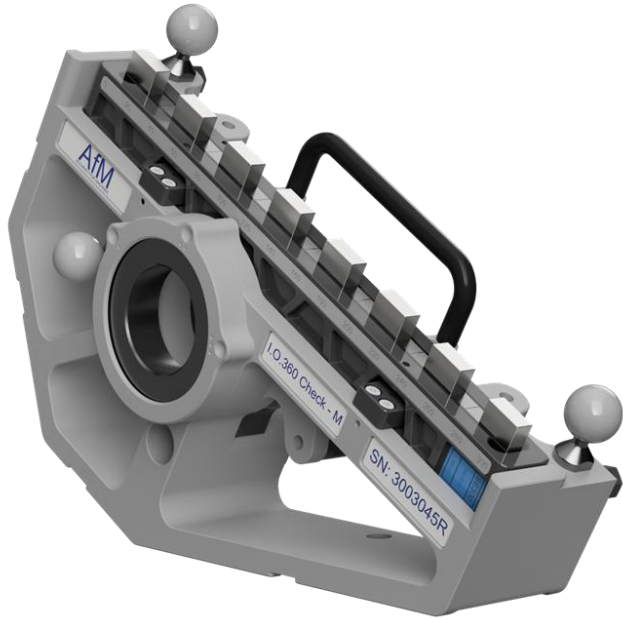


Limit value Determination of the measurement uncertainty for the workpiece „Ball Plate“

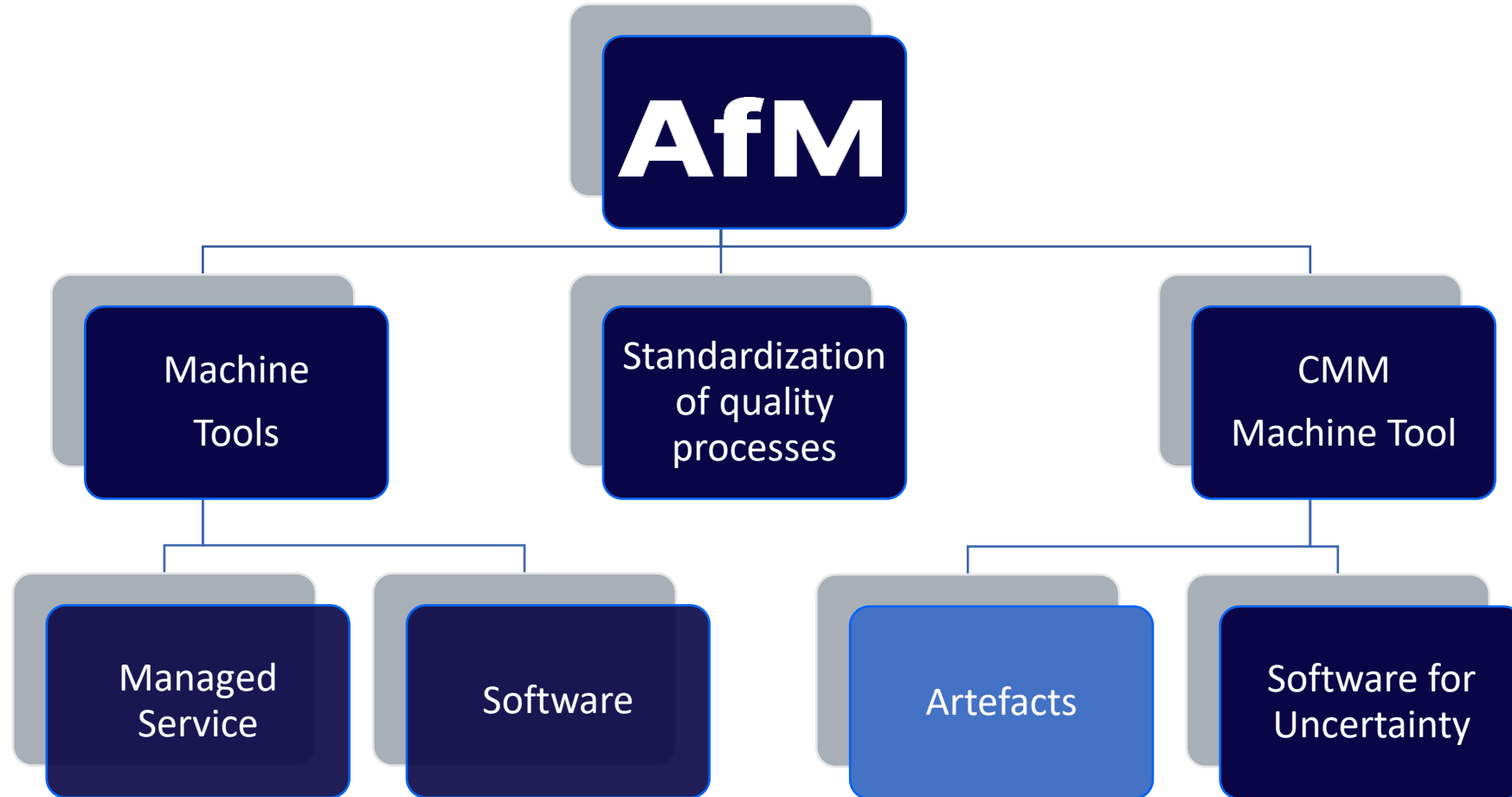
VCMM-User is configured with the specified limit values for the probing error, the length measurement error, and the measurement room class, and then the uncertainties for the “Ball Plate” workpiece are calculated



- The measurement uncertainties of workpiece characteristics are calculated for a specific workpiece and for a specific CMM or machine tool with the environmental conditions
- VCMM User has been configured with the limit values of the CMM or machine tool. The determined uncertainties are therefore greater than the limit values
- No knowledge or experience regarding the determination of measurement uncertainties necessary and therefore very practical to use



The validation of this method was carried out using artefacts according to DIN EN ISO 10360 and DIN EN ISO 1101





"I.O.360 Check – medium"

Length

Step Gage

300 mm, gradation of 20

Ring

50mm

Sphere

25mm

Option Rotary Table ✓



"I.O.360 Check – large"

Length

Suitable for Step Gage from Koba and ITS from 300 to 700 mm

Ring

50mm

Sphere

25mm

Option Rotary Table ✓

Current availability for

CMMs with

- CALYPSO (Zeiss)
- QUINDOS (Hexagon)

- currently no horizontal arm measuring devices



Current development projects

- PC-DMIS (Hexagon)
- MCOSMOS (Mitutoyo)
- QUARTIS (Wenzel)
- Polyworks (DUWE 3D)
- CAMIO (LK Metrology)

- CMM with video measuring head system

- Horizontal measuring arm devices with tactile measuring head systems



Thank you!

Your AfM Team