

# Measurement Uncertainty and Accuracy of CT and CMM in Additive Manufacturing

## Motivation

- Challenges in dimensional accuracy testing due to surface roughness and geometric complexity.
- Comparison of measurement uncertainty and accuracy of coordinate measuring machine (CMM) and computer tomography (CT) for AM components made of AlSi10Mg.

## Methodology

### Test artefact according to ISO/ASTM 52902:

- Geometric elements: pins, holes, hemispheres, length measurements, inclined surfaces.
- Production with AlSi10Mg on DMG Mori Lasertec SLM 30 system.



Figure 1: Test artefact according to DIN EN ISO/ASTM 52902

### Measuring systems:

- **CMM (Reference system):**  
*Hexagon Reference HP 10.7.6,*  
 $MPE_E = 0.6 \mu\text{m} + L/400 \mu\text{m/mm}$
- **CT system:**  
*Werth TomoScope XS,*  
 $MPE_E = 3.5 \mu\text{m} + L/400 \mu\text{m/mm}$

## Results

- **Unidirectional measurements:**  
Minor deviations of up to  $5 \mu\text{m}$  between CT and CMM (mainly scaling errors).
- **Bidirectional measurements:**  
Systematic offset of approx.  $40 \mu\text{m}$  between CT and CMM measurements, due to surface roughness and systematic errors.
- **PTB reference hole plate:** Validation of systematic deviations (scaling errors), confirmation of the higher uncertainty in bidirectional measurements.

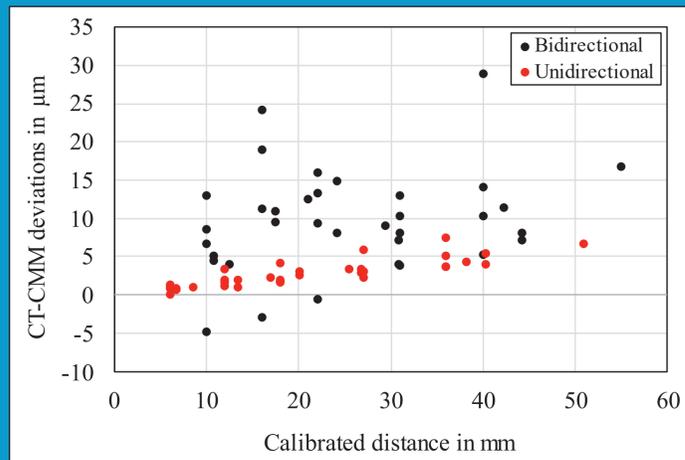


Figure 2: Deviations between CT and CMM measurements for unidirectional and bidirectional distances for the calibrated PTB hole-plate standard

## Uncertainty analysis

### Calculation of the expanded measurement uncertainty (U):

$$U = k \cdot \sqrt{u_{cal}^2 + u_p^2 + u_w^2 + u_b^2}$$

### Main results of the uncertainty analysis:

- Expanded measurement uncertainty bidirectional:  $U \approx 56 \mu\text{m}$
- Largest contributions to measurement uncertainty:
  - Roughness  $u_w = 23.5 \mu\text{m}$ ;
  - Systematic error  $u_b = 15 \mu\text{m}$

## Conclusion

- **CT:** Advantage for rough and complex surfaces, good for internal structures.
- **CMM:** Limited suitability as a reference for rough AM surfaces.
- **Recommendation:** Optimised surface treatment and precise adjustment of process parameters to reduce uncertainty.