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Advanced Instrumentation for Micro-Vibration Characterization of Satellite Components

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Thursday 11 February 2016

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Summary

- Vibration challenges
  - AM production process
  - Performance verification of AM parts
- Applications
- NPL project: Measuring ALM components

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NPL in brief

We are UK's national standards laboratory

- Founded in **1900**
- World leading **National Measurement Institute**
- ~800 staff, from over 150 different nationalities; 550+ specialists
- State-of-the-art laboratory facilities
- The heart of the UK's **National Measurement System** to support business and society
- Large capacity for **bespoke Instrumentation**
  - Sentinel IV, mechanical test centre at ESTEC

36 000 m²
388 Laboratories
purpose built

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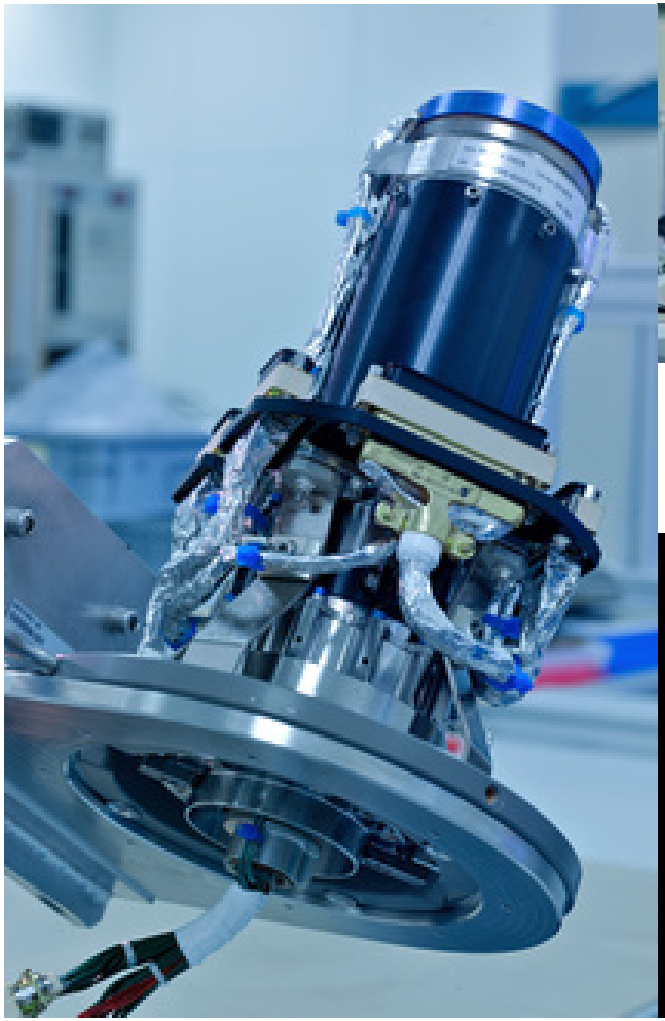
European Space Agency: Their need 5 years ago

Solar Array Drive



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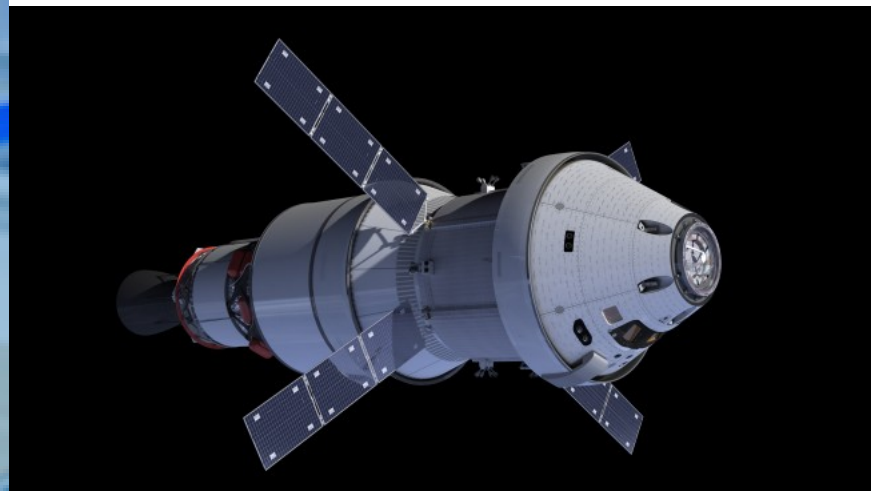

Orion multipurpose crew vehicle
© NASA

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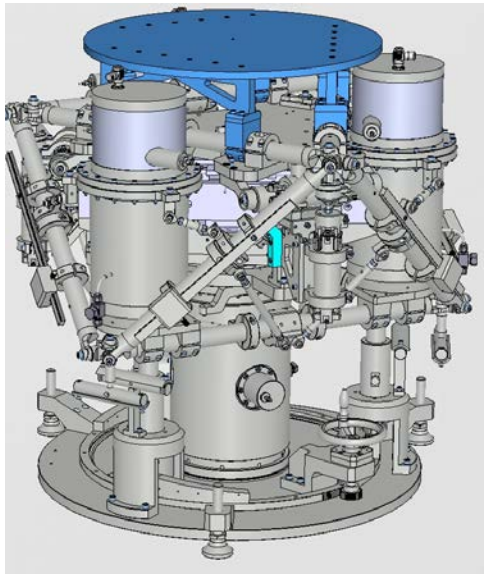
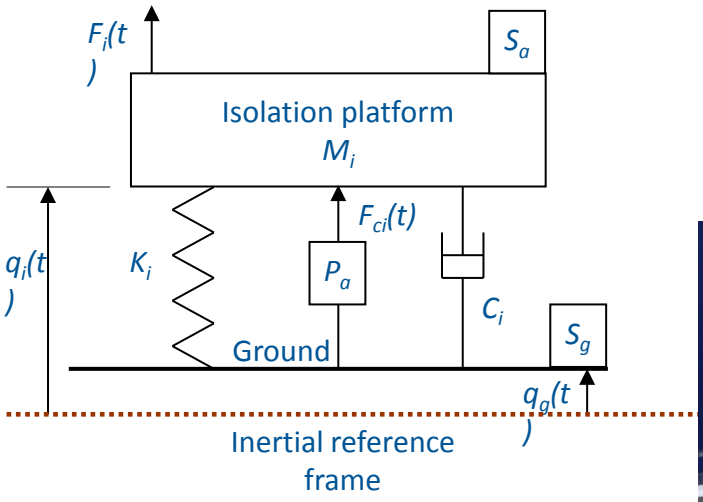
ESA vibration measurement test requirements

- Mass: 2-50 kg
- Payload Power: 0.5-20 kW
- Size: Up to $(0.4\ m)^3$
- Measure Interface Forces – 10 µN to 0.1 N
  - For reference: Weight of 1 eyelash = 0.5 µN
- Equivalent accelerations for 50 kg payload:
  - 20 ng to 0.2 mg

Technologies developed to meet stringent test requirements (1/2)

- Generic active vibration isolation system





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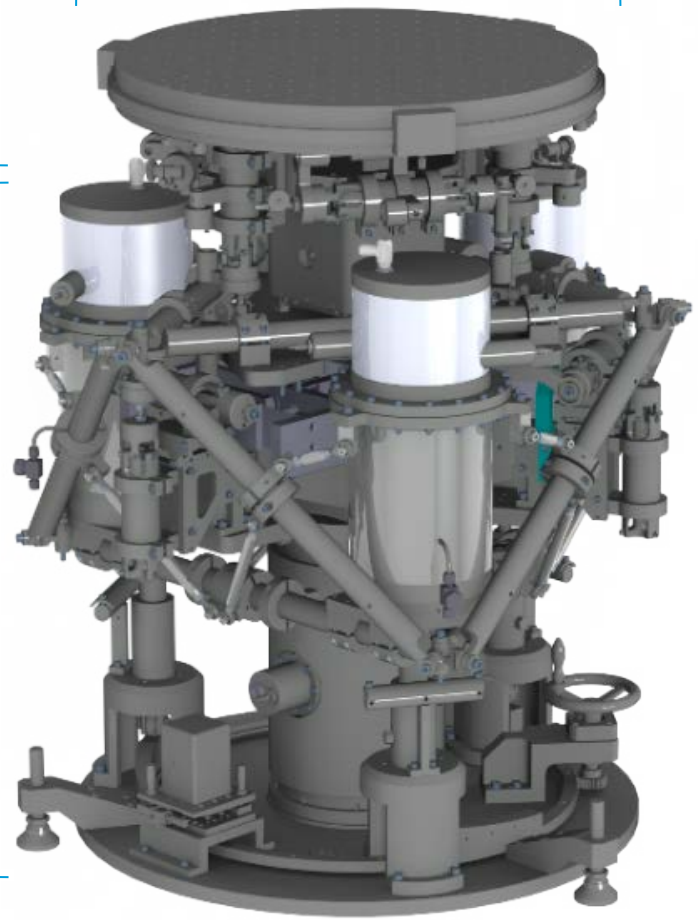
Technologies developed to meet stringent test requirements (2/2)

60 cm top plate

Measurement stage

6 DoF measurement platform

Active isolation stage – ultra-quiet background



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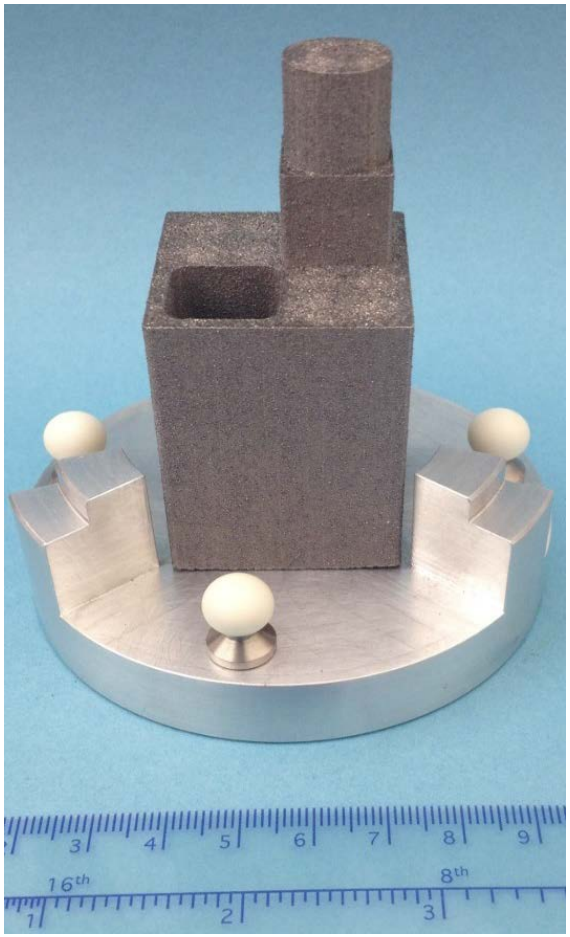
Applications vibration isolation facilities/technology for AM and Space

- Improve operation of advanced manufacturing facilities
  - Active Isolation retrofit for:
    - Semiconductor industry
    - Advanced machining
- Verify performance of AM parts/mechanisms/instruments
  - 6 DoF facility as test bed for performance
    - Performance of optical instruments with AM parts under different vibration backgrounds
    - Fine differences in vibration signature of AM mechanisms versus traditional (unwanted vibration from surface contact, etc)

UK funded collaborative research: Design of an NPL test artefact with ALM



- Parallel flat side faces
- Common shapes (cubes, cylinders)
- Internal and external features
- Reference tooling balls

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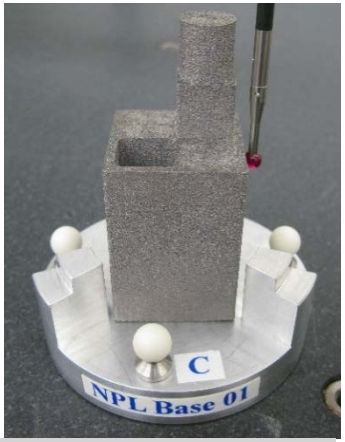
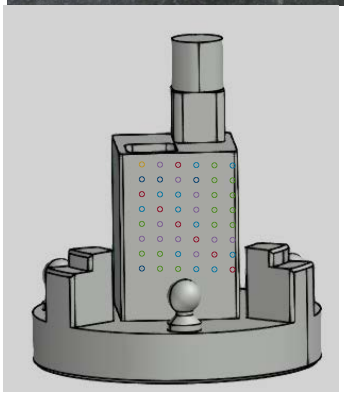
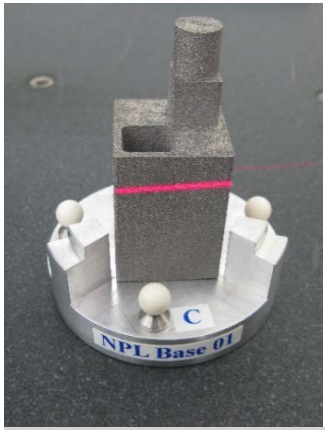
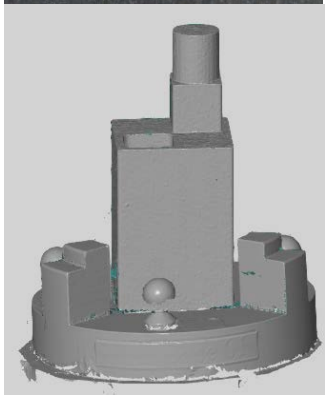
Measured with three different measurement techniques: Tactile (CMM), Optical and XCT



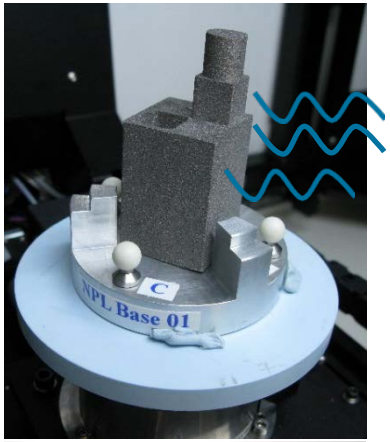


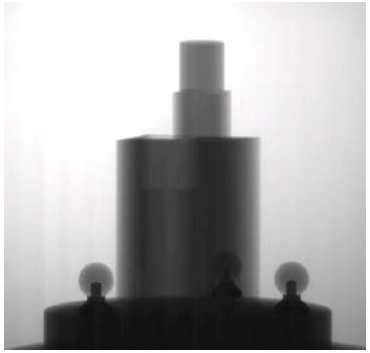
Tactile





Optical





XCT

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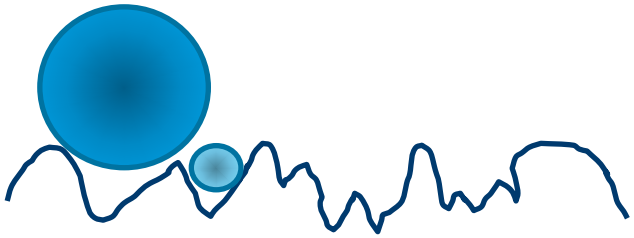
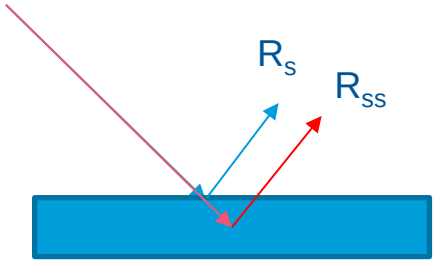
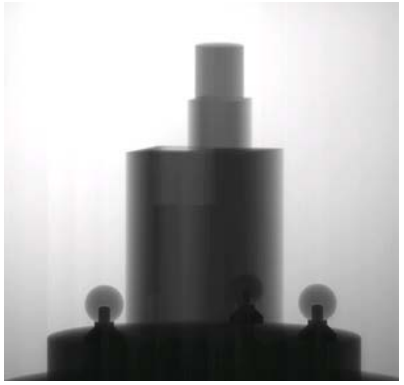
Differences and issues between techniques



Tactile



Optical



XCT

- Up to 300 um *systematic* error between techniques, even though STD ~10s of um
- Take home message: be very careful when trusting measurements of ALM parts…

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Surfaces – all with *Ra* of 0.8 um

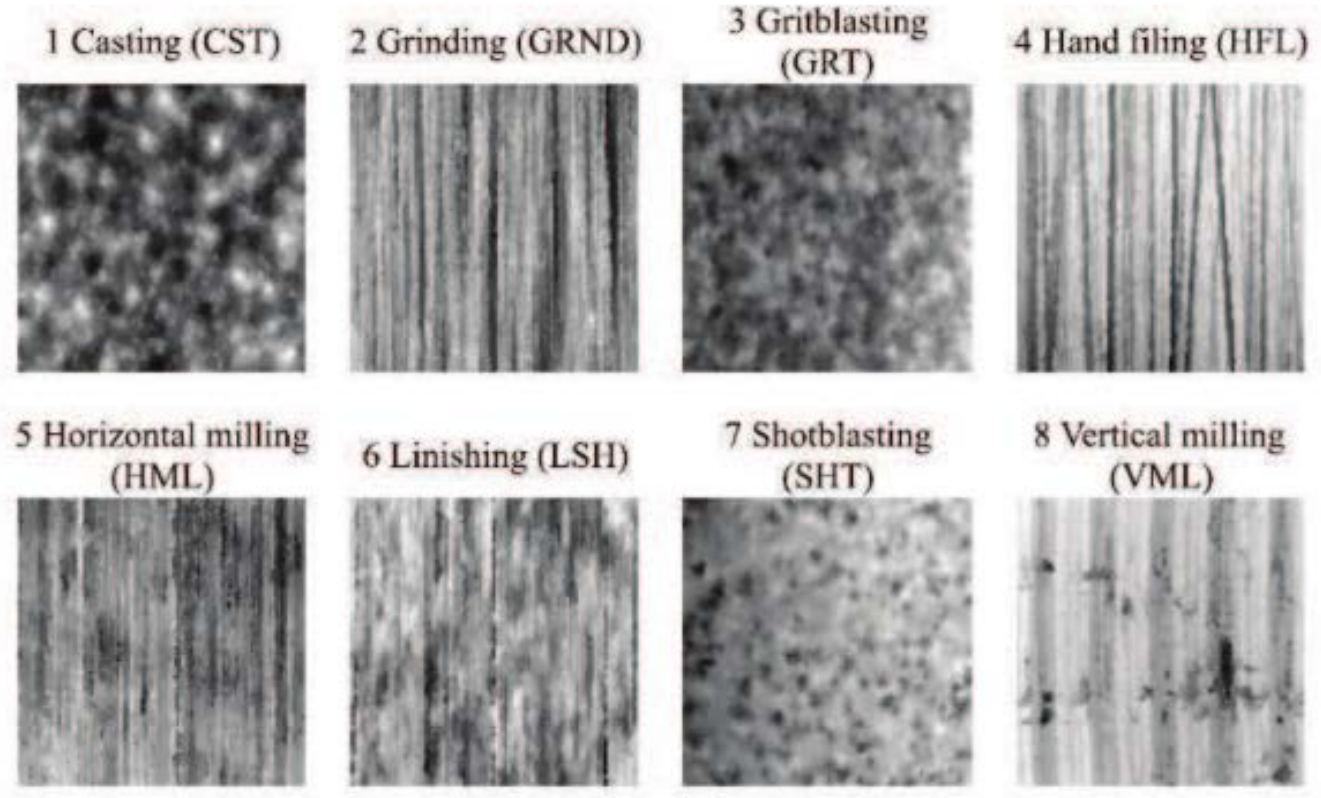

Figure 3. Samples of machined surfaces, all with 0.8 µm *Ra* (Josso, et al., 2000)

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Thank you

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Backup slides

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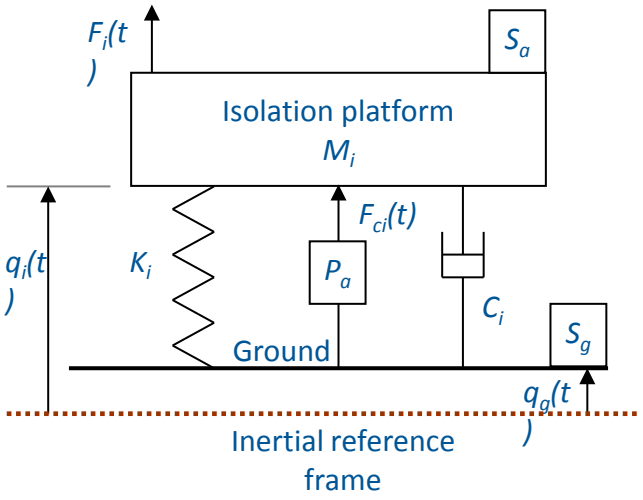
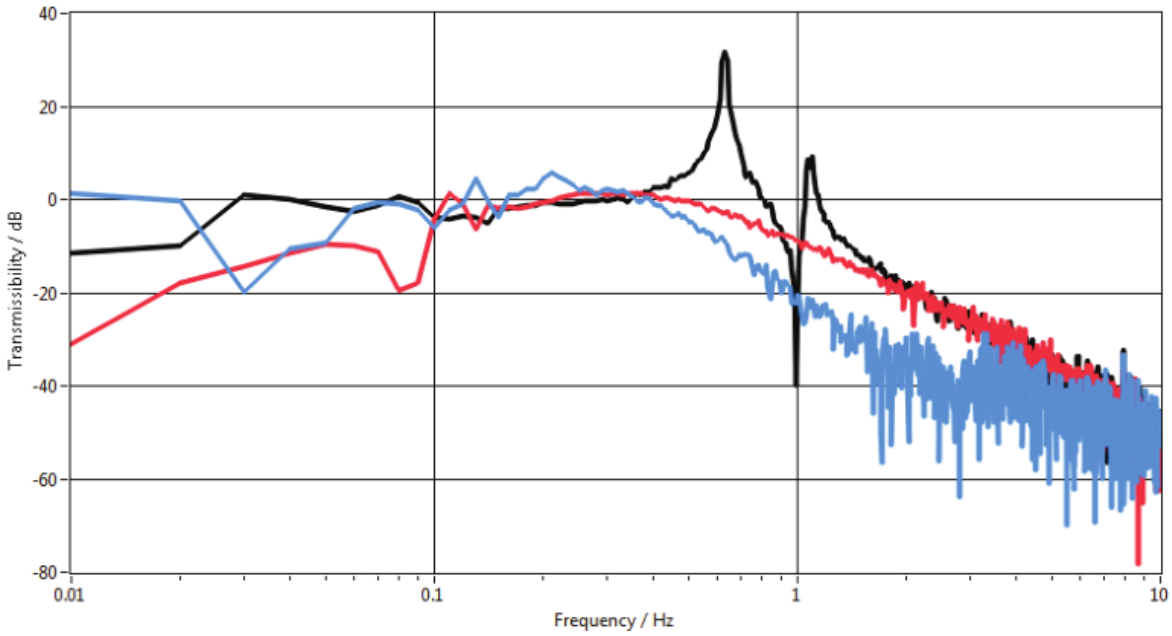
Technologies developed to meet stringent test requirements (1/2)

- Generic active vibration isolation system





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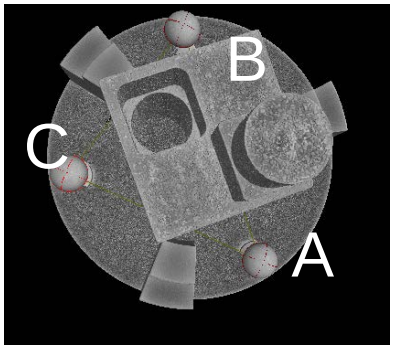
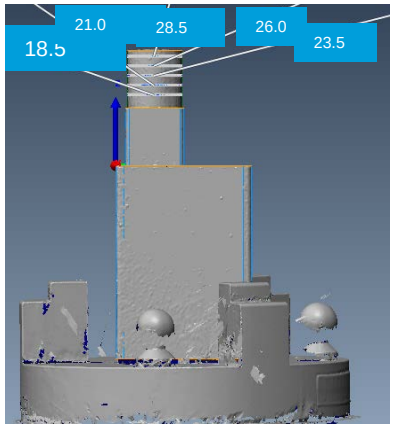
Dimensional measurements - Summary



Item	CMM	CMM-Optical	CMM-XCT
A(Dia)	9.991	0.079	0.005
B(Dia)	9.991	0.188	0.006
C(Dia)	9.992	0.064	0.006
A-B	68.381	-0.063	0.014
A-C	50.769	-0.026	0.013
B-C	57.820	-0.025	0.008

- Comparison of data from CMM, XCT and optical.
- Sphere diameter and distance
- Circle diameters and standard deviation (Std)

All units are in mm



Height	CMM	Std	CMM - Optical	Std	CMM - XCT	Std
18.5	14.070	0.037	0.206	0.030	0.165	0.012
21.0	14.051	0.036	0.232	0.029	0.177	0.012
23.5	14.066	0.043	0.246	0.030	0.192	0.013
26.0	14.052	0.040	0.202	0.035	0.163	0.012
28.5	14.059	0.034	0.201	0.034	0.177	0.013