Demonstration of Metralis within an Advanced Manufacturing Cell

Aachen, Germany

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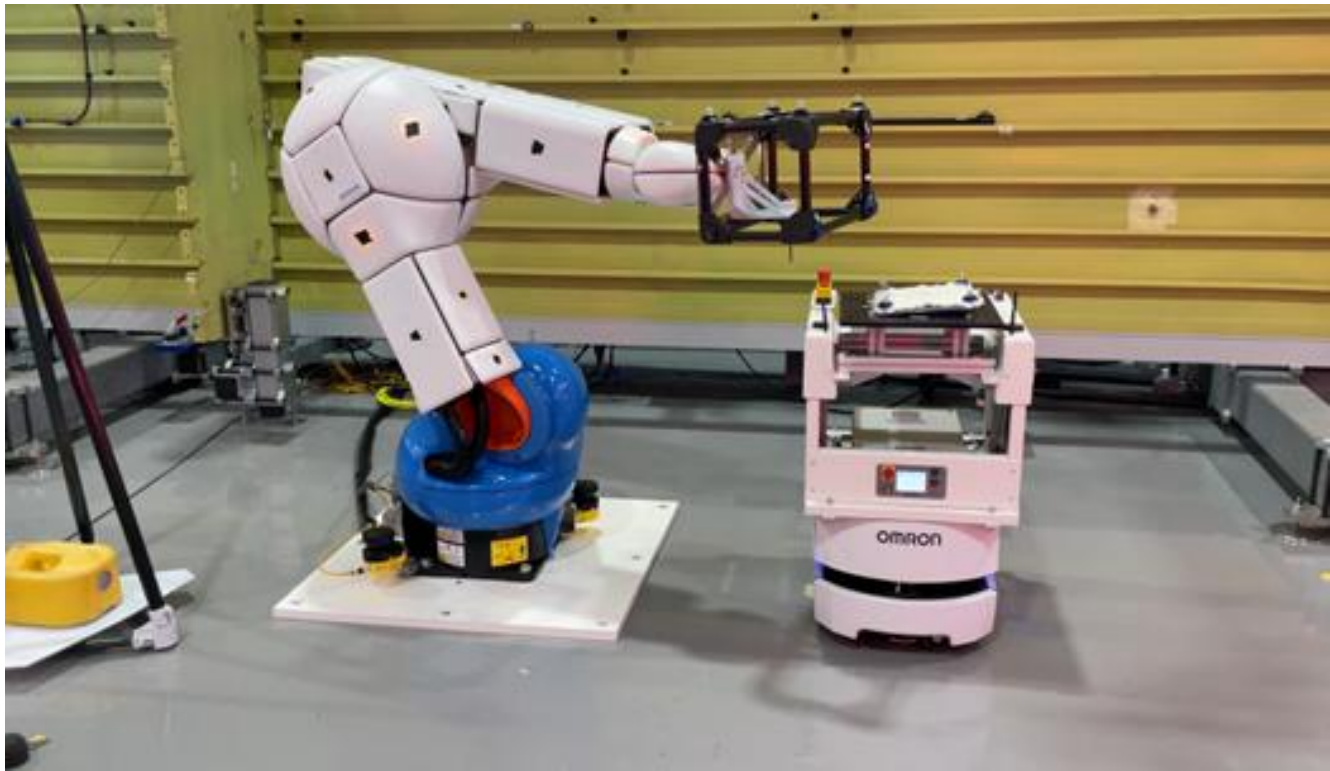


Outline

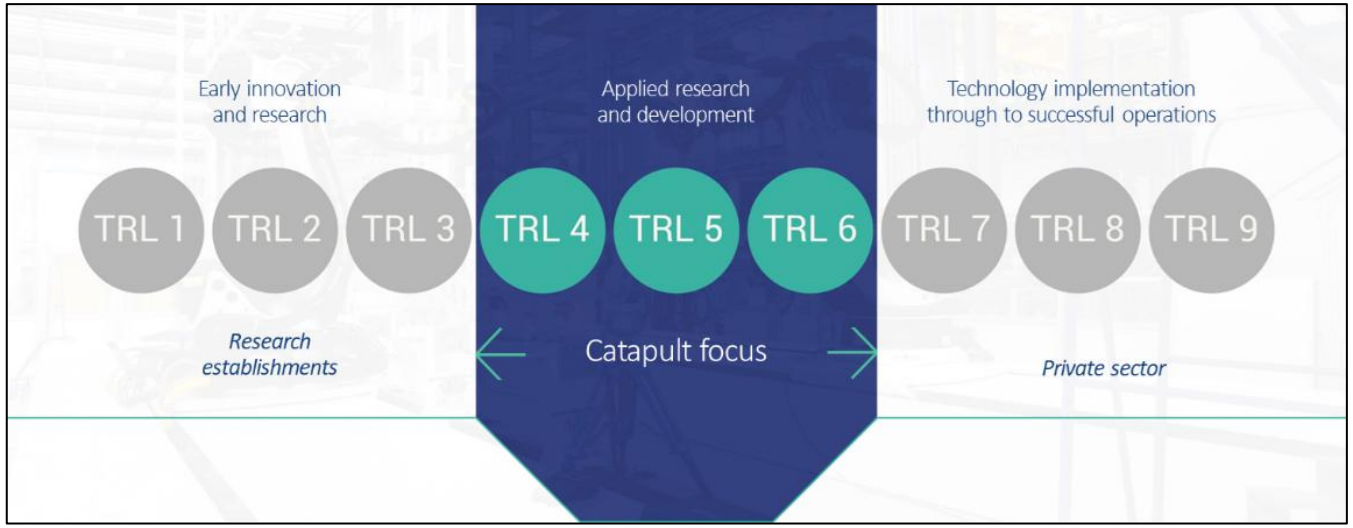
- Introductions
- What is Metralis
- Concept
- Current Development Status
- MMC Setup and Processing
- System Uncertainty
- Potential applications and digital twin

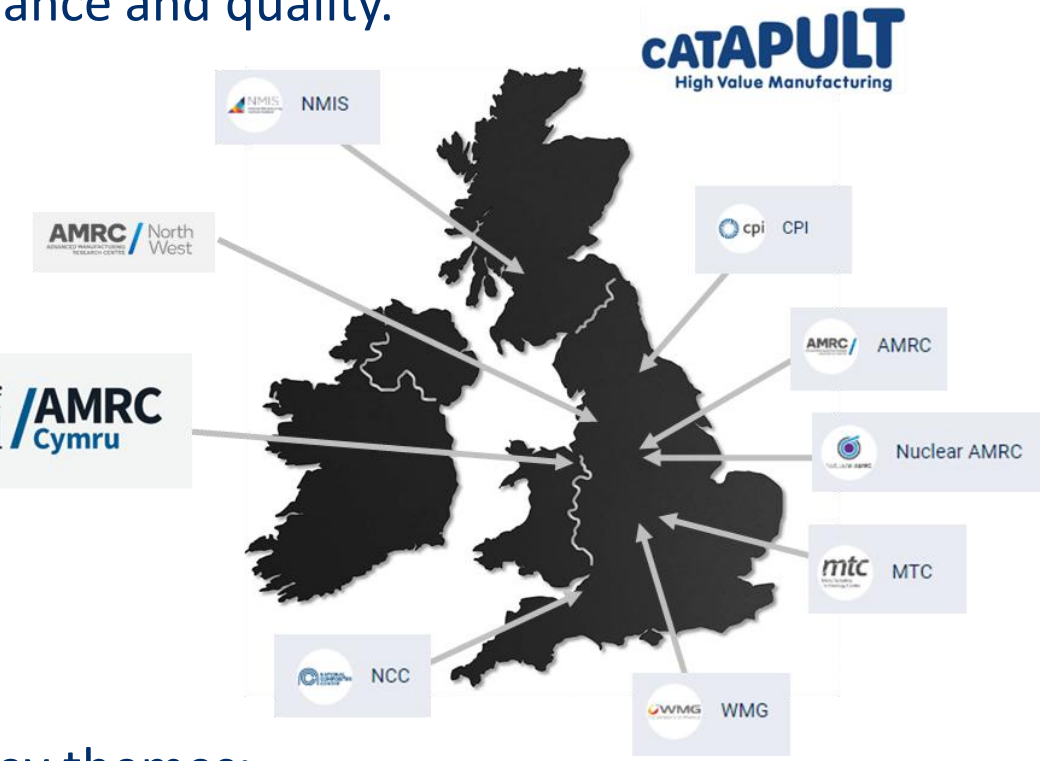
About NPL

- UK’s National Metrology Institute founded in 1900
- A public corporation owned by the Department for Science, Innovation and Technology (DSIT)
- Based in Teddington (London) with locations in Strathclyde, Surrey, Cambridge, Huddersfield and Solihull
- Strategic partners DSIT, the University of Surrey and The University of Strathclyde
- 1000 scientists and engineers with a breadth and depth of metrology expertise.

About AMRC Cymru

Introduced to support the region's manufacturing community access advanced technologies to drive improvements in productivity, performance and quality.





Key themes:

- New products
- New processes
- Industrial digitalisation

Metralis – high accuracy coordinate metrology using frequency scanning interferometry (FSI) and multilateration

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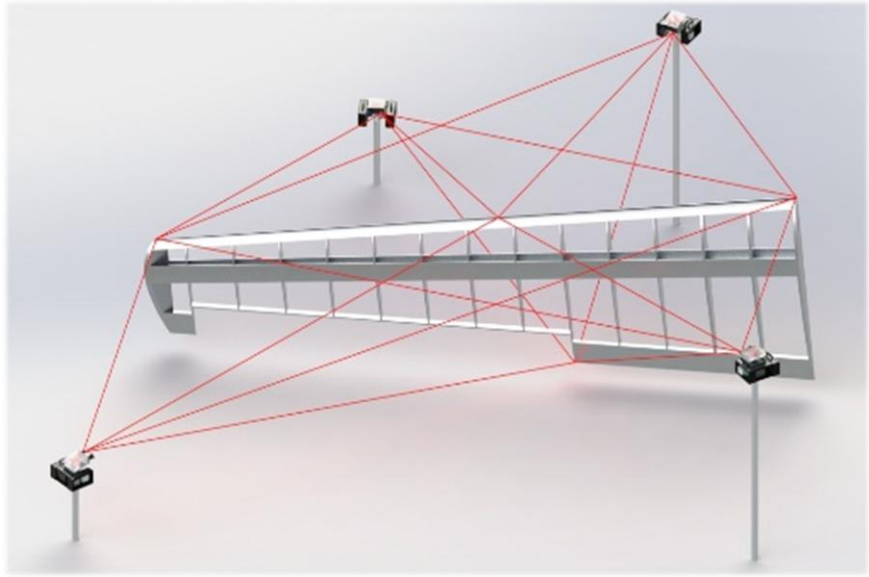

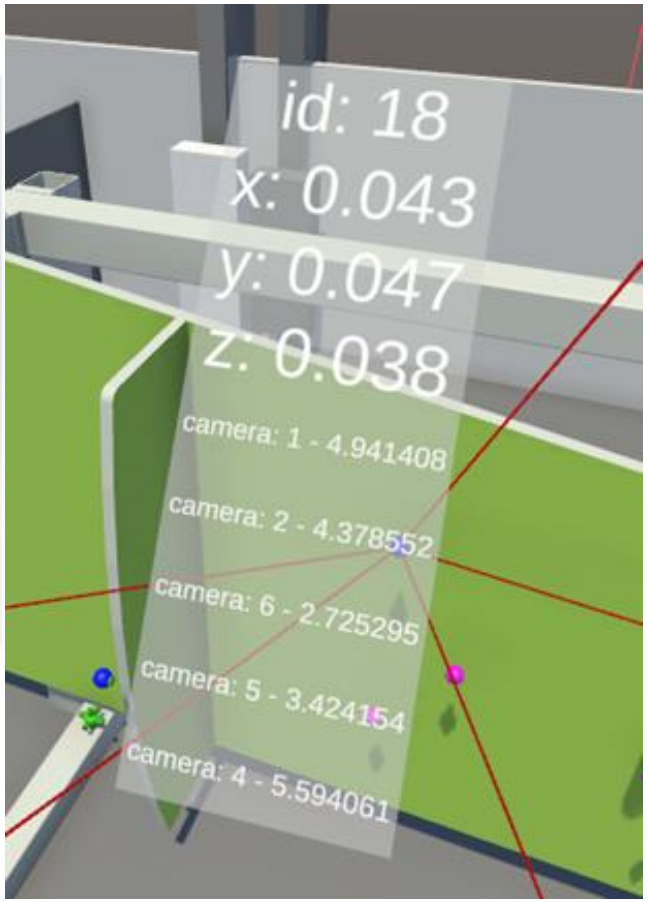

Analogy - The Global Positioning System (GPS)

1. Is accurate
2. Measures multiple points simultaneously
3. Self-calibrating - built-in compensation for systematic errors
4. Has built-in traceability to SI
5. Gives on-line uncertainty estimation

Current development status

- Sensor hardware operational
- Hardware improvements to reduce noise
- Photogrammetry system using onboard cameras operational
  - Target tracking implemented
- User software in development
  - Interfaces with SpatialAnalyser
  - API developed, integrates with MQTT IOT applications
- On-going collaboration with AMRC Cymru on development and testing

Metralis MMC Setup

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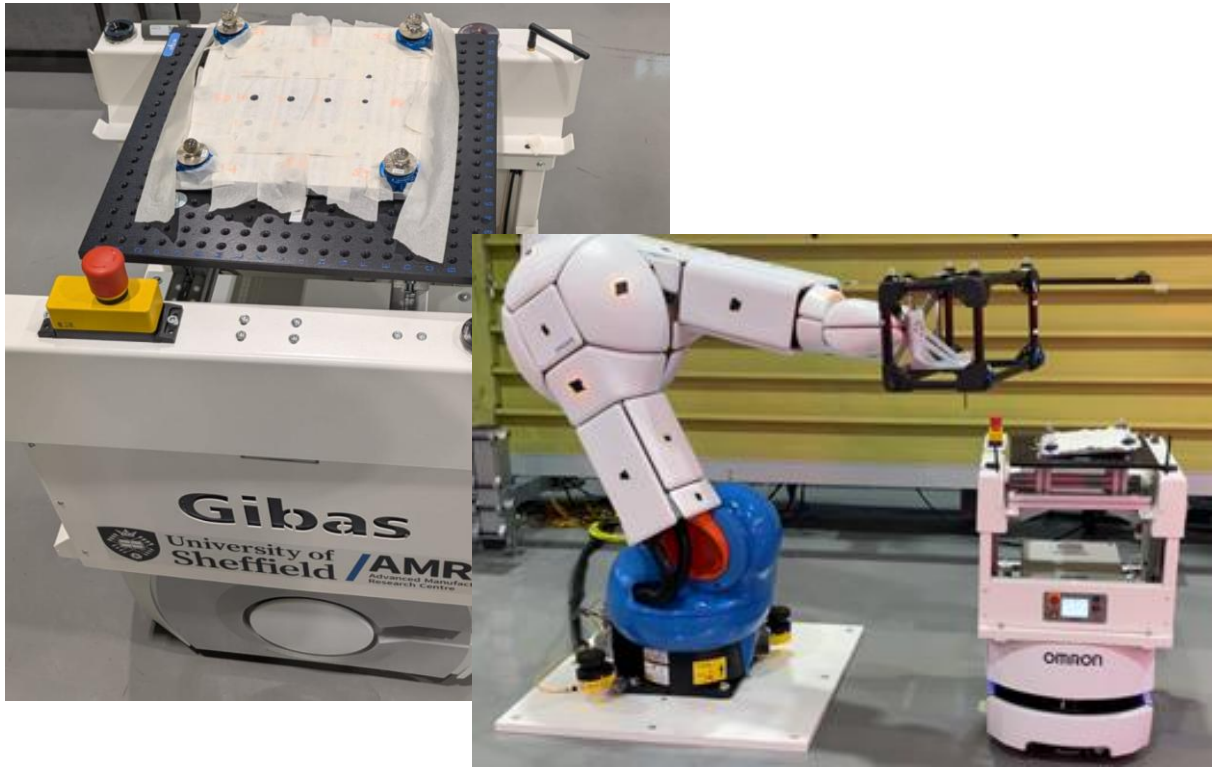
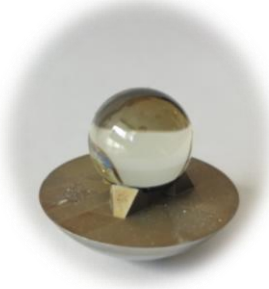
Objectives:

1. Measure pose of a 6 axis robot and perform a Move Measure Correct (MMC) Operation.
2. Use MMC to guide a pin into a hole



Setup:

- Six Metralis sensors placed around volume
- Hexagon AT960-mr and Leica SMR
- Metralis glass retro-reflectors
- 1 m Brunson scale bar
- 28 Fixed nests placed arbitrarily in the cell
- 6 Axis Robot + simulated tool
- Autonomous factory bot (OMRON)
- Hole artifact



Metralis setup at AMRC Cymru

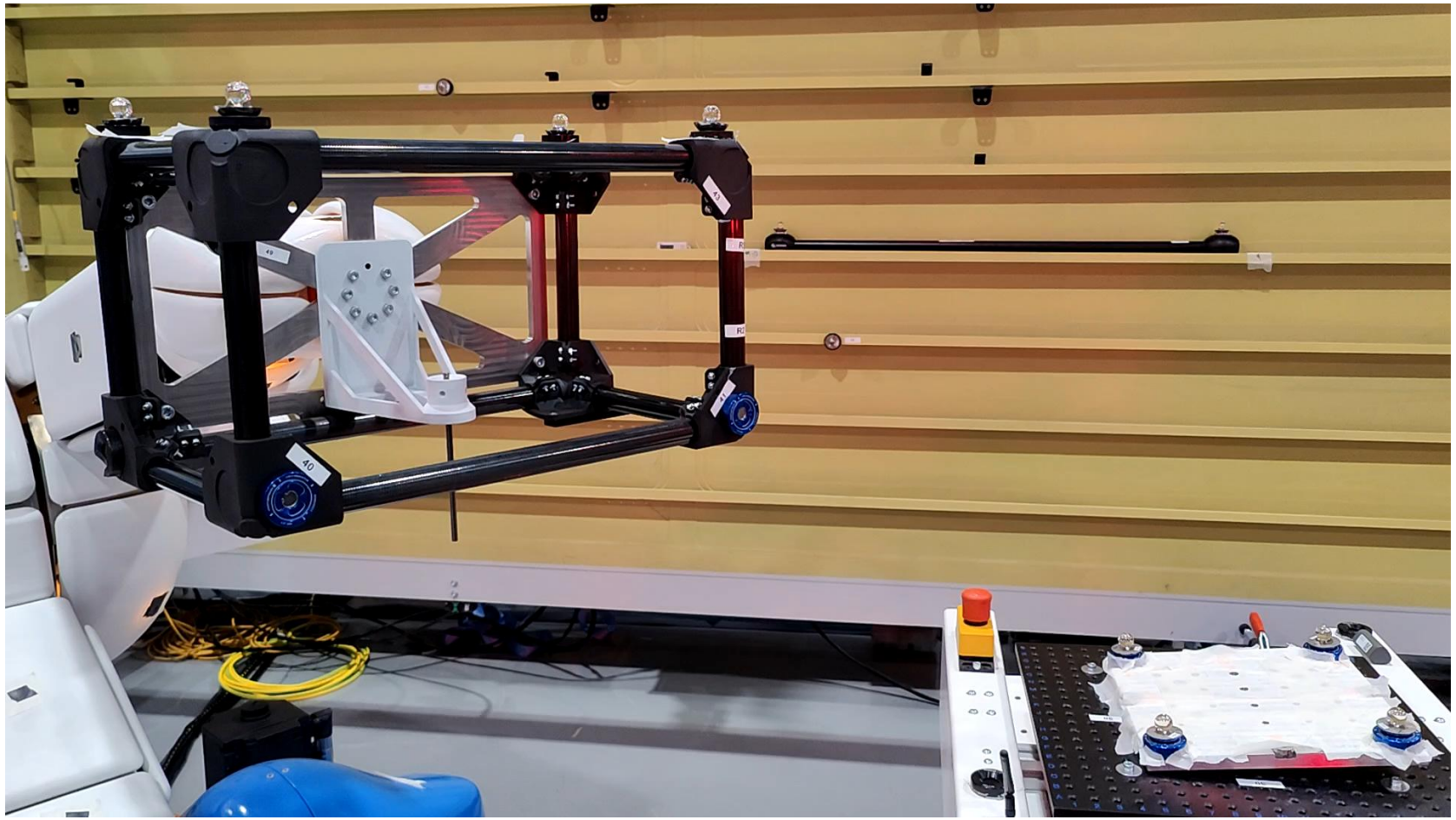
MMC processing pipeline

1. Use tracker to obtain initial locations for targets

2. Start photogrammetric tracking of targets

3. Project beams onto targets and optimise position of control points.

4. Acquire range data for each target and compute first multilateration solution



5. Move robot, photogrammetric tracking tracks and issues a status update when robot stops

6. Project beams to new robot position, perform multilateration, repeat steps 5 and 6 until tolerance threshold is met

7. Perform pin in hole operation

8. SUCCESS!

Test results

Targets (ID, X, Y, Z, Flag)

19

0

44	708.804	2152.28	1409.44	0	0.040562	0.01768	0.045264
45	842.441	2337.06	1407.01	0	0.035345	0.01422	0.038997
46	1208.92	2077.49	1404.41	0	0.031931	0.016178	0.034176
47	1071.74	1885.44	1404.84	0	0.036317	0.019335	0.040544
61	1219.39	1254.32	845.903	0	0.010969	0.018665	0.028744
62	1010.6	1248.29	844.935	0	0.013166	0.018471	0.033093
63	1004.47	1456.18	825.542	0	0.011896	0.016333	0.030701
64	1213.62	1461.95	826.821	0	0.009732	0.016519	0.027622

Robot (44-47) and artefact (61-64) position in robots ‘home’ position
First MMC move: Translation (mm): 592.5631, 546.2618, -182.7058
Rotation (deg): 0.5669, -5.0625, 37.2123

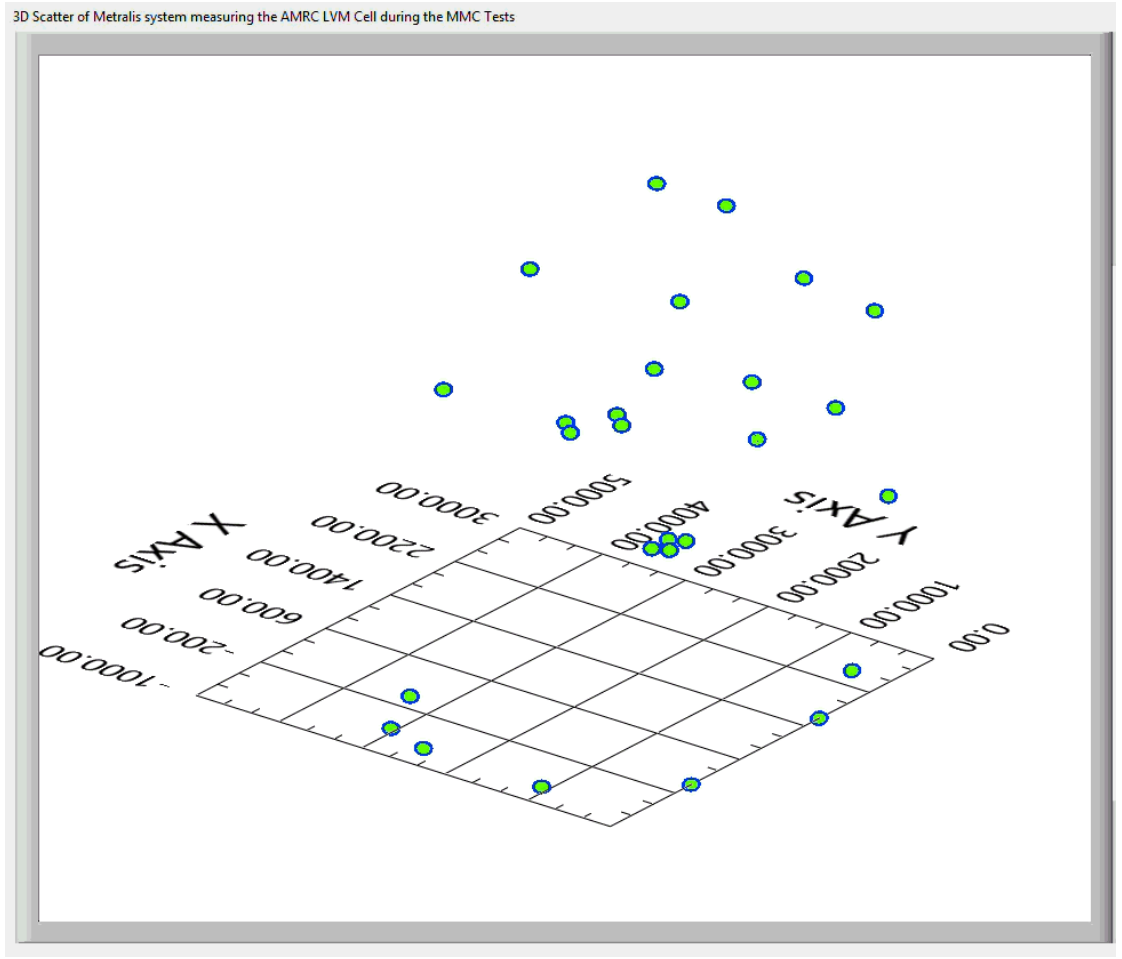
Targets (ID, X, Y, Z, Flag)

19

0

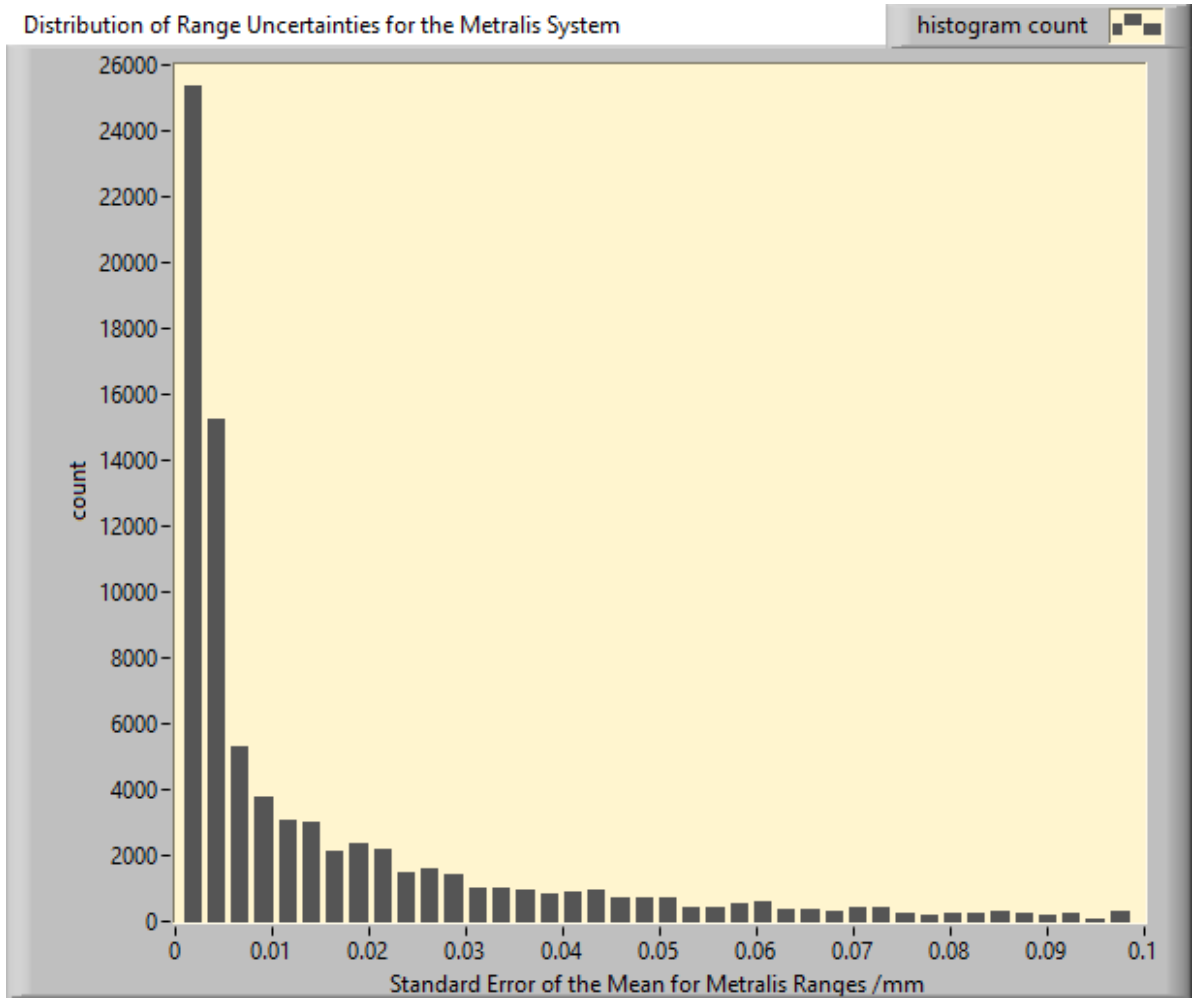
44	829.839	1229.09	1235.01	0	0.025035	0.019717	0.030197
45	824.485	1456.03	1212.92	0	0.023495	0.017436	0.028239
46	1273.34	1471.11	1213.56	0	0.018197	0.016012	0.020802
47	1280.27	1236.09	1234.28	0	0.019281	0.018155	0.022178
61	1219.21	1254.32	845.777	0	0.007531	0.014001	0.016724
62	1010.41	1248.29	844.817	0	0.009003	0.013951	0.018926
63	1004.27	1456.17	825.41	0	0.008515	0.012209	0.018148
64	1213.44	1461.93	826.675	0	0.007226	0.012278	0.016103

Robot (44-47) and artefact (61-64) position after 1st MMC move
Second MMC move: Translation (mm): 0.0150, -0.1887, 0.9200
Rotation (deg): -0.0670, -0.0005, 0.0194



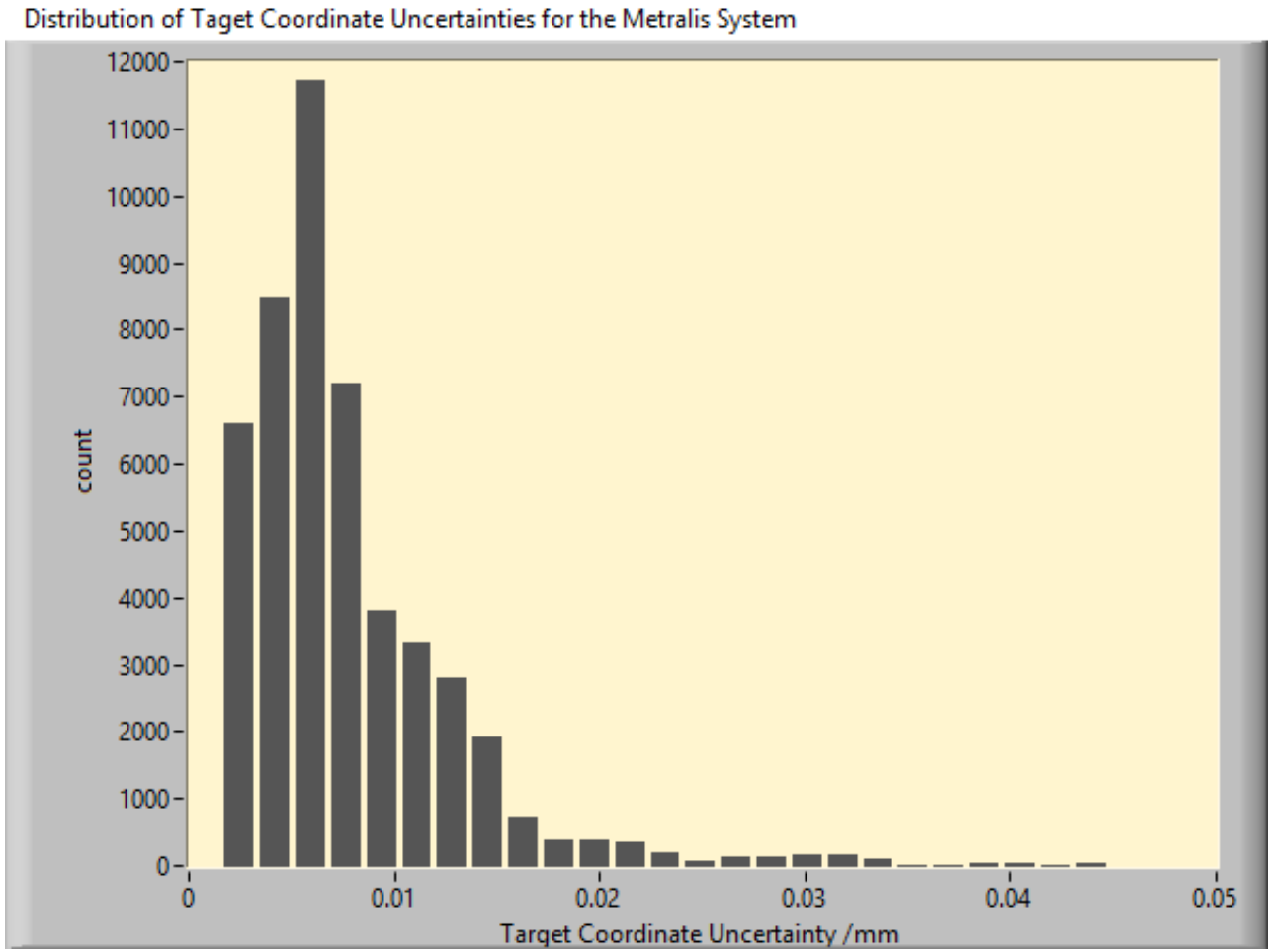
Uncertainty Calculation

- Each range consisted of 10 acquisitions averaged, with the standard error of the mean reported as it's uncertainty
- Scale factor applied, but associated uncertainty yet to be assessed
- Target uncertainties calculated by propagating range uncertainty through the stochastic model



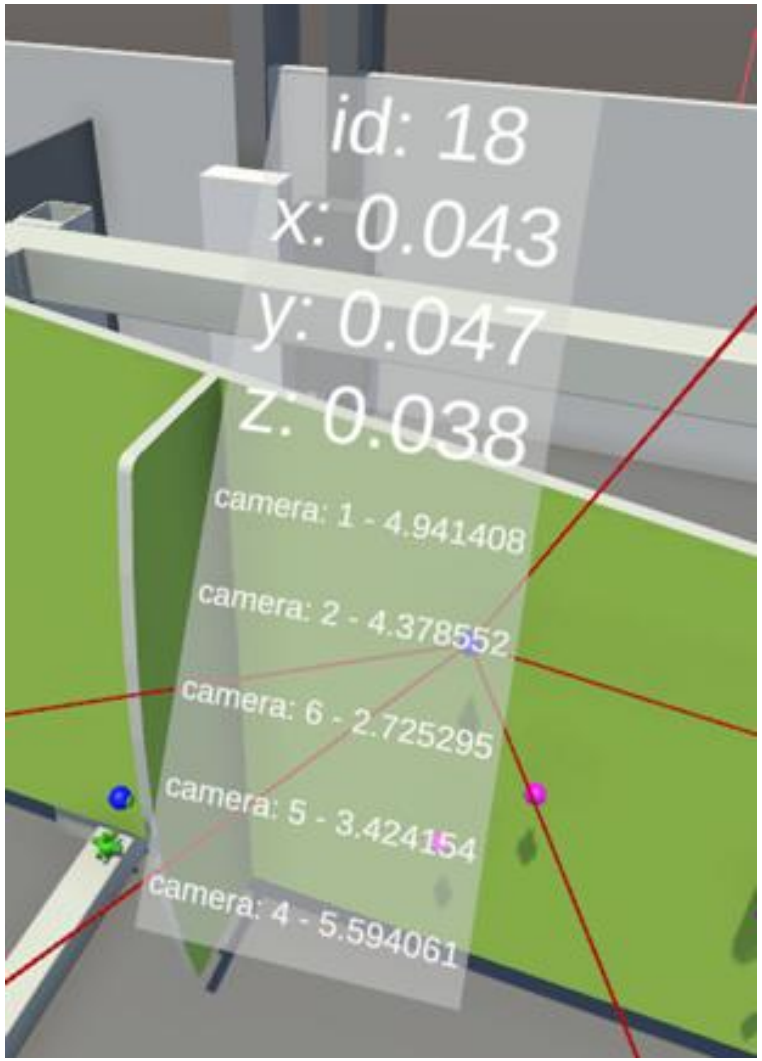
Target Coordinate Uncertainty

- 600 repeats of static targets in AMRC LVM cell
- Mode 6.1 µm
- 95% of data is below 16.2 µm



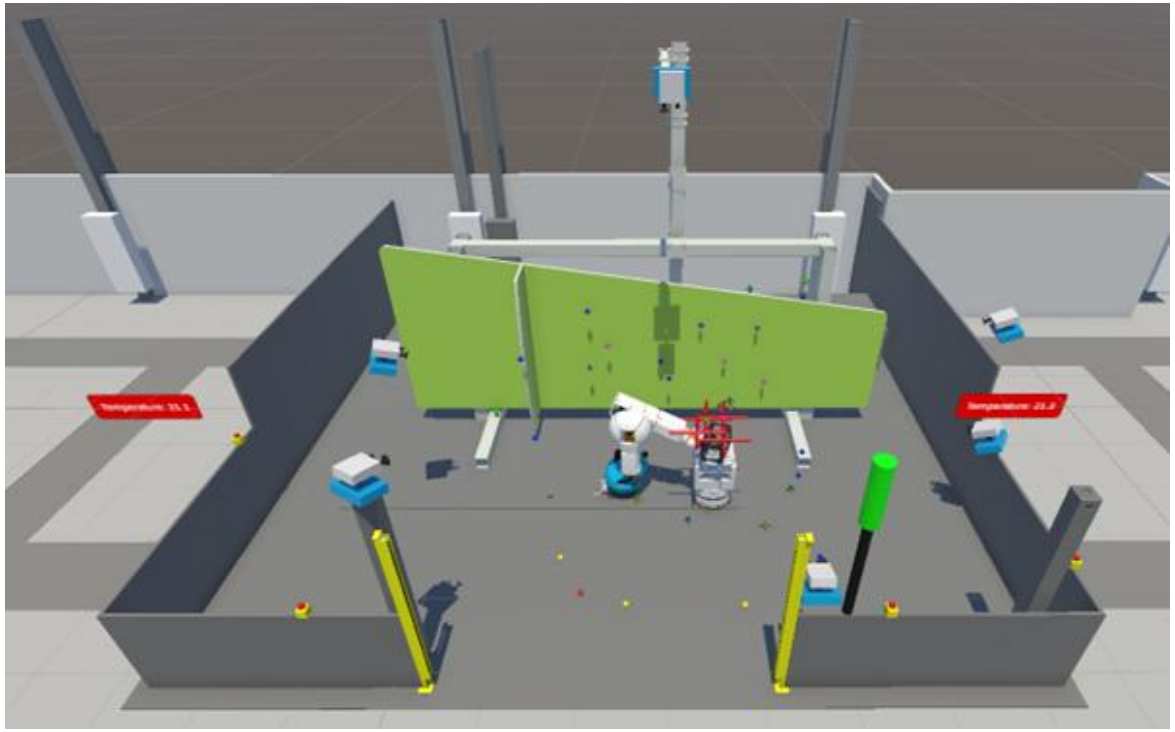
Potential Applications

- Simultaneous tracking of multiple robots/parts/tools
- Automated Machine tool/robot calibration
  - 6DOF frame tracking
  - 360° target view
  - Complete automation, improved health and safety and cycle times



Digital Twin

- Node-RED – PLC send data to an influx database
- Unity to query database and update digital model
- Fairly basic functionality, but to be expanded. Target location, robot position, sensor position, cell condition



METRALIS
Autonomous Mobile Robot
Move Measure Correct

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TOMORROW.
DONE BETTER.

Questions?

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NPL

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