

AUTOMATE 3D INSPECTION NOT JUST WITH ROBOTICS, BUT WITH DATA AUTOMATION



Connected Quality Data across Supply chain

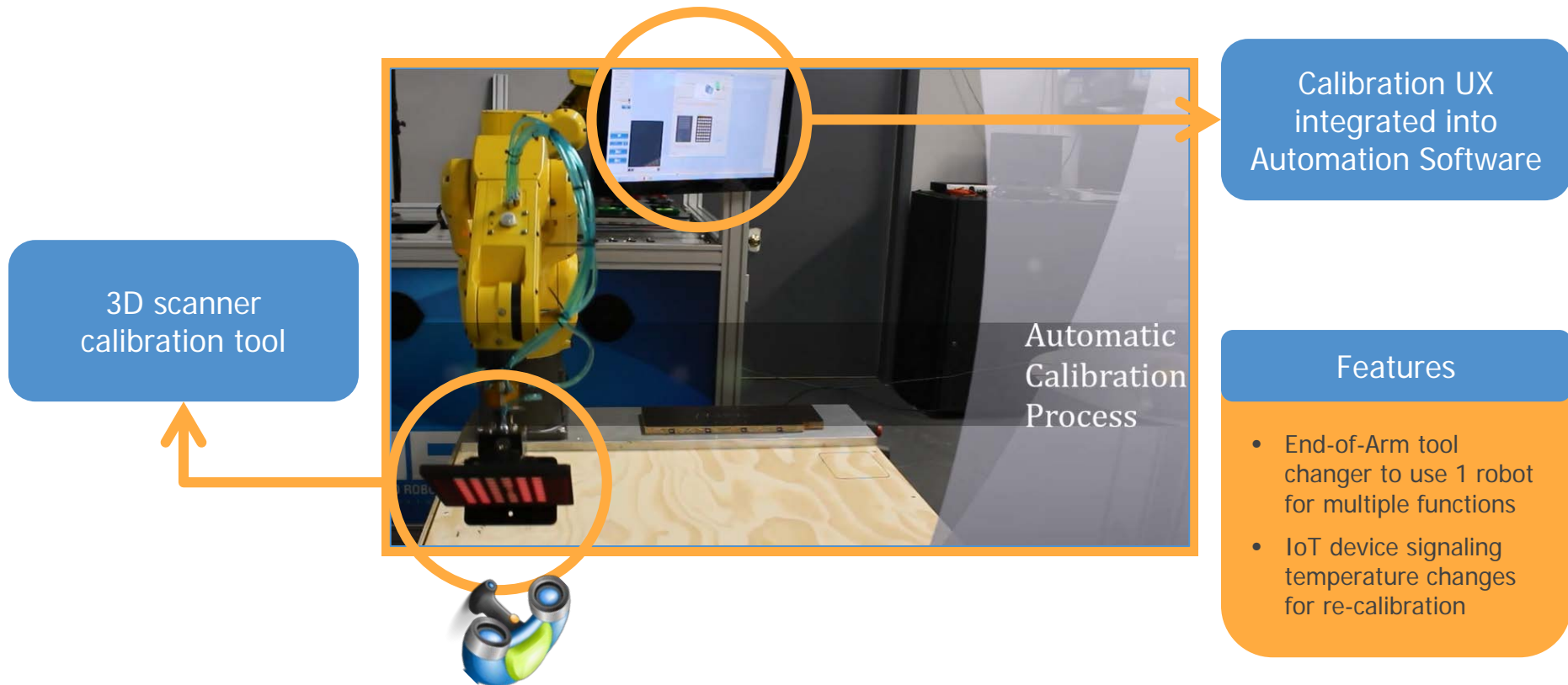


Facility 1



Facility 2

Automated Calibration of 3D Scanners



Automated Calibration of Robots



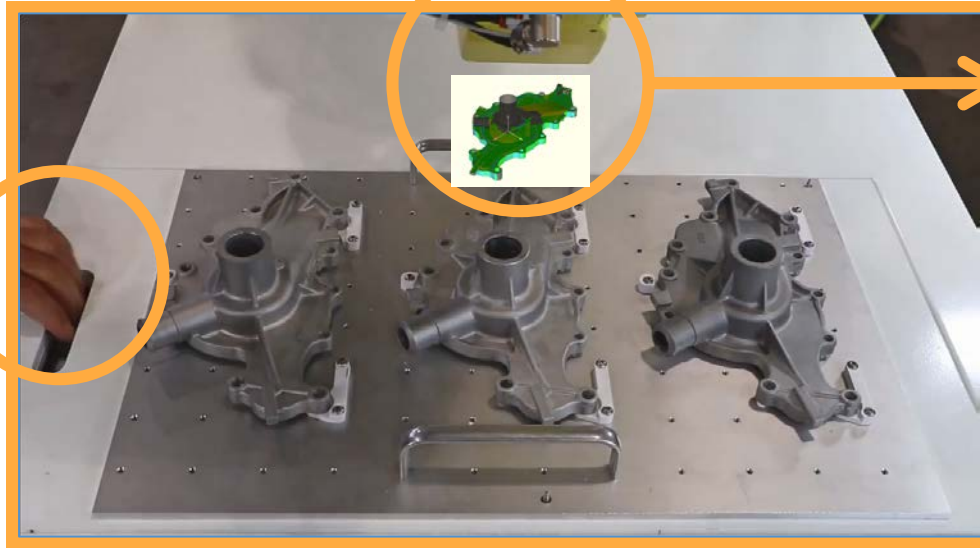
Features

1. Understand a theoretical measurement of the calibration tool (e.g. center of a sphere ball)
2. Take N number of shots from X, Y, Z axis deltas and rotations
3. Perform “optimal” image registration of these N shots through an iteration in x.x mm increments from the theoretical measurement, in all three X, Y, Z directions
4. The “optimal” image registration method is determined by the meta data about the calibration tool (e.g. sphere ball)
5. Identify the one that resulted in the least amount of movement (transformation) according to the registration process.

Gage R&R Process

Reproducibility

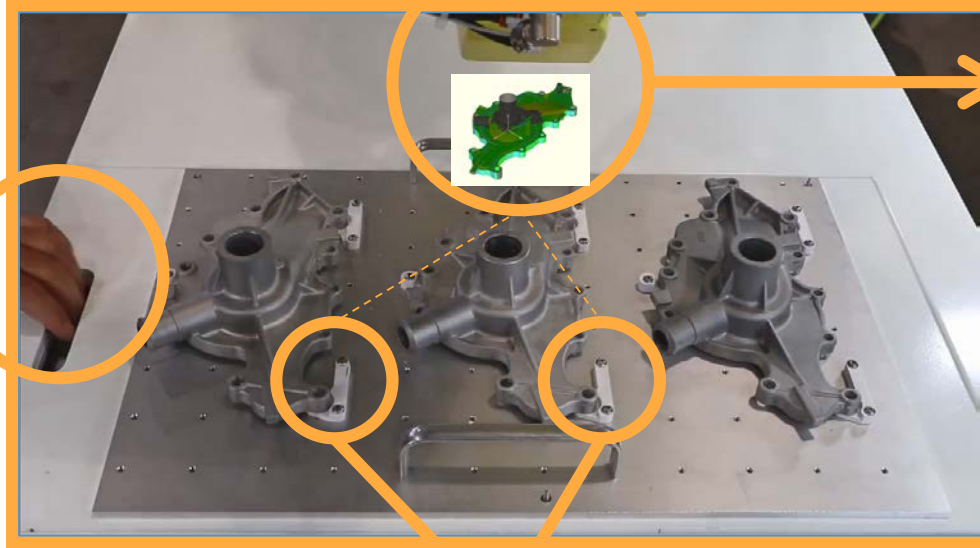
Repeatability



Gage R&R Process

Reproducibility

Repeatability



Inexpensive MakerBot 3D printed fixtures

Source of Biases

1. Fixtures
2. Grippers
3. 3D scanning
4. Image processing
5. Human consistency



Maximize precision by iterating various 3D scan data image registration

Gage R&R Process

Metric	Part #1	Part #2
Average $\sigma_{R\&R}$	0.64 (thou) / 16.3 (μm)	0.69 (thou) / 17.6 (μm)
$6 \times \text{Average } \sigma_{R\&R}$	3.85 (thou) / 97.8 (μm)	4.16 (thou) / 105.6 (μm)
Acceptable Tightest Tolerance	12.8 (thou) / 0.33 (mm)	13.9 (thou) / 0.35 (mm)

Compared to CMMs, the precision is

- Slightly worse than in-lab CMMs
- Comparable or slightly better than portable CMMs

Comparison Study vs CMM Process

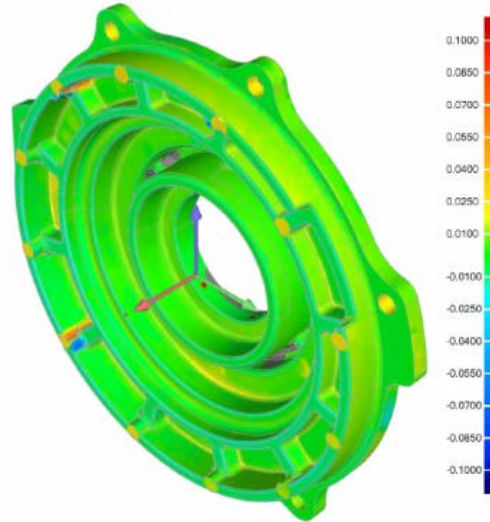
Initial Part Setup

75%+ implied time and cost savings

Step	Automated 3D Scanning		Current Process	
	# Operator Hours	# Machine Hours	# Operator Hours	# Machine Hours
(Step 1) Fixture Design	1.0	0.0	1.0	0.0
(Step 1) Fixture Printing	0.5	6.0	0.5	6.0
(Step 2) End-of-arm Tooling	0.0	0.0	N/A	N/A
(Step 3) Creating an Inspection Report Template	2.0	0.0	20.0	0.0
(Step 4) Creating a Tray to Hold Fixtures	0.5	0.0		
(Step 5) Programming Pickup Locations	0.5	0.0		
(Step 6) Programming Scan Locations	0.5	4.0		
Total	5.0	10.0	20.0	6.0

Comparison Study vs CMM Process

Inspection Results



Dimension	Measured	Nominal	Deviation
D1	3.4020	3.3980	0.0040
D2	1.0761	1.0740	0.0021
D3	1.6082	1.6090	-0.0008
D4	3.6267	3.6250	0.0017
D5	3.6256	3.6250	0.0006
D6	2.1027	2.1060	-0.0033
D7	2.0865	2.0820	0.0045
D8	3.4701	3.4680	0.0021
D9	1.2799	1.2770	0.0029
D10	2.9724	2.9740	-0.0016
D11	3.2526	3.2540	-0.0014
D12	0.8724	0.8750	-0.0026
D13	0.6308	0.6250	0.0058
D14	2.9628	2.9570	0.0058
D15	115.0592	115.0000	0.0592
D16	114.6941	115.0000	-0.3059
D17	3.9788	3.9748	0.0040
D18	2.6373	2.6410	-0.0037
D19	4.4295	4.4283	0.0013
D20	3.0526	3.0460	0.0066

Key Results	Automated 3D Scanning	Current Process
Number of Data Points Collected	2,000,000	200
Cycle Time (Min)	8	15
Preparation (Setup & Tear Down) Time (Min)	5	10

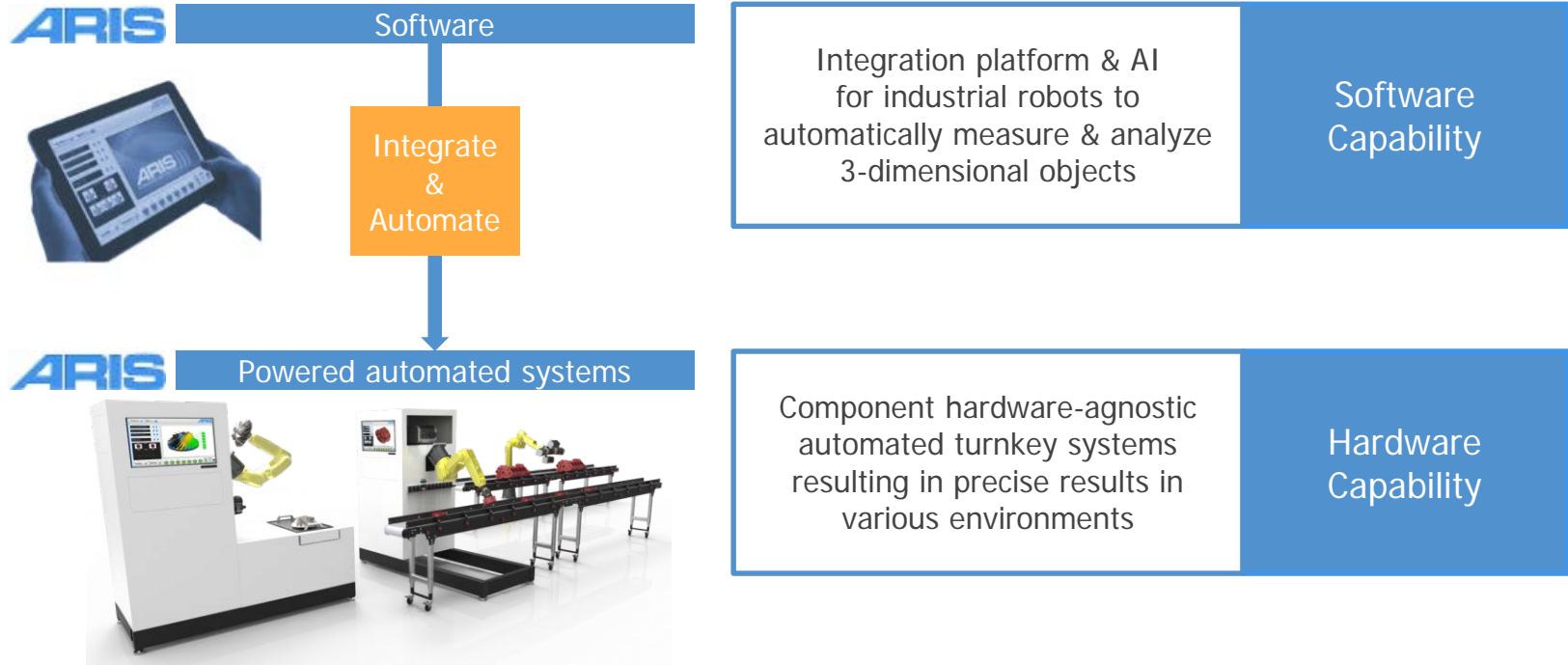
Flexible Forms of Automation



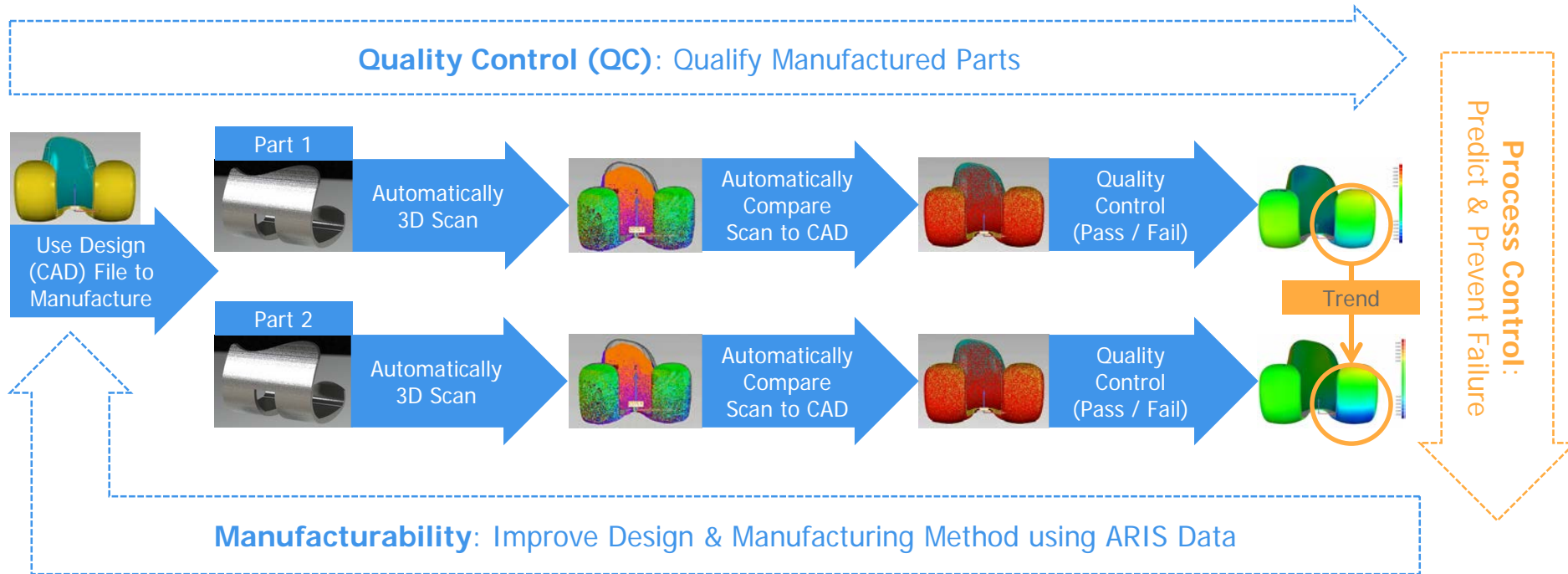
Flexible Forms of Automation



How Does it Work?



Outcome to the Supply Chain



THANK YOU

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