Use Collaborative Robots to Easily Program Complex Automated 3D Scanning for Dimensional Quality Control (QC) across Supply Chain

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Problem & Solution

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Problem: Manual 3D Measurements

3D measurement (including 3D scanning) is labor intensive and require trained experts.

Traditional Methods

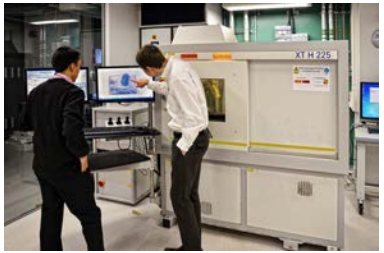
Contact based

Manual 3D Scanning

Highly trained engineer

Robotic 3D Scanning

Inflexible / Vendor Lock-in



X-Ray / CT Scanning

Extremely expensive

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Problem: Need for Automated 3D Scanning

Slow Contact Devices

Require Skill Labor

Expensive & Inflexible Systems

Need: Automated non-contact 3D scanning with an easy UX, which can be flexibly integrated & upgraded

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Solution: Robotic 3D Scanning

Slow Contact Device

Require Skill Labor

Expensive & Inflexible Systems

Robotic 3D Scanning

Solution: Easy User Experience & Programming

Slow Contact Device

Require Skill Labor

Expensive & Inflexible Systems

Robotic 3D Scanning

Easy UX & Programming

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Solution: Flexible Turnkey Systems

Slow Contact Device	Require Skill Labor	Expensive & Inflexible Systems
Robotic 3D Scanning	Easy UX & Programming	Flexible Turnkey Systems

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Comparison: Non-Contact (3D Scanning) vs Contact (CMM)

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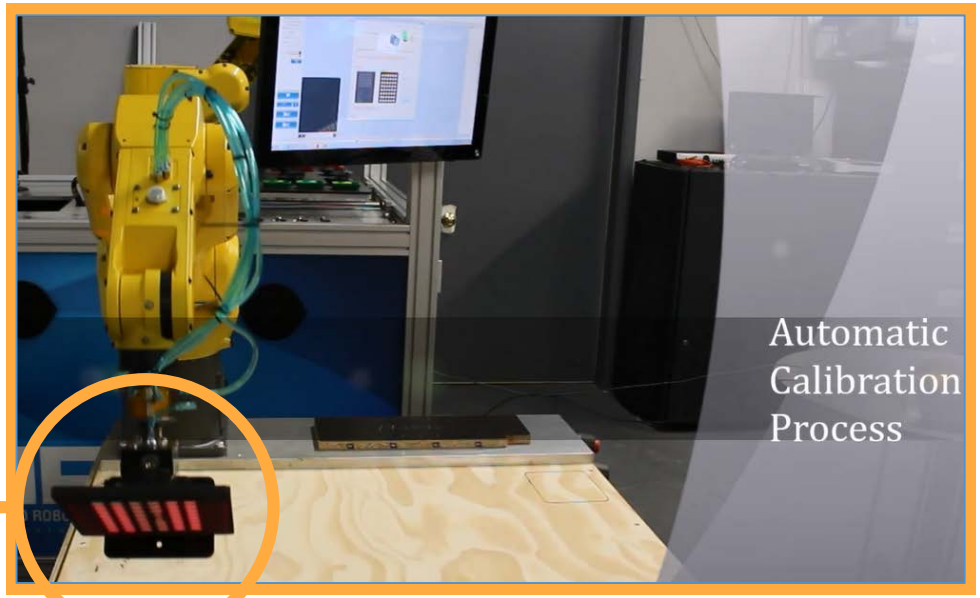
Calibration: 3D Scanner

3D scanner calibration tool



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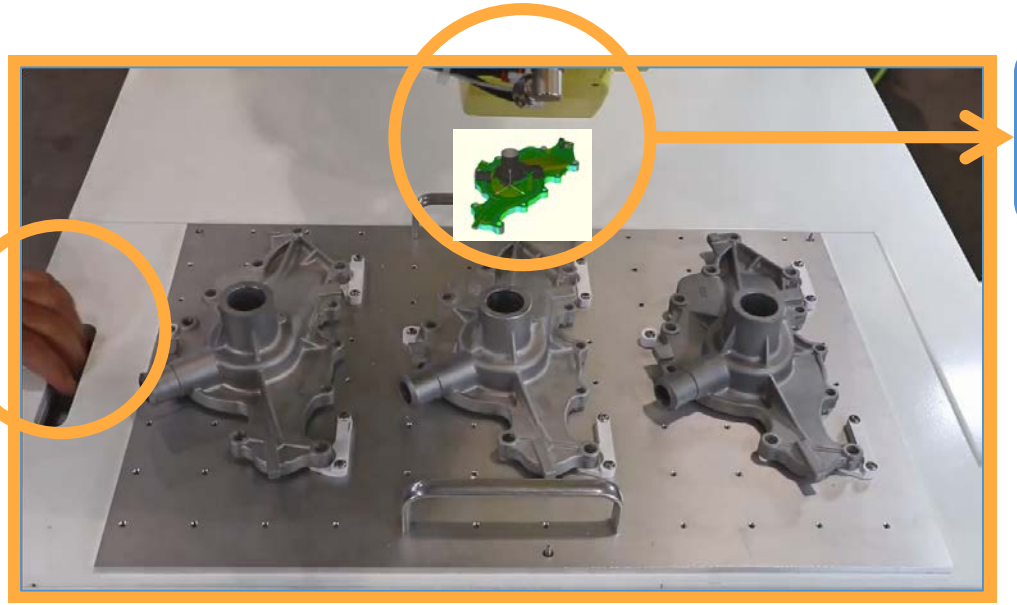
Calibration: Robot

Precision

Reproducibility



Repeatability

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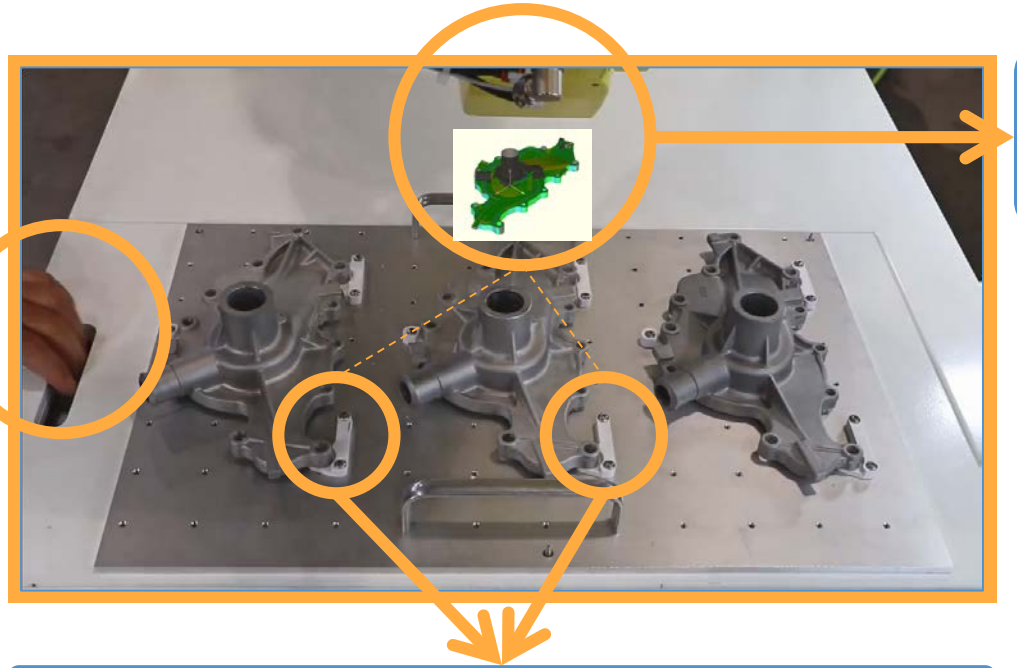
Precision

Reproducibility



Repeatability

Inexpensive 3D printed fixtures

Precision

Source of Biases

- Fixtures
- Grippers
- 3D canning
- Image processing
- Human consistency

Maximize precision by iterating various 3D scan data image registration

Precision

Metric	Part #1	Part #2
Average $\sigma_{R\&R}$	0.64 (thou) / 16.3 (μm)	0.69 (thou) / 17.6 (μm)
6 × 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

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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**

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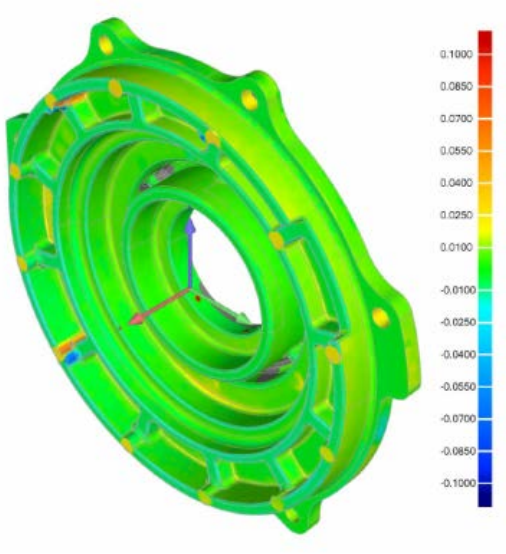
Comparison Study vs CMM Process

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

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Comparison: Cobot vs Industrial / Line -Laser vs Structured

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Why a Collaborative Robot?

Optimal for adapting automation programs to new designs and design modifications

	Traditional Industrial Robot	Collaborative Robot
Setup	Program: 7~10 hours Report: 3 hours	Program: 2 hours Report: 3 hours
Training	3 days	5 hours
Systems Integration	Software: 4 weeks Mechanical: 2 weeks	Software: 1 week Mechanical: 1 weeks

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Why Multi-Line Laser Scanning with External Tracking?

Faster; outperforms on shiny surfaces; can measure large size parts

	Structured Blue Light Scanning	Multi-Line Laser Scanning with External Tracking
Need to spray	O	X
Time for data acquisition	5-15 mins	3.5 mins
Need to use markers	O	X
Accuracy (for non-shiny surface)	.5-5 thou	1.5 thou
Accuracy (for shiny surface)	Lack of data	3-5 thou
Resolution	.013-.05mm	.3-1mm

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Case Studies

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Case Study I – Transmission Housing

Replace CMM + Scanner Head

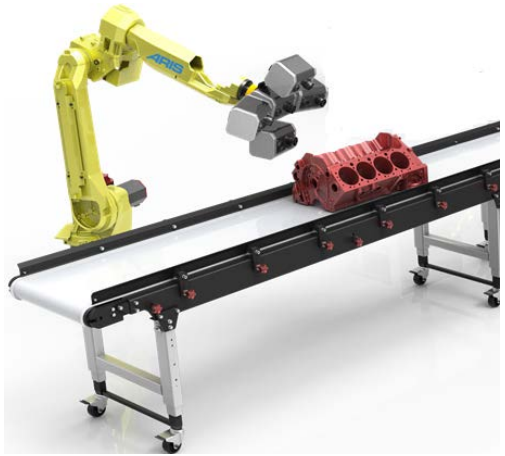
54 mins vs 5 mins

90% + Time Savings

Case Study II – Structured Parts

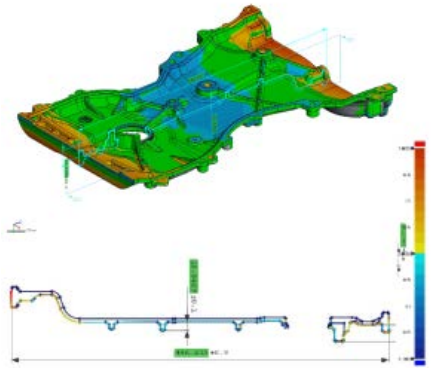
FCA
FIAT CHRYSLER AUTOMOBILES

Scrap Savings



$1MM+ Annual Savings

Replace CMM



Replace 4 CMM Programs 100%

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Impact

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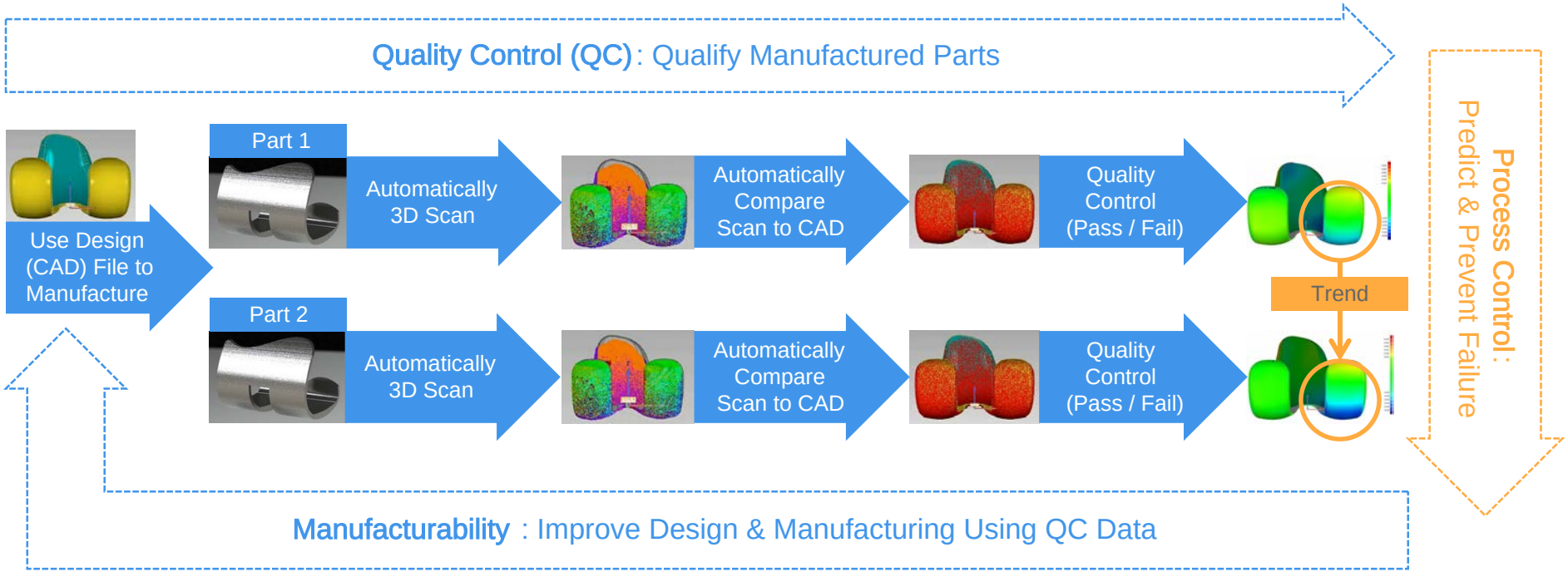
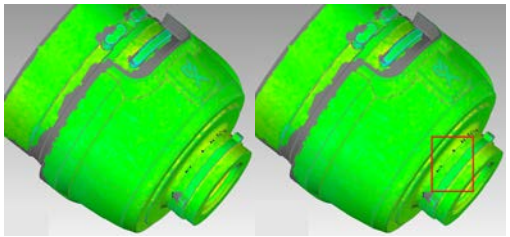
Impact to Design for Manufacturability

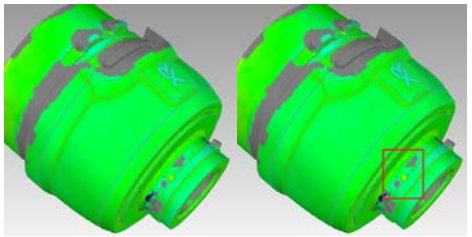


Impact to Supply Chain Quality Control

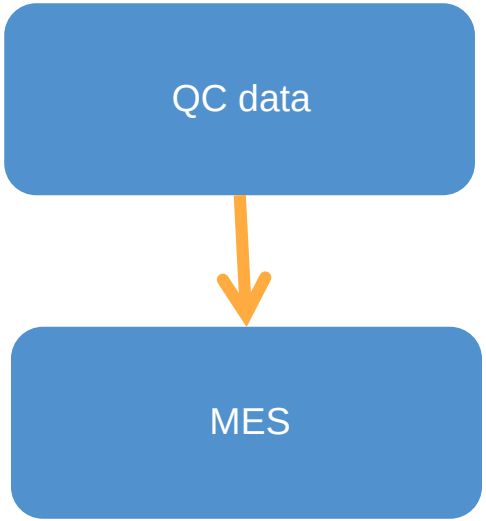
Ascast



Machined



Impact to Supply Chain Decision Making



THANK YOU

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