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# Automated Gauging: How to Improve Traceability and Process Control

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# Learning Objectives

- Getting started with QC automation
- Best practices for implementing collaborative robots in a quality department
- Robot video demonstrations with automated gaging
- Automation with existing shop floor gauge
- Building a business case and return on investment for implementing agile inspection tools
- Industry trends in automation



# New Paradigm Collaborative “Agile” Automation

- Serving high-mix small-batch manufacturing.
- People and robots working together
- Automate dull, dirty or dangerous tasks
- “There is an app for that”
- Teaching not programming



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# Introducing Collaborative Robots

- “Cobots” \*Coined in 1996 by J. Edward Colgate and Michael Peshkin
- Safe - Force and speed limited.
- Increase your team skills, productivity and engagement.
- Digitized and Networked to Industry 4.0



\* <https://wiredworkers.io/from-robot-to-cobot/>



# Cobots and People, Side-by-Side



<https://www.packagingdigest.com/robotics/cobots-packaging-2018-debriefing-universal-robots>



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# Agile Automation Opportunities (1)

## “Hard-Tooled” Automation

Turn-Key  
“Proprietary”

Mature & fixed  
processes

Limited variations.

> 100k parts/month

## “Agile” Automation

Open-Source Tools  
(Cobots, EOAT, Sensors)

New and dynamic  
processes

High-mix, small-batches

~ 10,000 parts/month



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# Agile Automation Opportunities (2)

## “Hard-Tooled” Automation

Dependent on system integrator for support.

~ \$1M / workstation

ROI is Many Years.

Project > 12 months

## “Agile” Automation

Independent in-house team supports.

~ \$100K / workstation

ROI < 1 Year

Project ~ 3 months



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# New Quality Challenges

- Skilled inspection staff are retiring
- Critical metrology know-how must be retained
- Labor costs (even at minimum wage) are too high for full-time manual inspectors
- Shortage of qualified/interested replacements
- Need more accurate real-time measurements
  - Improve internal processes
  - Satisfy customer demands & provide more data
- Increase capacity faster than headcount





# Motivations for Robot Inspection?

- Full-time staff completing dull and repetitive measurements.
- Difficult to increase capacity and throughput.
- Need to reduce operator-to-operator variations.
- Real-time digital data for process improvement.



# Video Intro: Robots meet Quality



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Video Link: [Introducing Q-Span Systems - Video](#)

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# Implementation – Getting Started

- Use incremental automation.  
Step by Step
- Pick most visible/worthy tasks.
- Optimize human and robot work.
- People are best at:  
“Seeing”, manipulating and overcoming the unexpected. Example: loading parts from random bins into organized trays.
- Robots are best at:  
Repetitive logical movements to known locations and repeatable part measurements.

“If you have a 10-step manufacturing process, you don’t have to automate all 10 steps to be successful,” “Identify one process step worthy of automation — implement it, and start generating the ROI very quickly.”

Joe Campbell  
Universal Robots



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# Contact Part Gaging (Manual)

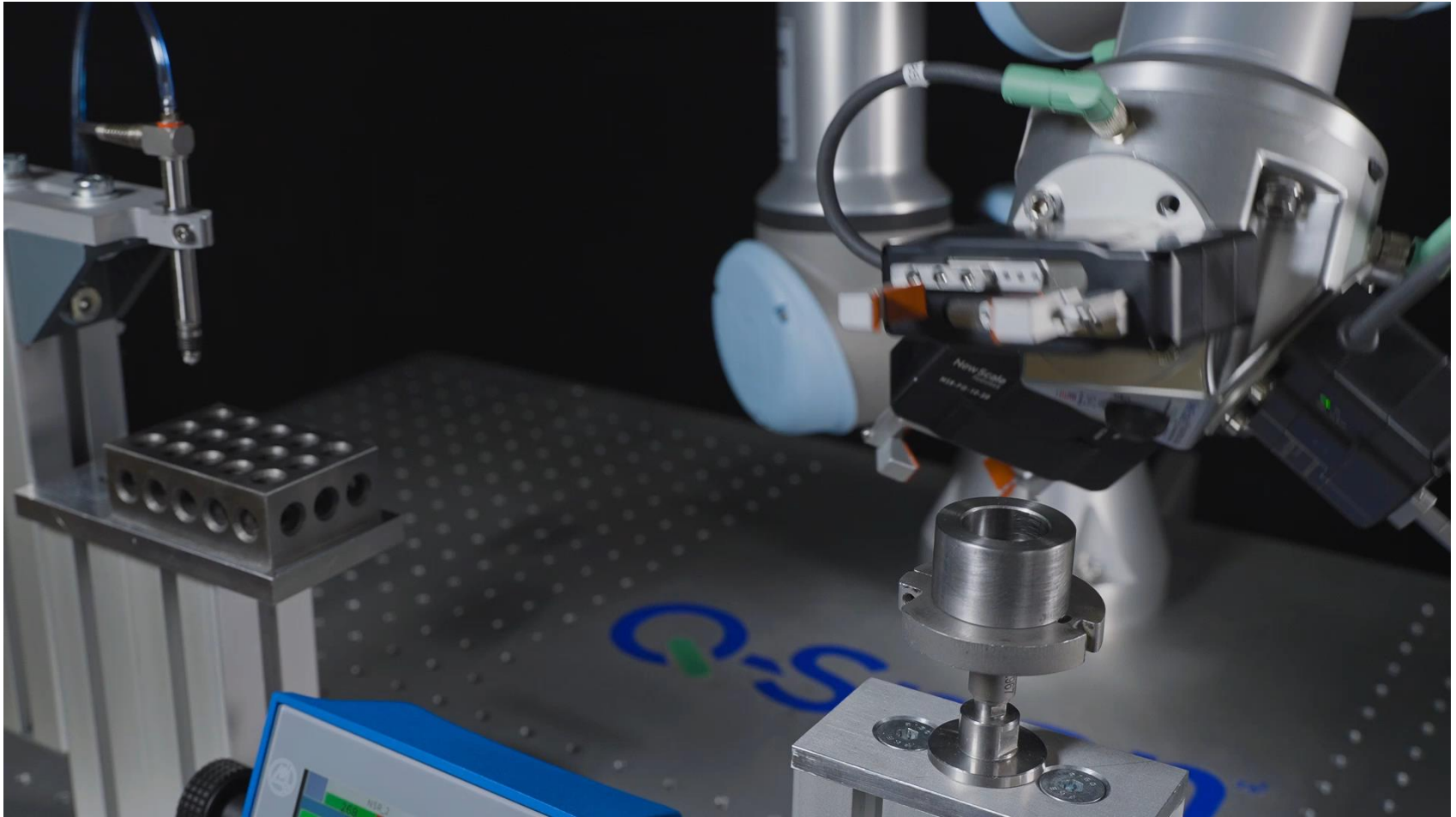
## Recent trends in gauging: Electronic data collection

- Wired
- Wireless
- Inspector pushes button to send data to QMS
- IOT...Every gauge is connected





# Contact Part Gauging (Automated)



Video Link: [3 Gauges on 1 Robot - Automated Gauging - YouTube](#)



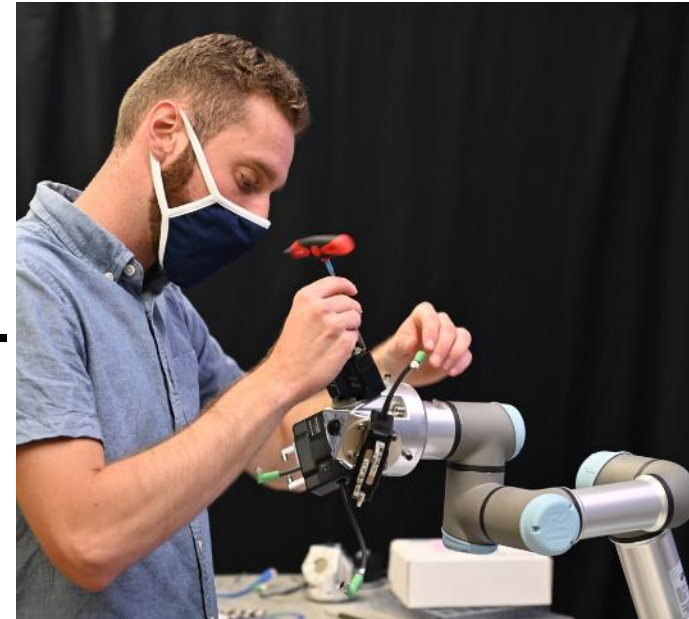
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# Contact Part Gaging (Automated)

- Fits in existing facilities and workflow.
- Operates safely next to staff.
- Pick parts from known locations.
- Measure features.
- Record data to QMS system.
- Place part to known location.  
Pass, Fail, Sort, etc.
- Fast re-deployment for high-mix manufacturing.

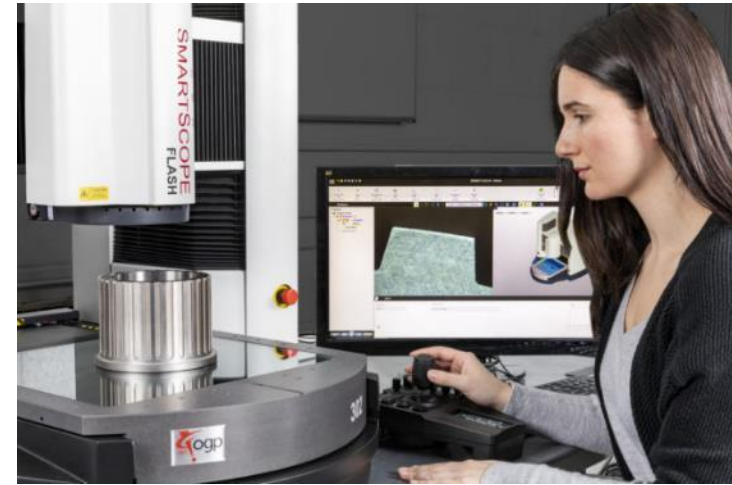


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# Non-Contact Part Gaging (Manual)

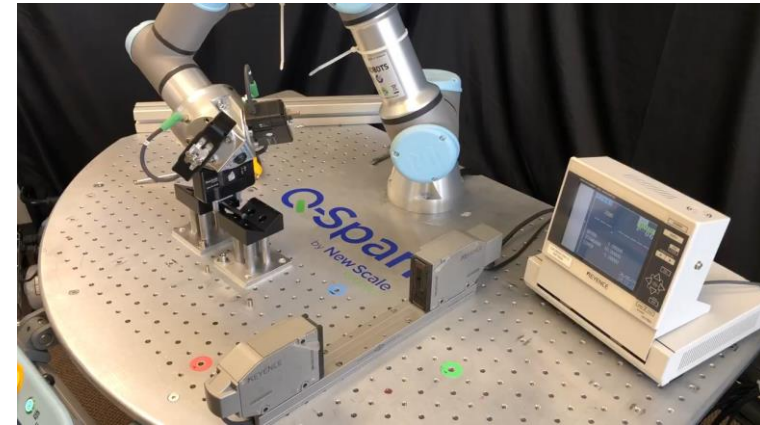
- Machine Vision
- Air Gauge
- Laser Fixed
- Laser Scanning



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# Non-Contact Part Gaging (Automated)



Q-Span Workstation with laser micrometer



Video Link: [Air Gauging with Q-Span Systems](#)



Video Link: [UR Handles Mission-Critical Inspection at Comprehensive Logistics](#)



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# Hybrid Applications: Contact & Non-Contact



Video Link: [OptiPro Systems Cobot Case Study](#)

Video Link: [UR and PrecisionForm Case Study](#)



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# Other Inspection Applications



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Video Link: [Universal Robots ensure faster blood sample results](#)

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# ROI Less Than One Year

## 1 Robot System Usage:

Disclaimer: Average Robot Electrical costs are roughly \$.50 per hour

2

Shifts/Day

5

Days/Week

50

Weeks/Year

## 2 Annual Labor Costs per Operator, Including Fringe Benefits:

Disclaimer: Average Robot Electrical costs are roughly \$.50 per hour

\$ 60,000

## 3 Number of Operators per Shift Removed:

1

## 4 Percentage of Labor Retained to Operate System per Shift:

10 %

## 5 Expected Productivity Gain:

20 %

## 6 Other Estimated Savings:

Additional Statement: We have found that there are often a number of additional unforeseen or industry specific values associated with the installation of Robotic Systems, such as: Scrap/Rework Saving, Material Savings, etc.

\$ 0

**Initial Cost of Cobot Workstation with Installation and Training is \$100,000**



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<https://www.automate.org/robotics-roi-calculator>

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# Benefits Beyond Simple ROI

- Improved Gauge Repeatability & Reproducibility (Gauge R&R)
- Reduced Measurement Variation
- Reduced Scrap/Rework
- More Engaged Team
- Less Turnover and Training Costs
- Greater Process Yields
- Improved On-Time Deliveries
- Increased Customer Satisfaction



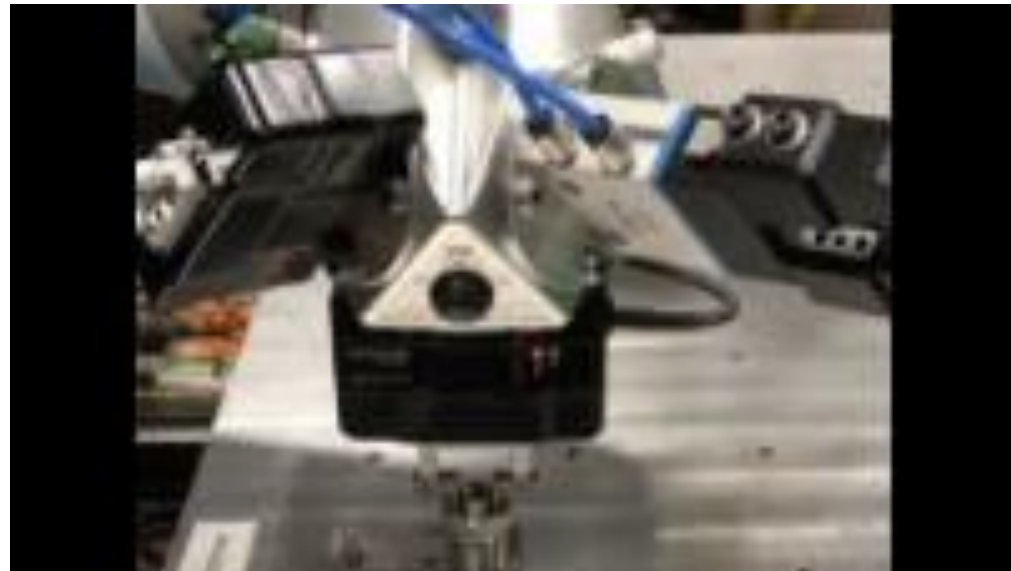
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# In-Process Gaging Application Example

## CNC Machine Tending

- Enable up to 100% inspection
- Monitor process drift and machine tool wear
- Improve uptime with preventative maintenance
- Reduce scrap
- Improve traceability



Video Link: [Tel-Tru Application Video - YouTube](#)



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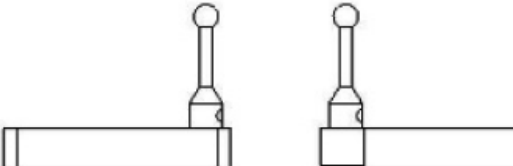
# Implementation – Robotic Gauge Selection

- Start by automating existing methods.
  - This expedites validation and correlation studies.
- Defined part process tolerances (T).
- Select gauge that measures with sufficient Gauge R&R.
  - Goal is  $< 10\%$



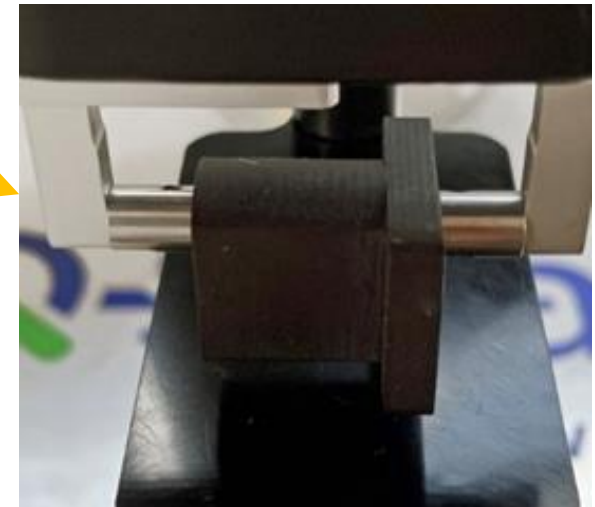
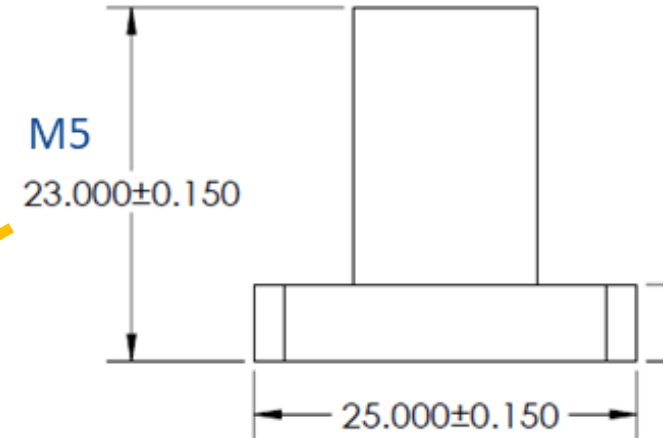
Example of robotic calipers with  $2.5 \mu\text{m}$  resolution (3 shown on one UR3e cobot).

# Selecting Caliper Fingertips

Fingertip shape	Type of Feature to be Measured	Typical Dimension Measured
<b>Flat</b> 	Flat Convex spherical Convex cylindrical	Outside Diameter of a sphere
<b>Hemispherical</b> 	Flat Concave spherical Concave cylindrical	Outside or Inside Distance between two flat surfaces
<b>Spherical</b> 	Flat Concave cylindrical	Outside or Inside Inside diameter of hole in a part

# Applying Gauge R&R as P/T%

- Establish part tolerances (T) being measured.
  - This is a  $\pm 3\sigma$  value
  - “T” for M5 is  $\pm 0.15$  mm
- From repeated measurements determine gauge precision (P)
  - Also  $\pm 3\sigma$  value
- A “capable” gauge has a (P/T%) less than 10 percent.



# Example Gauge R&R (P/T%) for M5

**M5 (23 mm)**

Part Serial Number

Runs

1 2 3 4 5 6 7 8 9 10

1	22.7725	22.8725	22.9425	22.8000	22.8825	22.9225	22.9200	22.9300	22.9525	22.8050
2	22.7700	22.8750	22.9400	22.8050	22.8825	22.9225	22.9200	22.9275	22.9525	22.8025
3	22.7700	22.8775	22.9425	22.8000	22.8825	22.9225	22.9200	22.9250	22.9475	22.8050
4	22.7725	22.8775	22.9375	22.8050	22.8825	22.9225	22.9175	22.9275	22.9475	22.8025
5	22.7725	22.8775	22.9425	22.8050	22.8800	22.9225	22.9225	22.9250	22.9475	22.8000
$\sigma$	0.0012	0.0020	0.0020	0.0024	0.0010	0.0000	0.0016	0.0019	0.0024	0.0019
$\sigma^2$	1.50E-06	4.00E-06	4.00E-06	6.00E-06	1.00E-06	0.00E+00	2.50E-06	3.50E-06	6.00E-06	3.50E-06
P ( $\pm 3\sigma$ )	0.0073	0.0120	0.0120	0.0147	0.0060	0.0000	0.0095	0.0112	0.0147	0.0112
T (See Figure 1)	$\pm 0.150$ mm									
P/T [%]	2.4%	4.0%	4.0%	4.9%	2.0%	0.0%	3.2%	3.7%	4.9%	3.7%

Combined  $\sigma$  0.0018

Combined P/T [%] 3.6%

Robotic Caliper is “Capable” for M5 measurement.



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# Fit for Robotic Calipers by Industry

Tolerance (T)	Machine	Mold	Stamp	Etch	Cast	Extrude	3D Printed
+/- 0.010" (200µm)							
+/- 0.008" (175µm)							
+/- 0.006" (150µm)							
+/- 0.005" (125µm)							
+/- 0.004" (100µm)							
+/- 0.003" (75µm)							
+/- 0.002" (50µm)							
+/- 0.001" (25µm)							
+/- 0.0007" (18 µm)							
< +/- 0.0007" (18 µm)							

*P= +/- 5 µm for a robotic caliper*



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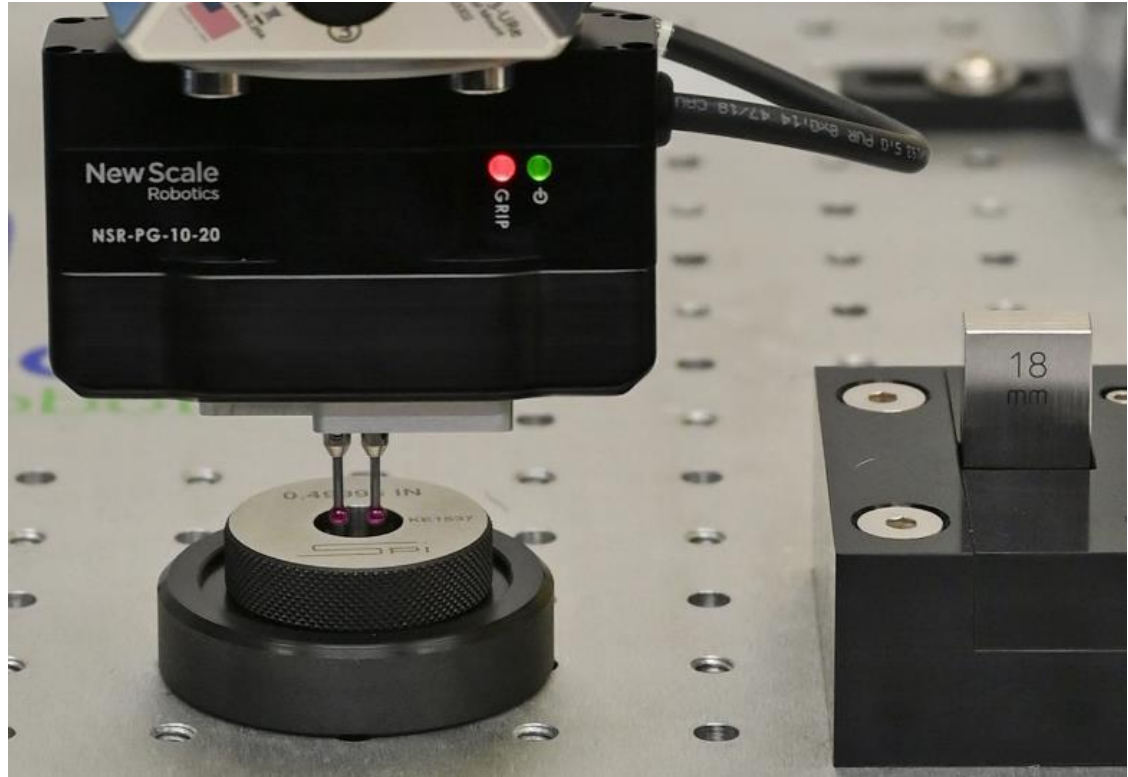
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# Embedding Reference Standards

Reference can be:

- Closing Fingertips to Contact (Zero)
- Gauge Block
- Gauge Ring
- “Golden” Part

***Frequency to set or check reference can be set as often as needed for any specific process.***

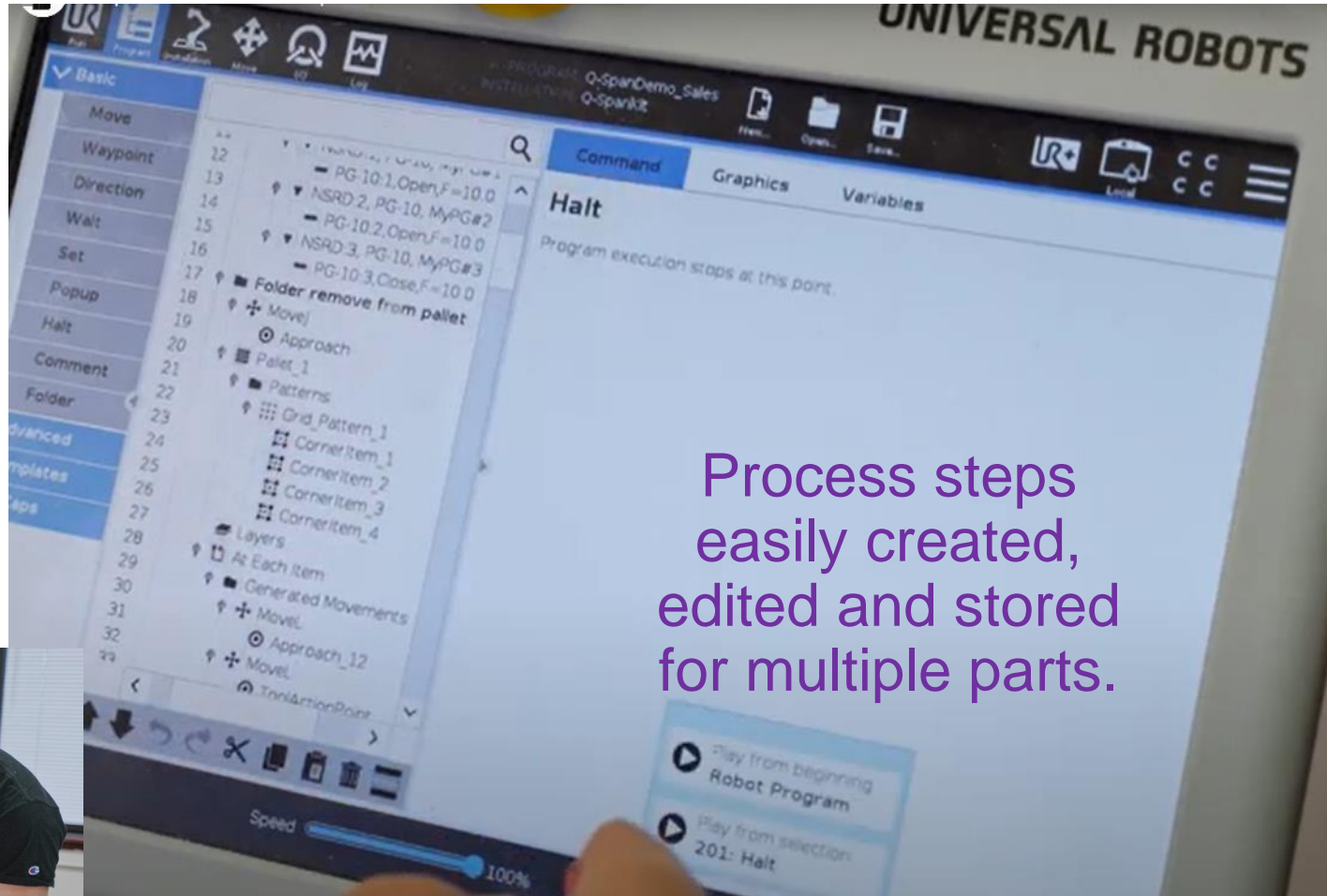


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# Teaching Cobot Inspection Steps

Teach  
Pendant  
with  
intuitive  
scripting  
application

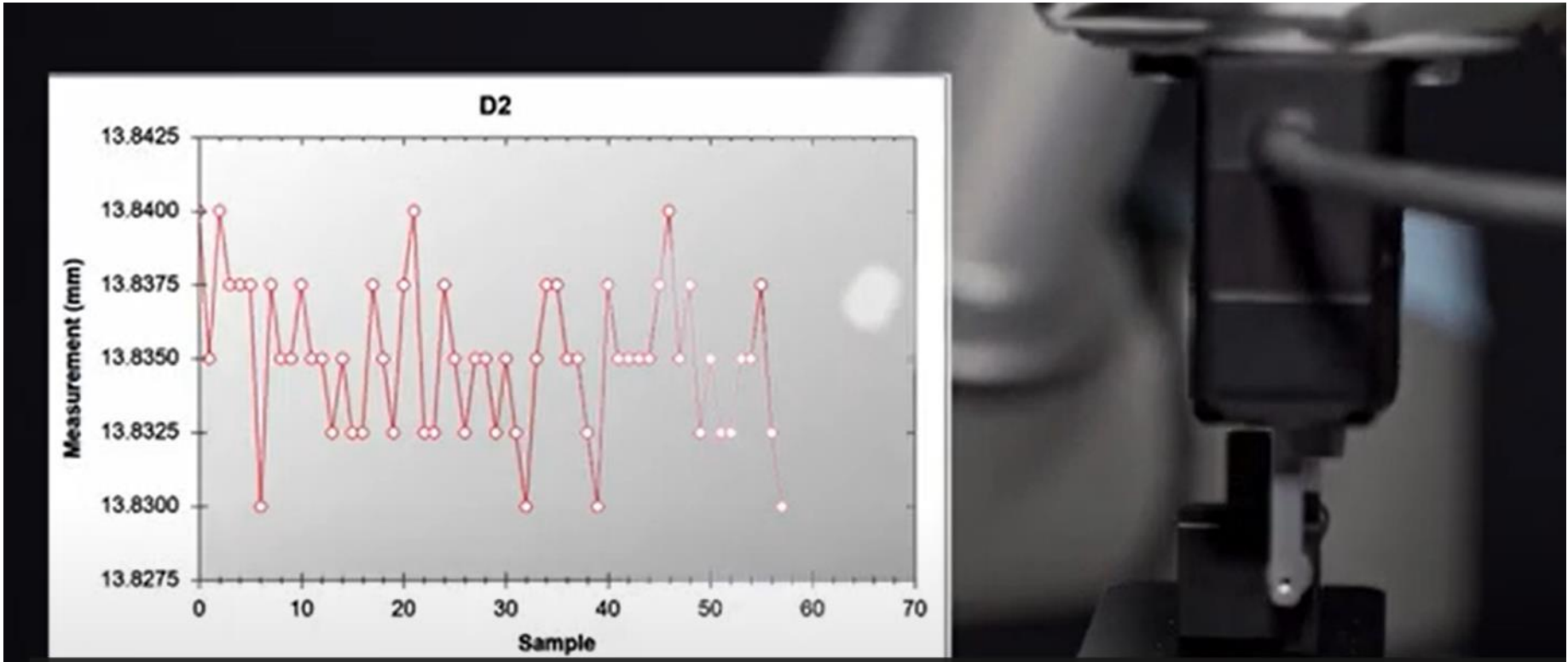


Process steps  
easily created,  
edited and stored  
for multiple parts.



# Logging Measurements to PC/QMS

Robot scripts log data with PN, SN, date, time, etc.



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# Take-aways

- New agile automation gauges are available including robotic calipers.
- Cobot-based inspection tools match the business needs of small-batch high-mix manufacturing.
- Best practice implementation uses incremental (step by step) automation
  - Faster deployment. Shorter ROI. Less capex.
  - Makes best use of people and cobots working together.





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# Questions?

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