

Intelligent, Rapid, Optimized Dimensional Inspection (IRODI)

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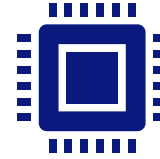
Outline

- The Need for Dimensional Inspection
- Traditional Geometrical Dimensional Inspection and the Speed Problem
- What is IRODI and How Does it Work?
- IRODI Applications
- Where do We go from Here?

The Need for Dimensional Inspection

Manufacturing touches every aspect of our lives including, but not limited to:

- Planting and harvesting of crops
- Shipping of goods and transportation of people
- Electronics
- Medical devices



Failing to perform dimensional inspection – or performing it improperly – can lead to serious consequences including, but not limited to:

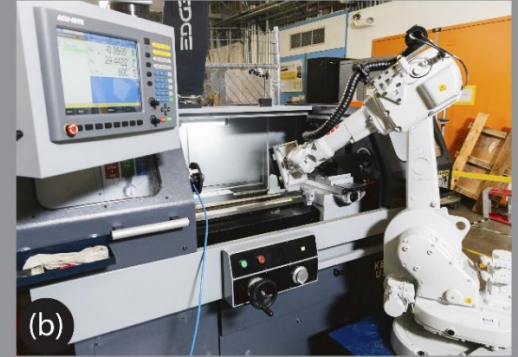
- Financial losses
 - 2024 – Acura engines with out-of-spec rods
- Diminished public trust in the product
 - Artificial implants with dimensional inaccuracies can cause the patient pain
- Potential loss of life
 - 2015 – fatal crash of Beechcraft A36 airplane



Photo credit: <http://www.kathrynsreport.com/2015/06/beeceh-a36-bonanza-36-n5626d-island.html>.

Traditional Geometrical Dimensional Inspection

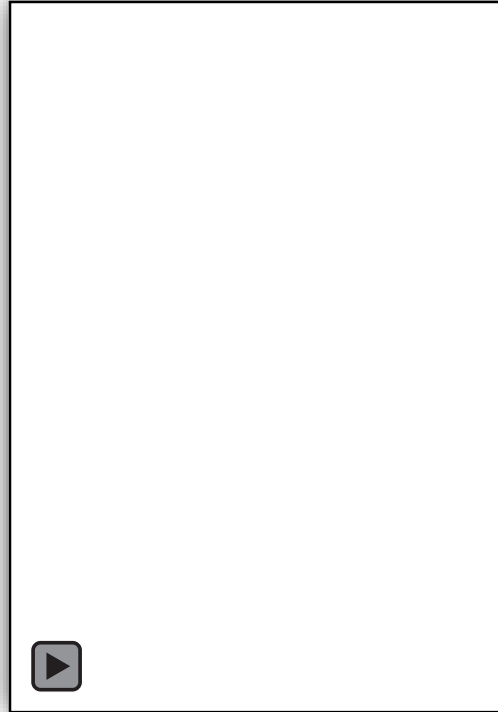
- *Quality control process that uses precision instrumentation and software to measure the size, shape, and alignment of components or assemblies to ensure they meet intended design specifications.*
- *The process ensures that parts are manufactured accurately and assembled correctly and will function as intended.*



Problem: Accelerating Component Dimensional Inspection



Accurate measurements
of a part contour are slow
and expensive



Cheap and fast
measurements produce noisy
data with large error-bars

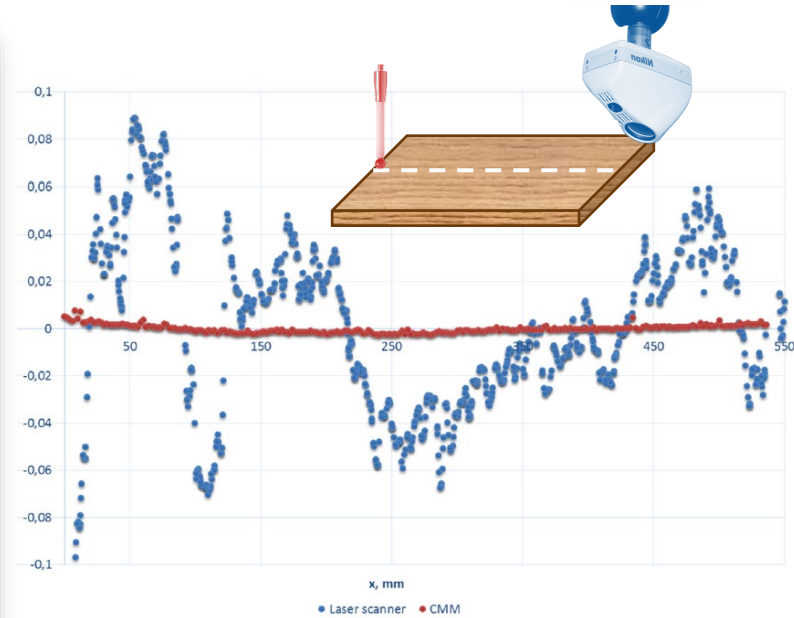
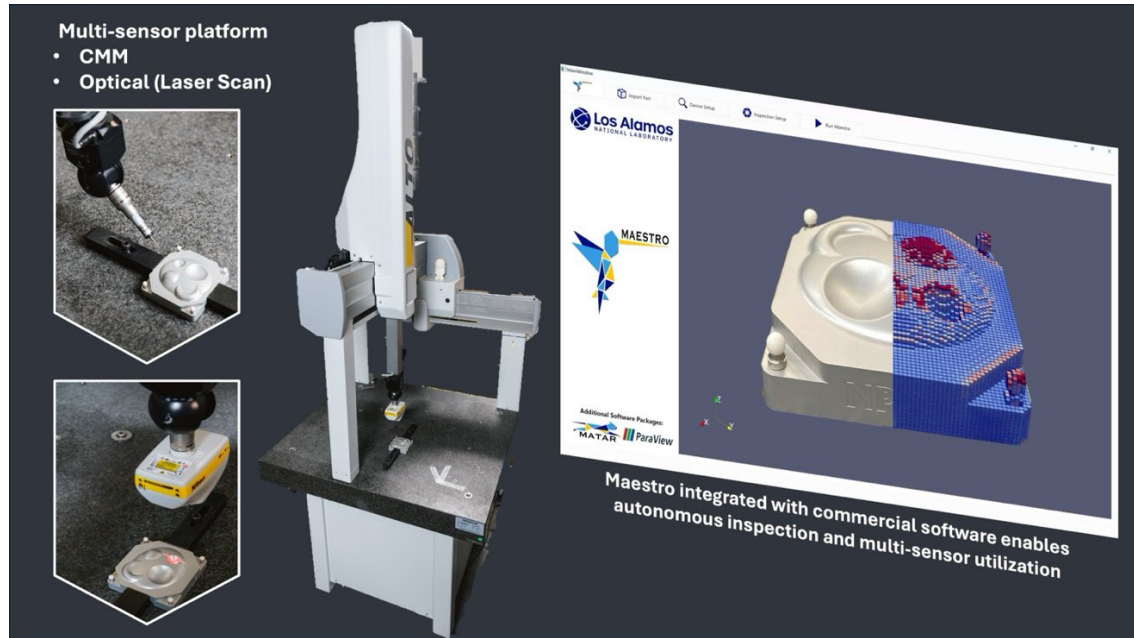


Fig. A flat surface measured with two different methods: laser scan (blue) and CMM (red)

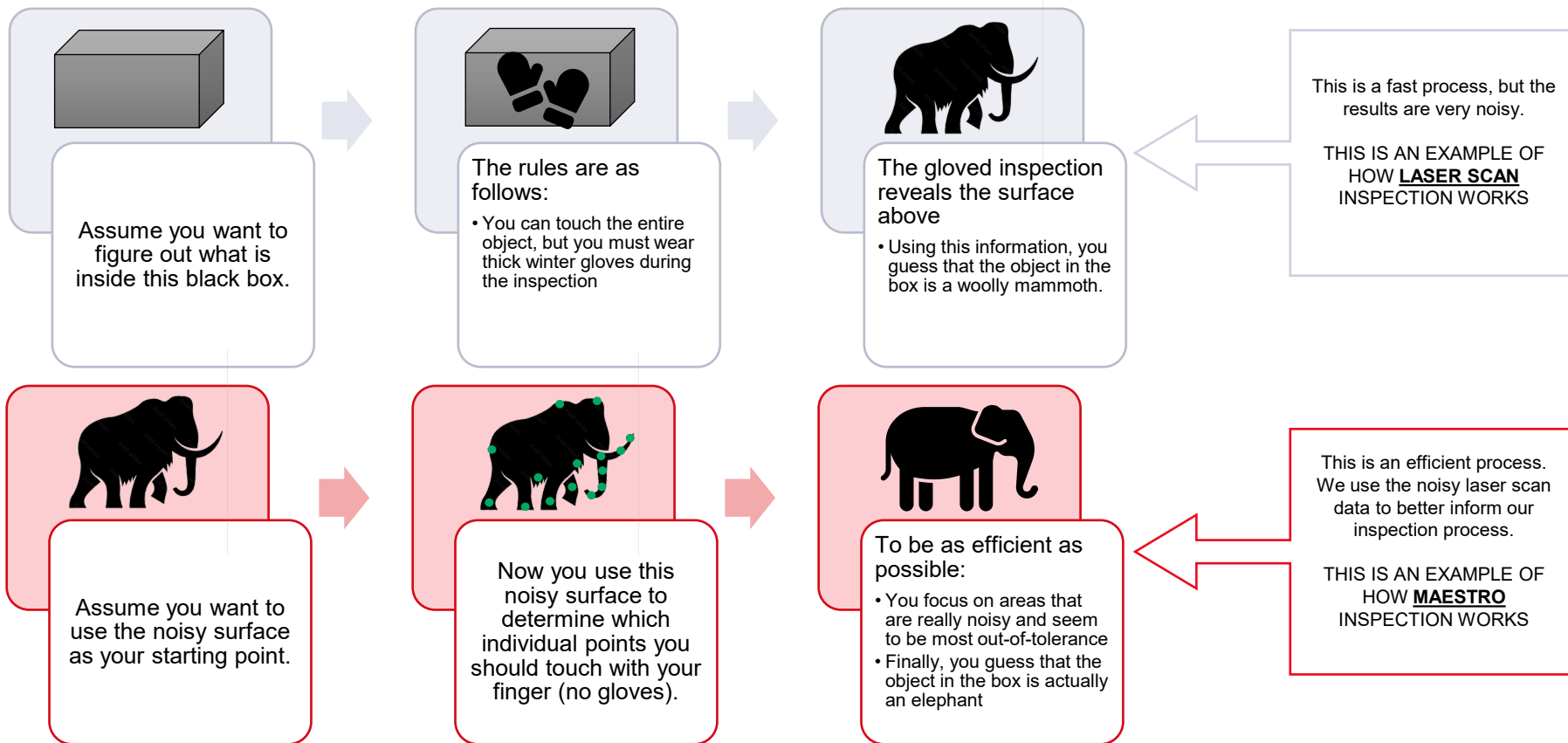
**How can we get
fast + accurate
inspection data?**

What is IRODI?

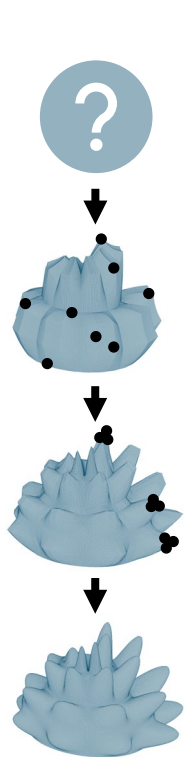
- IRODI is both a product and a system/process.
- **Maestro** is the LANL intelligent statistical inspection optimization software.
- Maestro runs on a PC and integrates with and directs commercial inspection software.
- Can be used with a combination of different kinds of commercial inspection hardware.



Maestro can exploit the noisy laser scan data



Maestro: A Smart Inspection Software



Workflow 1: CMM Only

The algorithm has *no initial guess* of the surface deviations and must build this through an early exploration of the surface

PROS:

- Fully autonomous inspection routine with no need for specialized metrology expertise

CONS:

- It could take longer to identify the most prominent defect due to initial exploration costs

Workflow 2: CMM and Laser

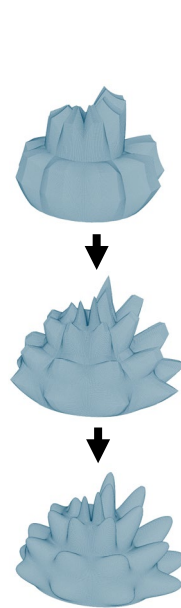
The laser data provides the algorithm with an *initial guess* of the surface deviations

PROS:

- The algorithm will start by inspecting the regions that have the largest deviations

CONS:

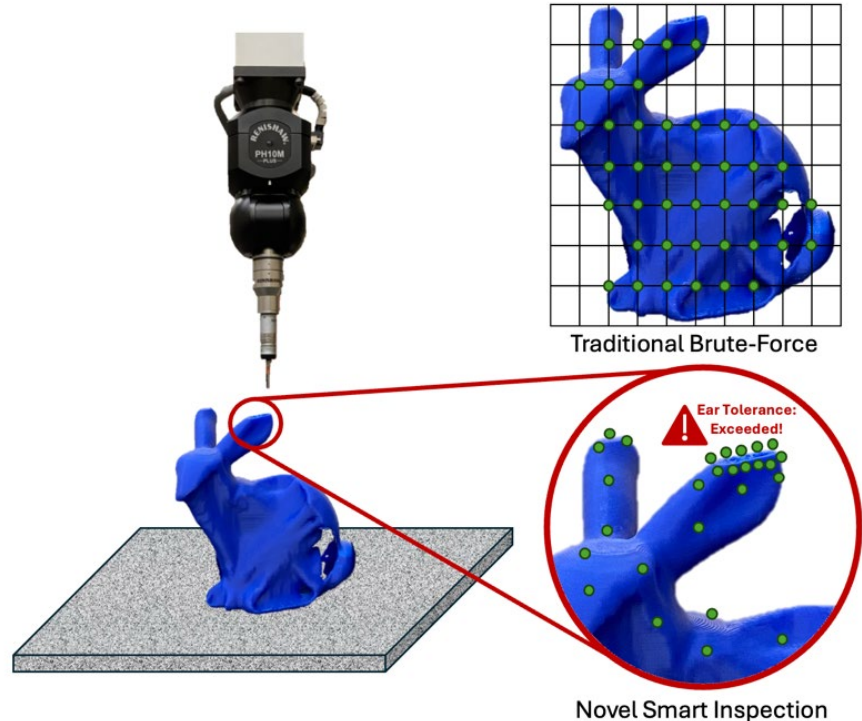
- Obtaining the laser data adds more time and could be difficult to acquire with shiny surfaces



**Maestro only requires a CMM
but supports laser data.**

IRODI Can Find Flaws that a CMM Might Miss

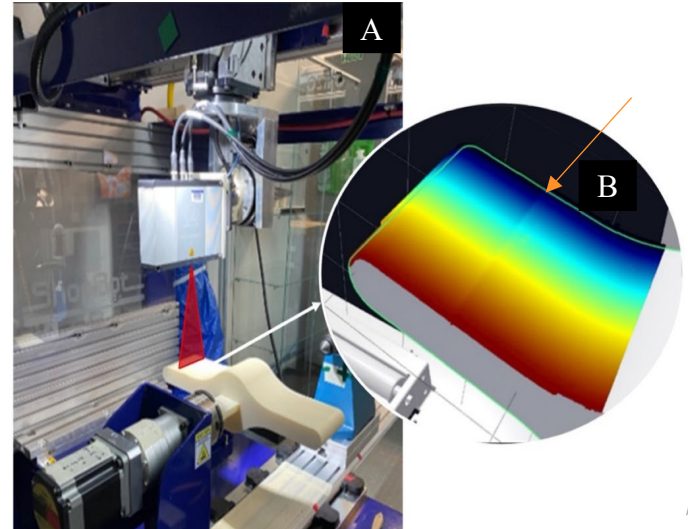
- CMM by itself might use a traditional fixed or operator defined grid that may bypass a flaw (rabbit's tip of left ear is missing).
- Maestro commands the CMM to inspect locations in greater detail where geometry has large gradients and is more likely to find flaws.



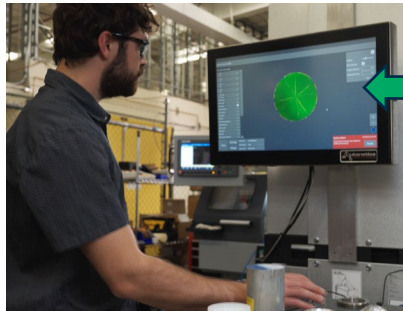
How Does IRODI Work?

In-Process Inspection

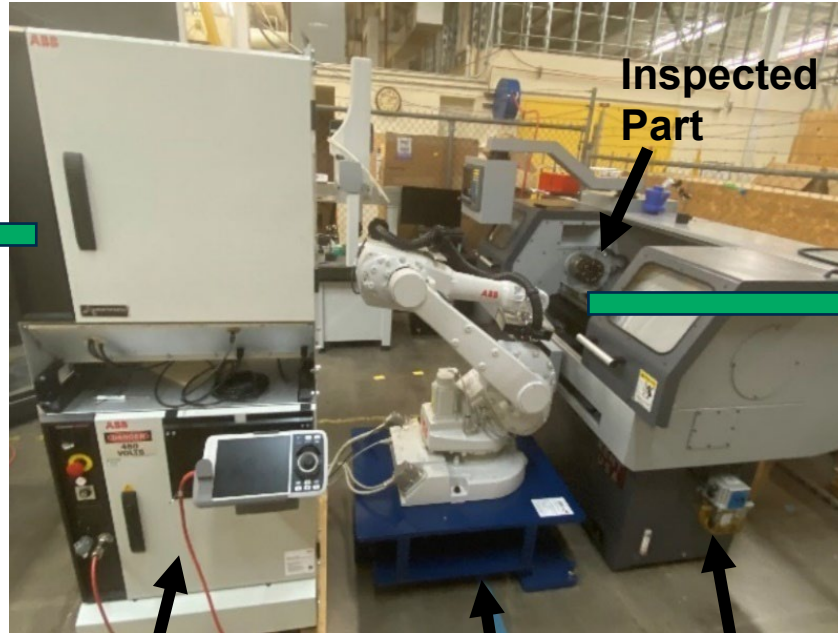
- Use optical point cloud data stream to inform high accuracy CMM inspection.
- Can be used on both subtractive and additive manufacturing.
- Provide dimensional data that can identify machining errors from tool wear, improper programming, machine degradation, early on and support feedback control.
- Currently in development:
 - Inclusion of tactile touch probe inspection tool
 - Real-time step-wise CAD model tracking from G-code data



In-Process Dimensional Inspection – Current Testbed



Operator Interface
Defect Detection

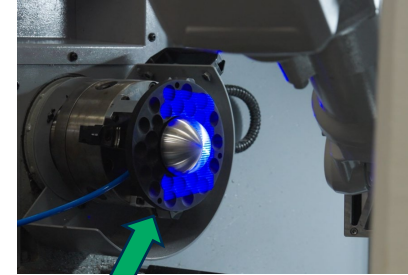


Control System

Robot with
Micro-Epsilon
Optical Scanner

Lathe

Inspected
Part



Optical Scanning of
Machined Part

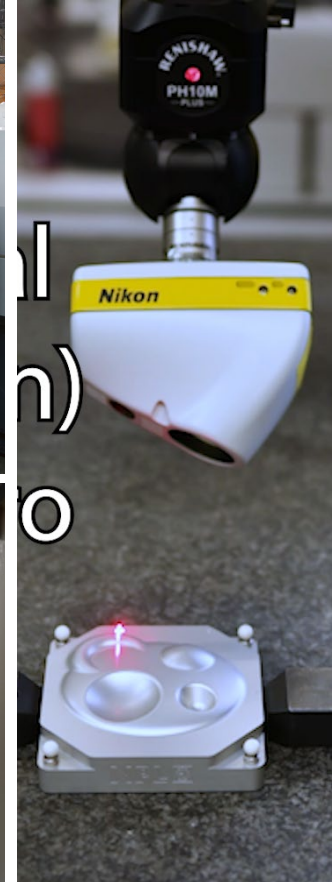
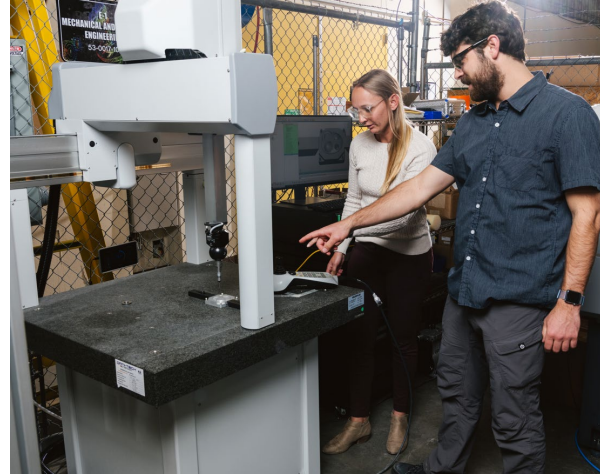
In-Process Dimensional Inspection - Example

- (a) At some point during the machining process stop for an inspection.
- (b) Bring in an inspection system to quickly analyze the part.
- (c) Analyze the inspection data to determine if the machining process is on track.
 - Does the inspection data match the geometry created from the G-Code?

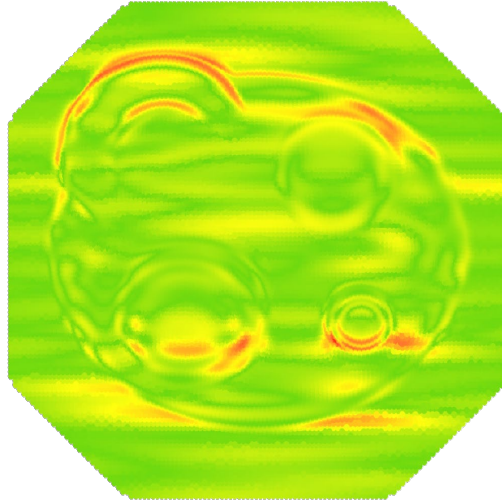


How Does IRODI Work? Post-Process Inspection

- Utilize a combination of inspection devices with Maestro software to rapidly and accurately inspect the geometry of a part to ensure compliance with dimensioning and tolerancing requirements.
- Autonomous probing by a CMM to reduce programming time and likelihood of missing manufacturing flaws.
- Merge touch probe and optical scanning to speed up inspection process.



Post-Process Dimensional Inspection - Example



Advantages that IRODI Brings

Technology

- Patent pending **autonomous** dimensional inspection.
- **No** path planning, programming, or debugging.
- **Rapid identification** of potential disqualifying defects.
- Demonstrated ability to **reduce inspection time by 9x**.
- **Statistically grounded** confidence level, removing the need for judgement calls by SMEs.
- Parts can be inspected **on machine** and appropriately modified before completion

Value Proposition

- Increase efficiency and **reduce costs** by catching defects early and reducing inspection times.
- **Seamless integration** with existing metrology systems. No costly hardware upgrades.
- **Pairs** with commercial inspection software to maintain familiar and trusted interface.

Innovation without interruption.

IRODI Innovations for Dimensional Inspection – Current Capabilities

Post-process Inspection

- Improved surface inspection coverage and defect detection with optical that CMM missed.
- Reduced inspection time.
- Improved dimensional inspection accuracy over purely optical methods.
- Statistically meaningful quantification of the inspected as-built geometry versus the intended mechanical design geometry.

In-process Inspection

- Robotic optical inspection integrated with a CNC lathe.
- Early component defect detection and correction during manufacturing, leading to improved production yield, reduced scrap, and reduced manufacturing time and costs.

How to Get Involved

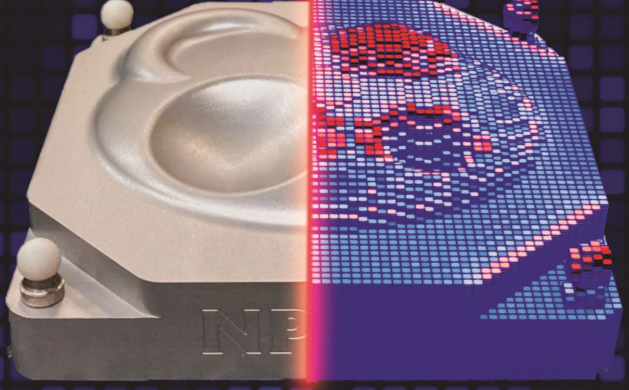
We are looking for collaborators:

- Process and software development
 - Volume certification
 - Cloning assembly procedures
 - Drag probe inspections
- Metrology assessments
 - Post process assessments
 - On-machine assessments
- QA vetting
 - Comparisons to qualified inspections
 - Known defect testing

2025 R&D 100 ENTRY

IRODI

INTELLIGENT, RAPID, AND OPTIMIZED DIMENSIONAL INSPECTION



Revolutionizing manufacturing efficiency and accuracy with in-process and post-process inspection methods

COMBINES advanced metrology hardware with intelligent inspection algorithms

INSPECTS complex surface geometries rapidly and autonomously

MERGES the best data from multiple inspection sensors

MINIMIZES time and material waste during manufacturing

 **Los Alamos**
NATIONAL LABORATORY

IRODI

INTELLIGENT, RAPID, AND OPTIMIZED DIMENSIONAL INSPECTION

