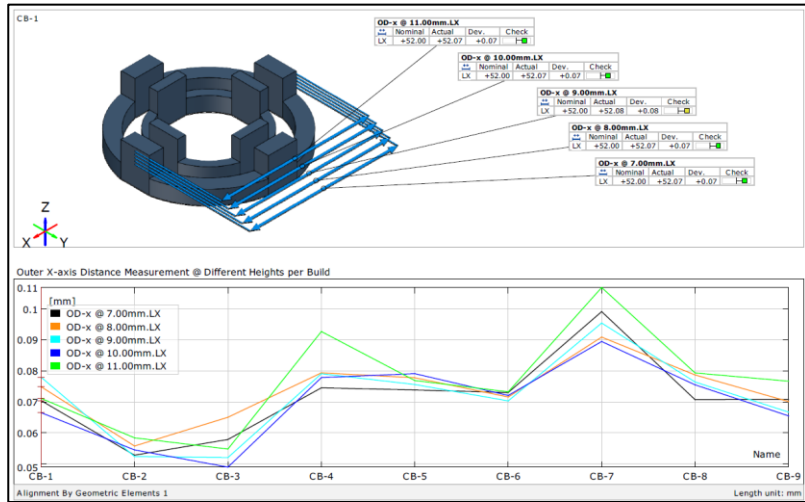


Structured Light Scanning and Capabilities

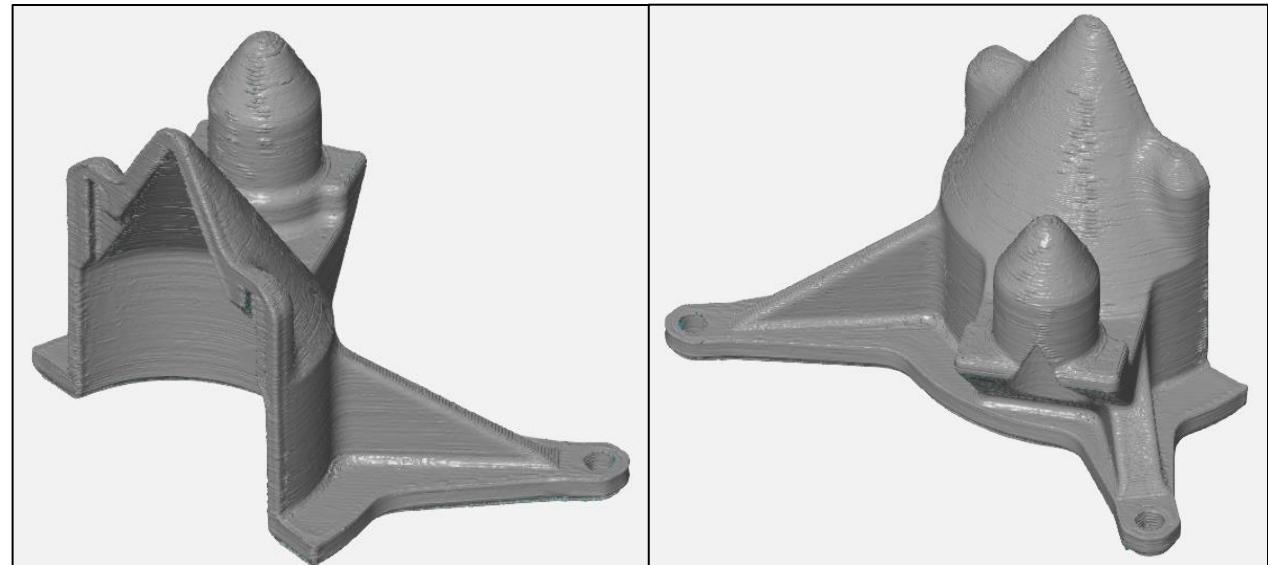
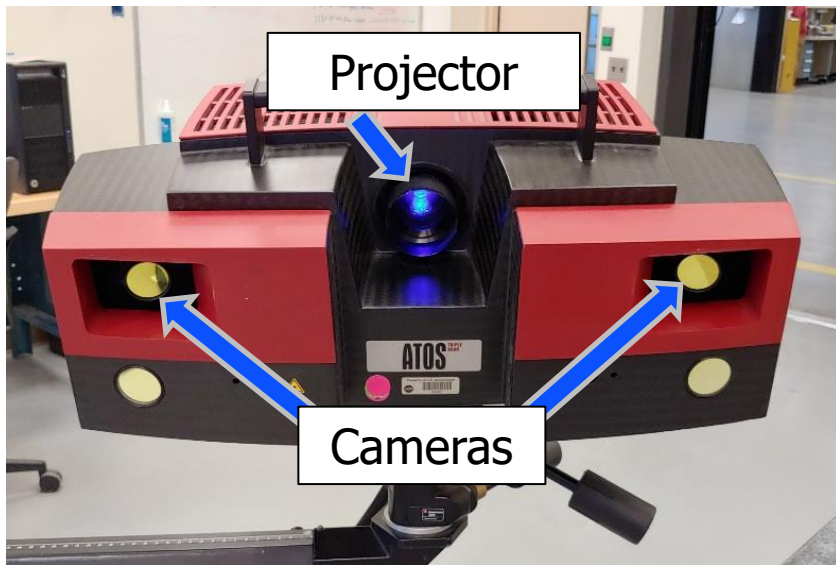


John Ivester
EM42, MSFC, NASA



Structured Light Overview

- Is a non-contact optical technique used to quickly and accurately capture as built 3D surface geometries
- Capture unit has a projector centered between stereoscopic cameras

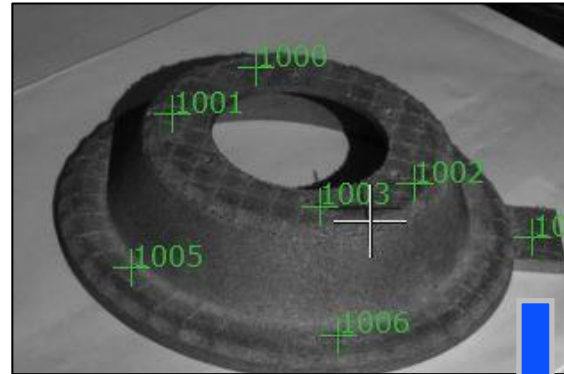
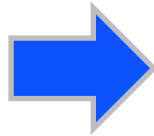


Structured light scan of additive manufactured plastic part

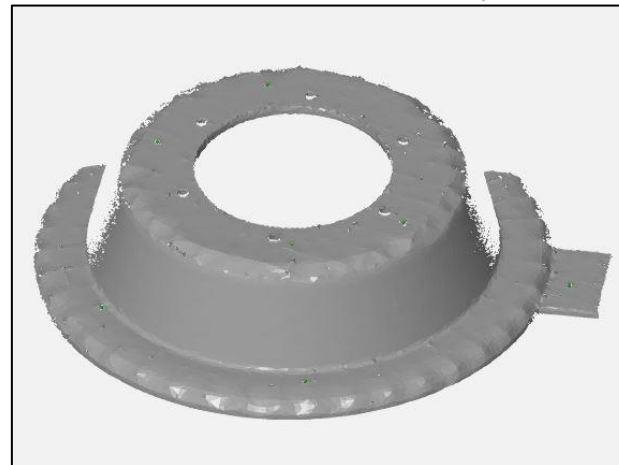
- Projector produces fringe pattern



ATOS structured light scanning unit projecting fringe pattern on to part

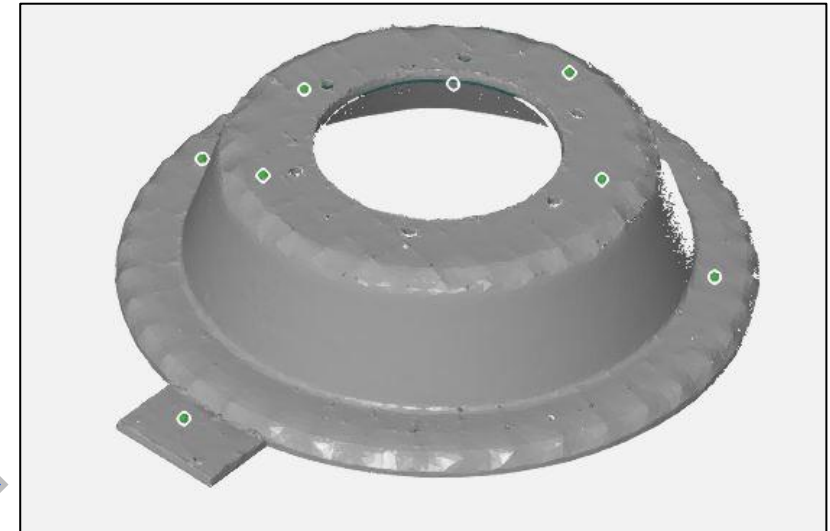
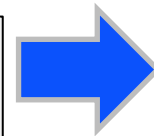


Camera View



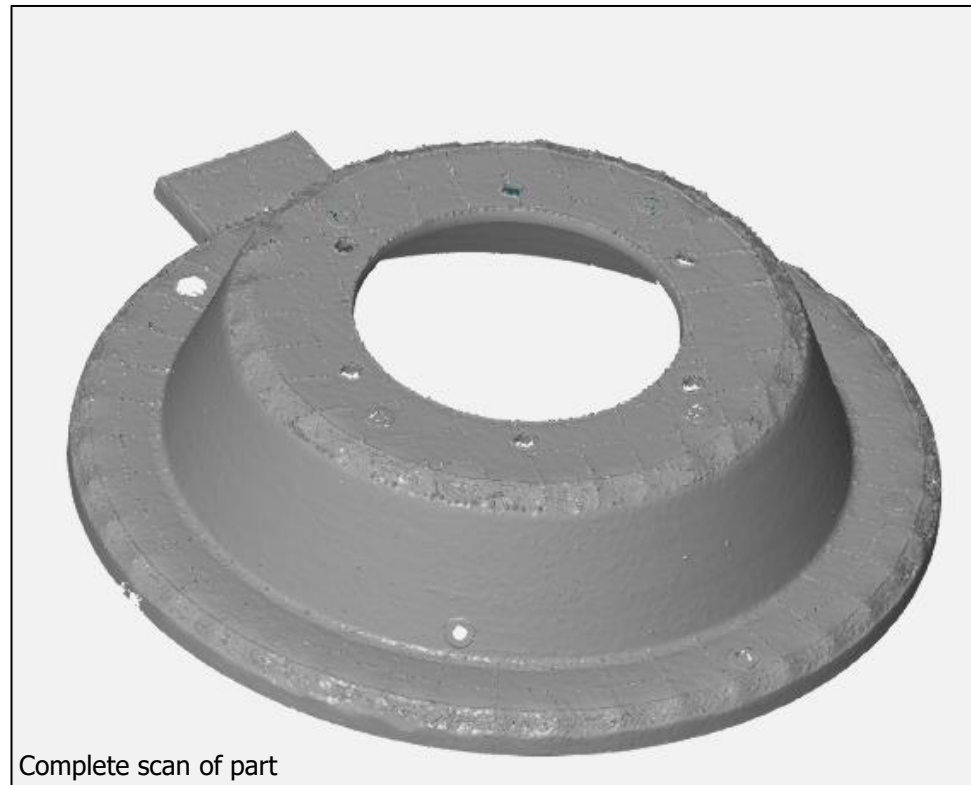
Single Scan data capture of 3D printed part from scanner perspective

*Note: Millions of points per scan



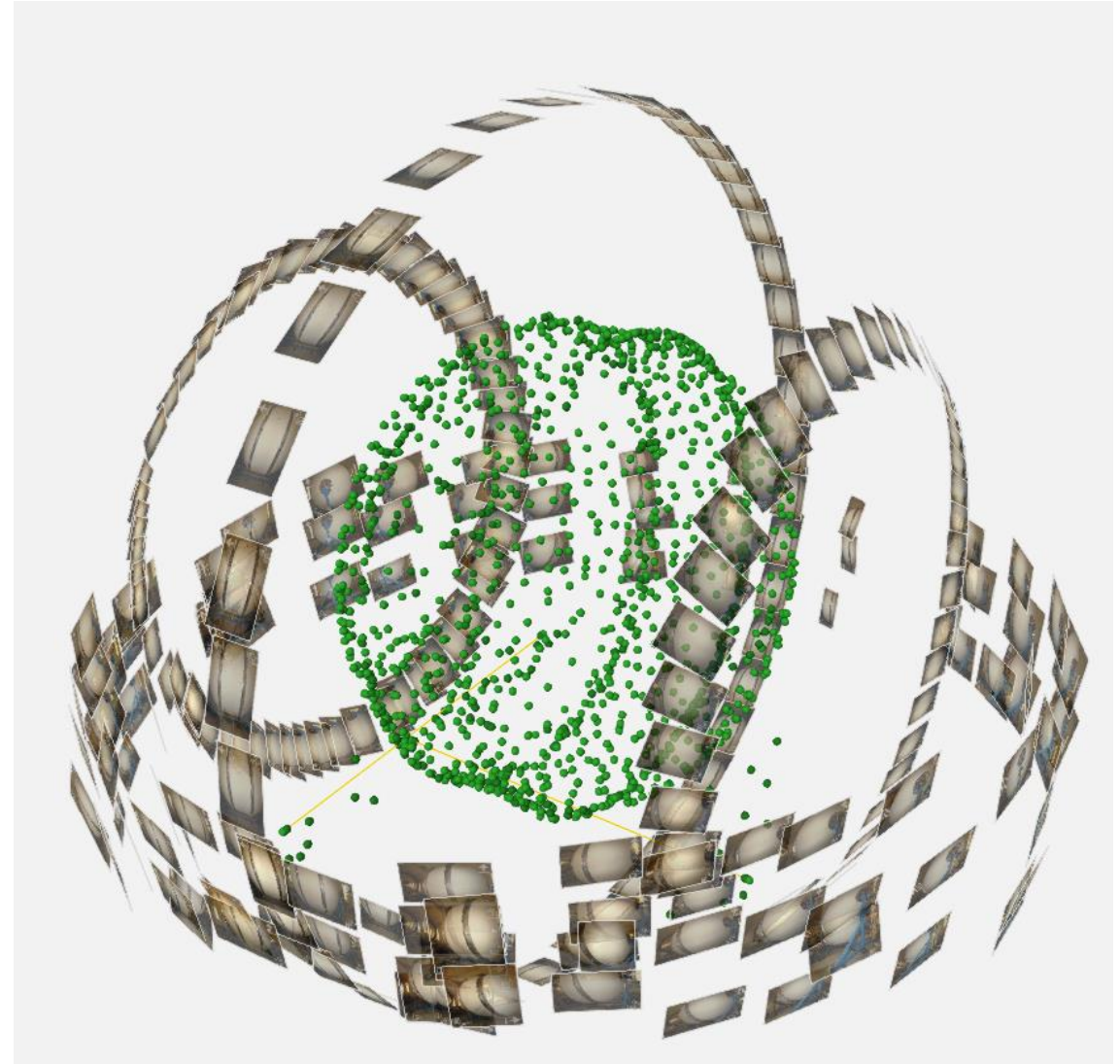
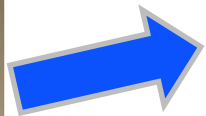
Second Scan data capture of 3D printed part from scanner perspective

- Fully captured additive manufactured part
 - Multiple perspectives are captured to provide an accurate 3D representation of the parts current condition.

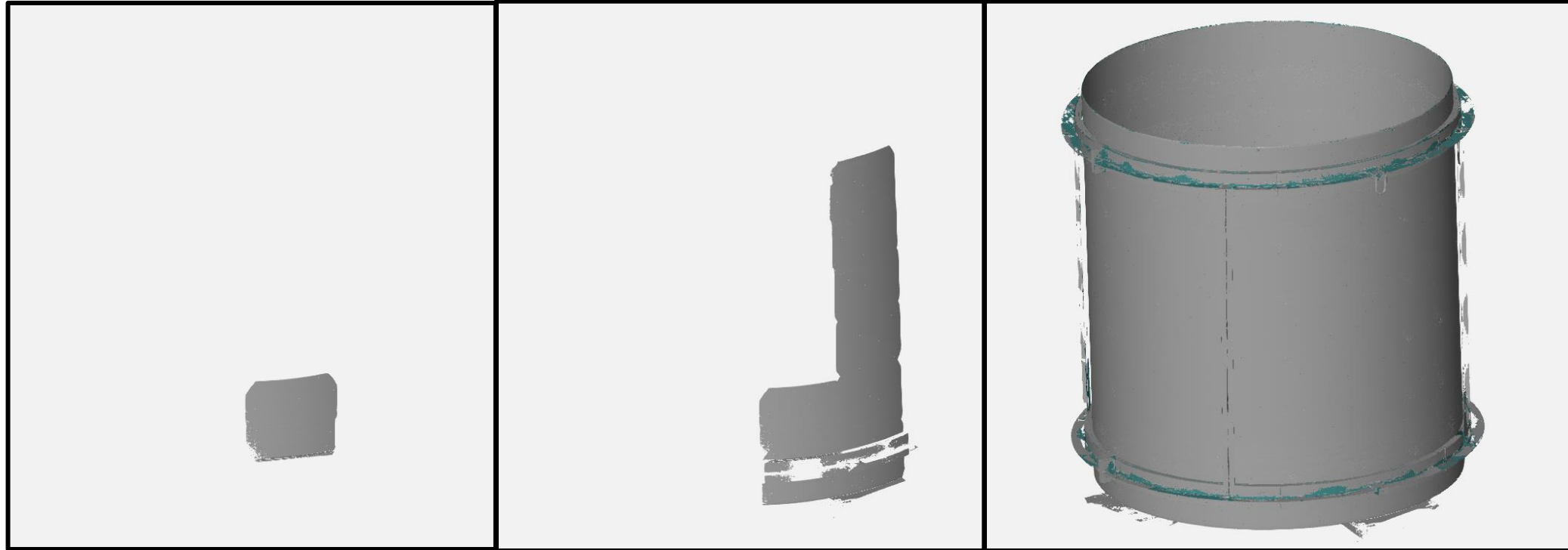


Complete scan of part

- Used to capture the 3D locations of reference targets, shown in green.
 - Typically used for larger hardware data capture



- Individual scan data captures can be stitched together using the 3D location of the reference targets

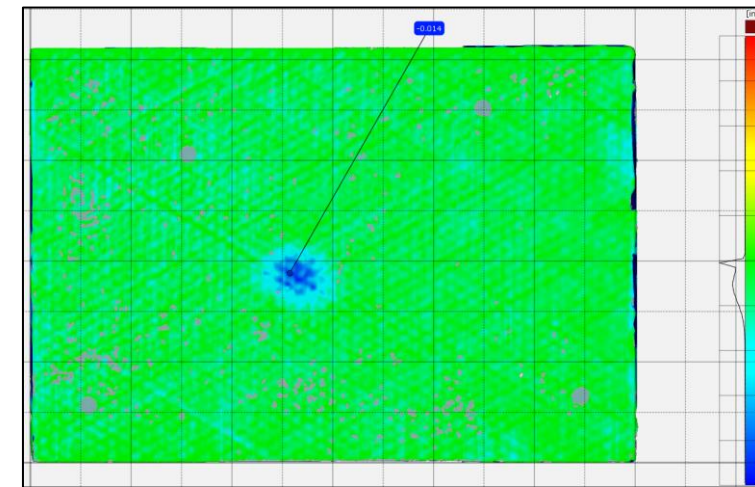


Single scan data capture

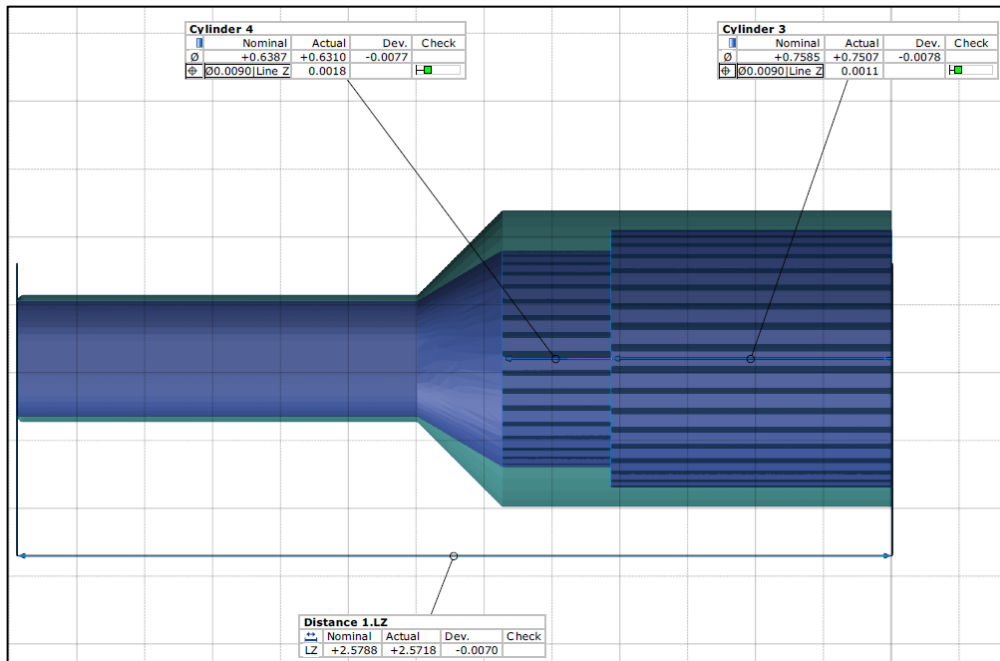
Multiple scan data captures

Completed capture – approximate size ~ 8ft Ø x 8ft Length

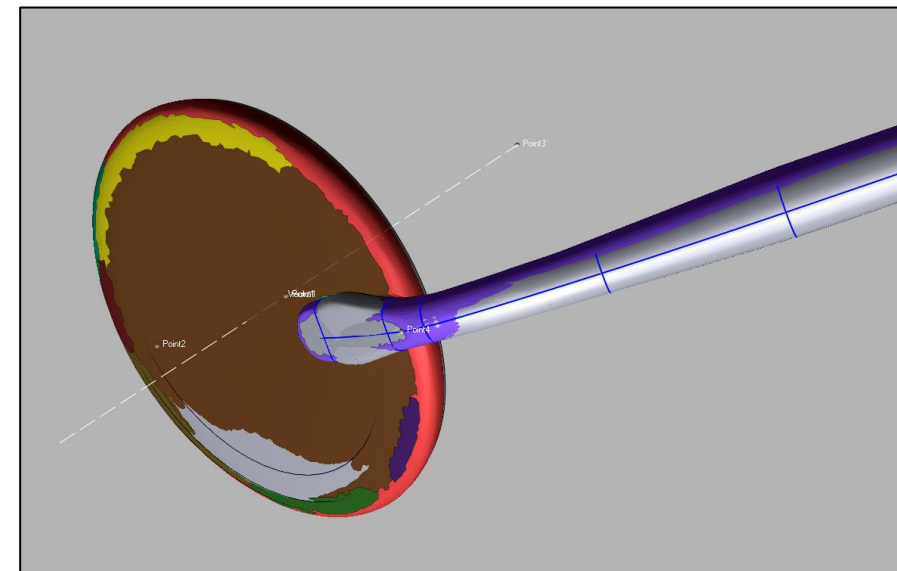
- Inspection/Quality Acceptance
- Reverse Engineering
- Digital Assembly
- Manufacturing/Process Development



Surface Defect Depth Mapping

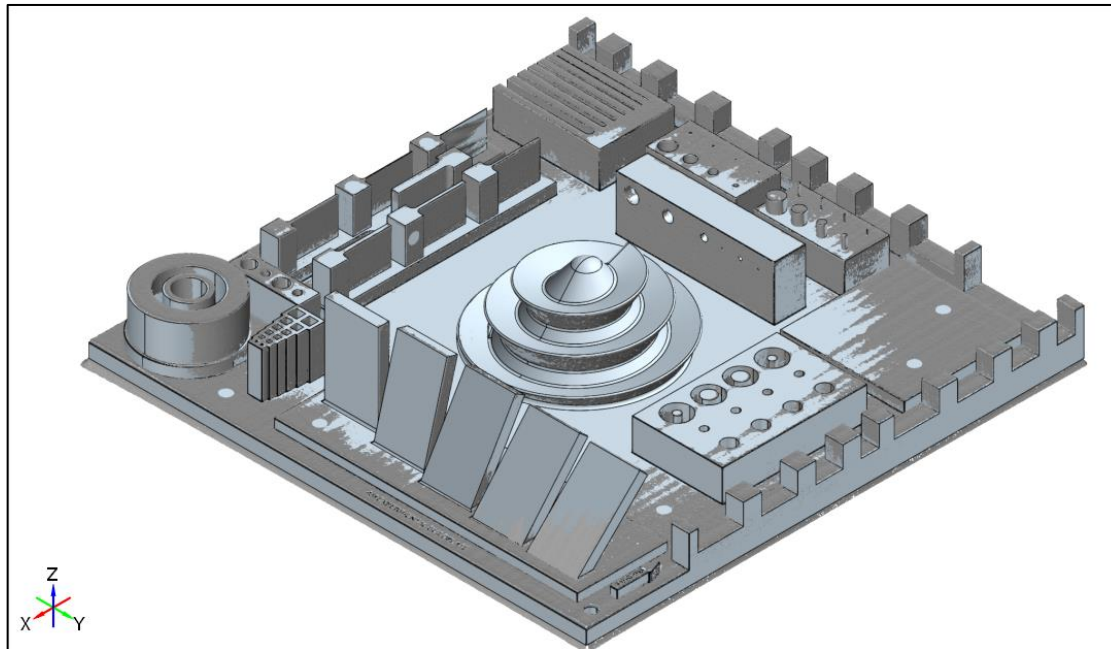


Part Inspection

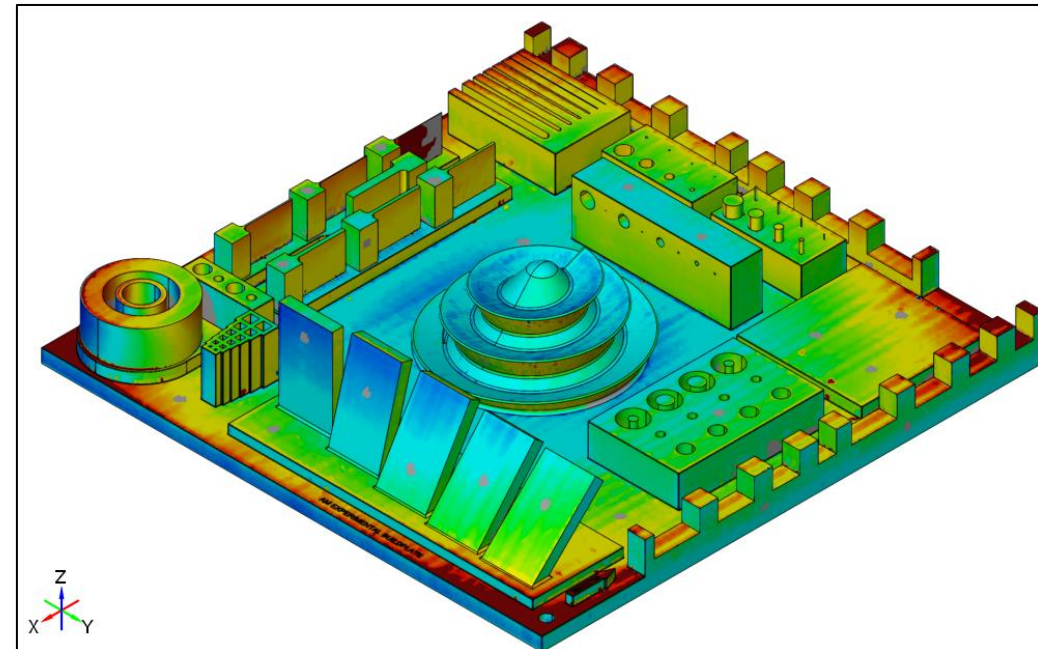


Reverse Engineered Part

- **Surface Comparison**
 - Shows deviations of scan data from nominal data via color plot



Scan Data/CAD Model Overlay

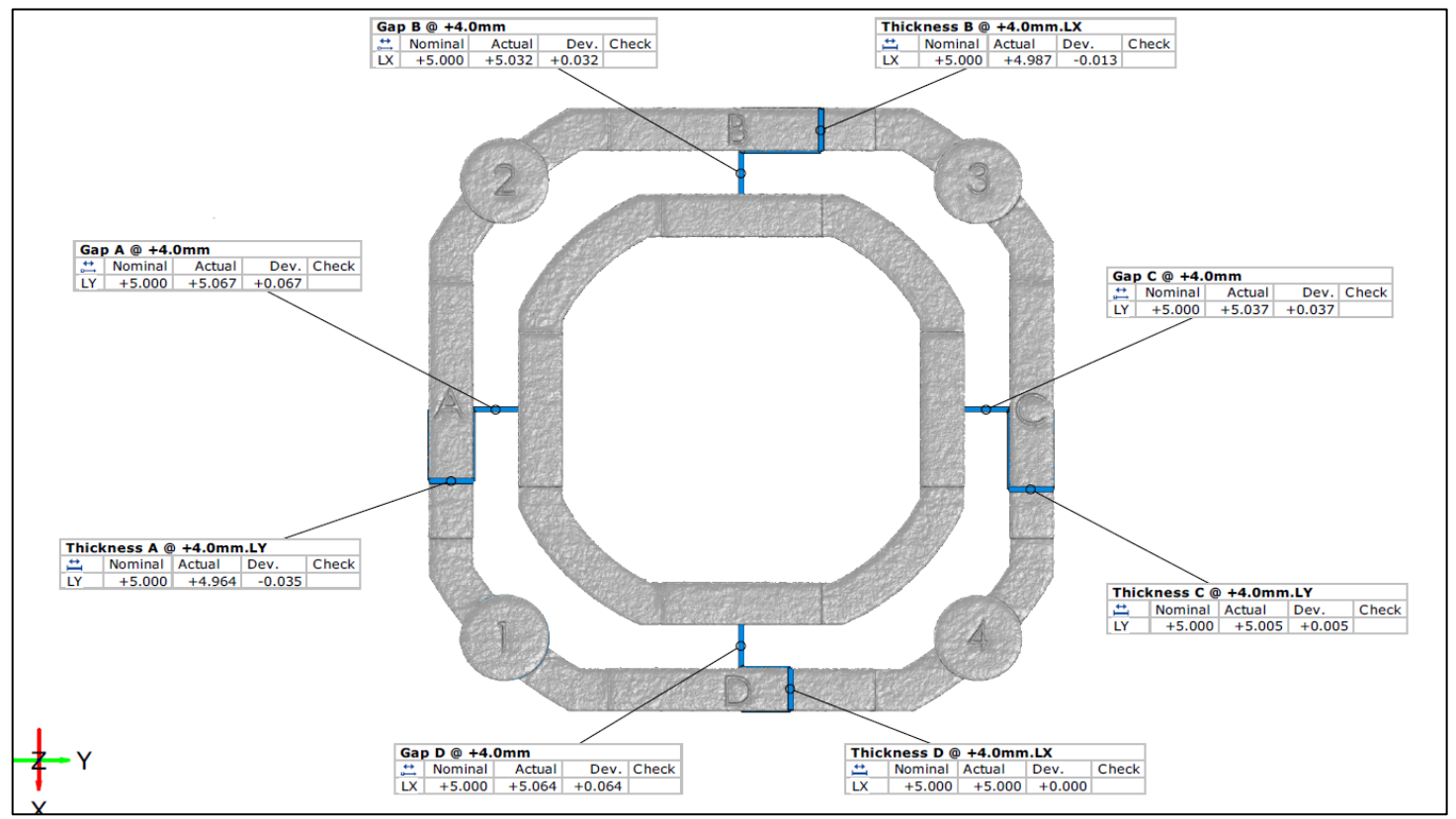


3D Deviation Color Plot

- Basic Dimensional Measurements

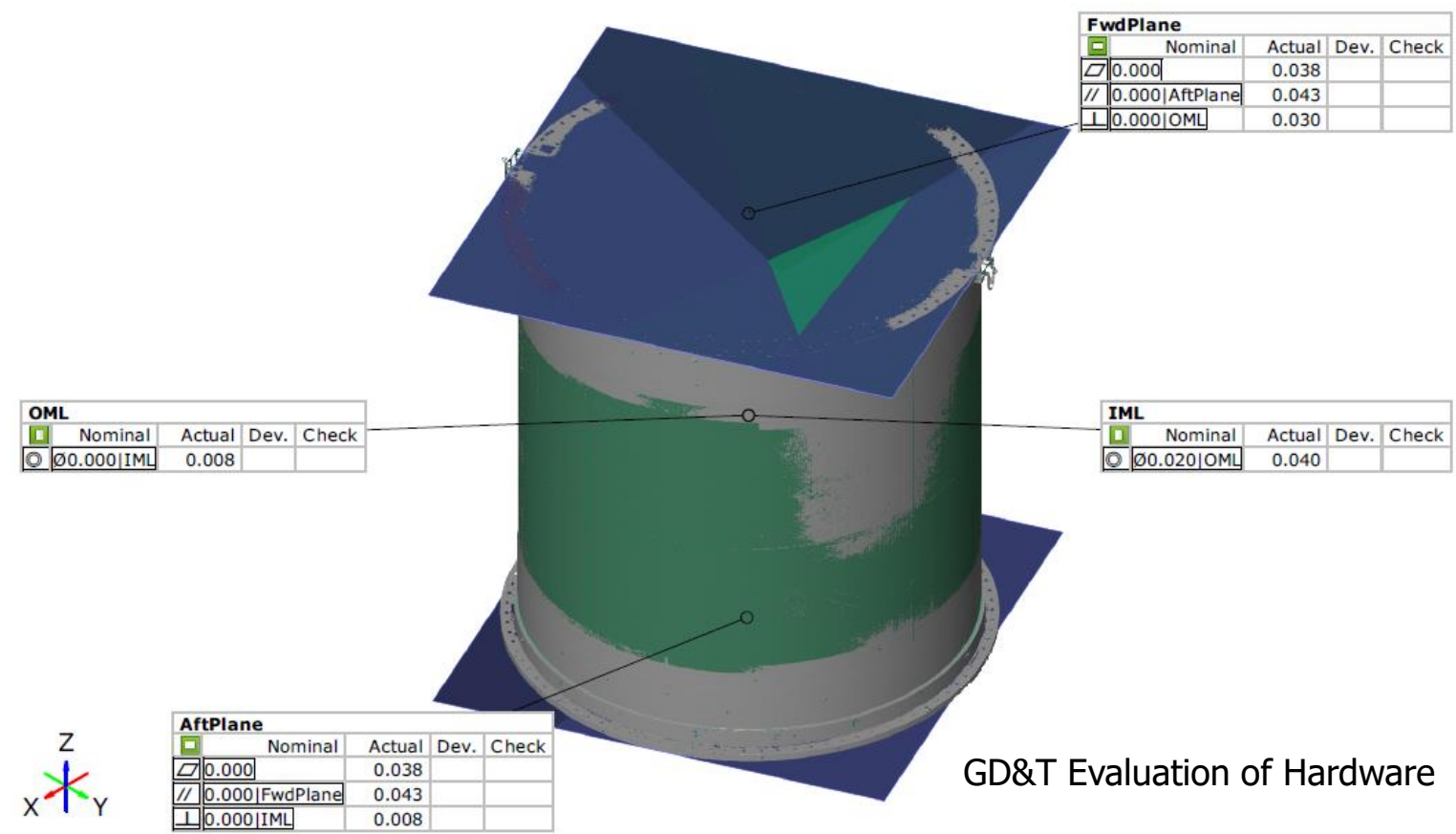
- Measures

- Distance
- Radius, Diameter
- Angle

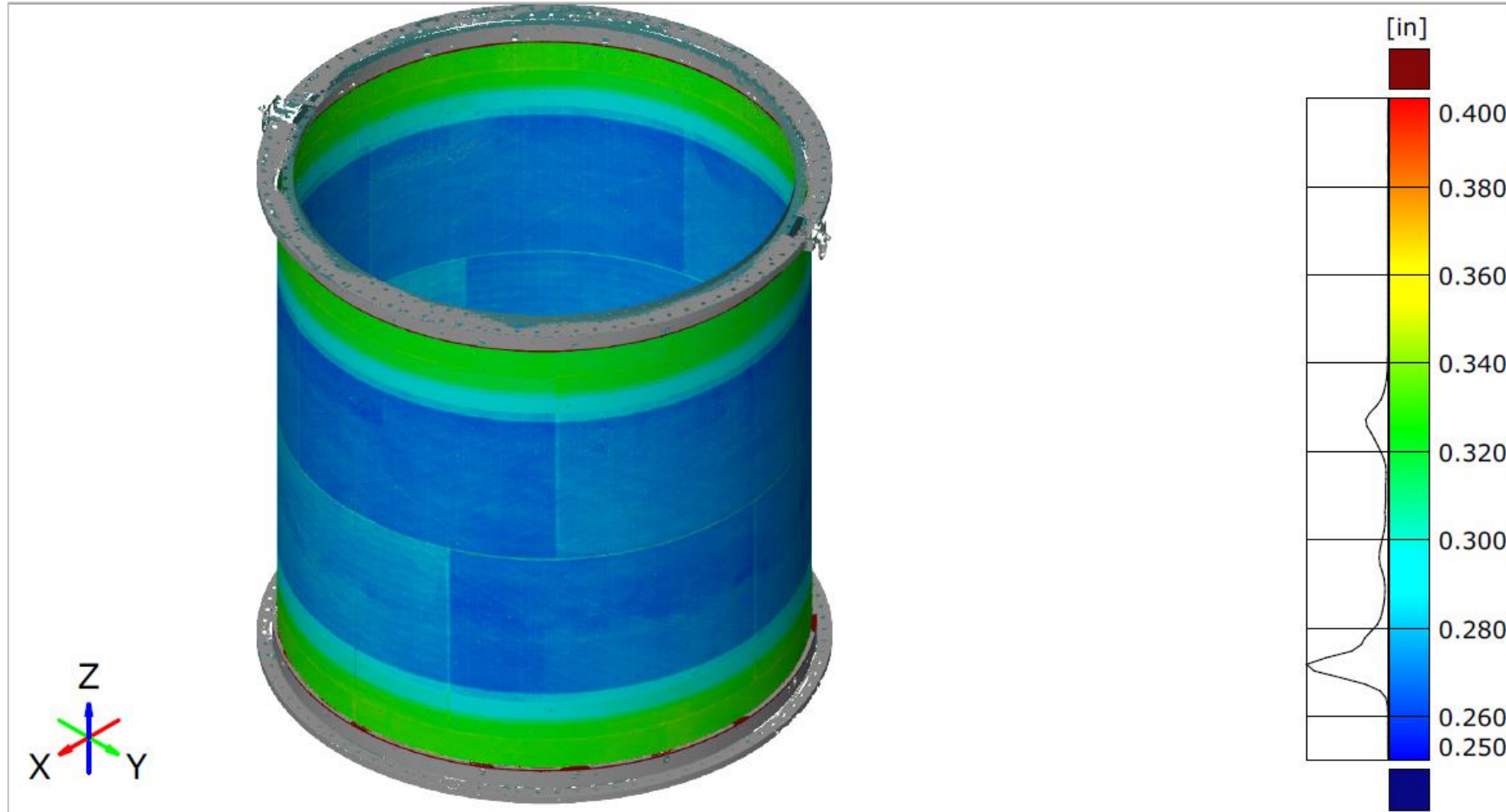


Dimensional Measurements

- Evaluation of Geometric Dimensioning and Tolerancing(GD&T)
 - Provides interrogation of GD&T callouts



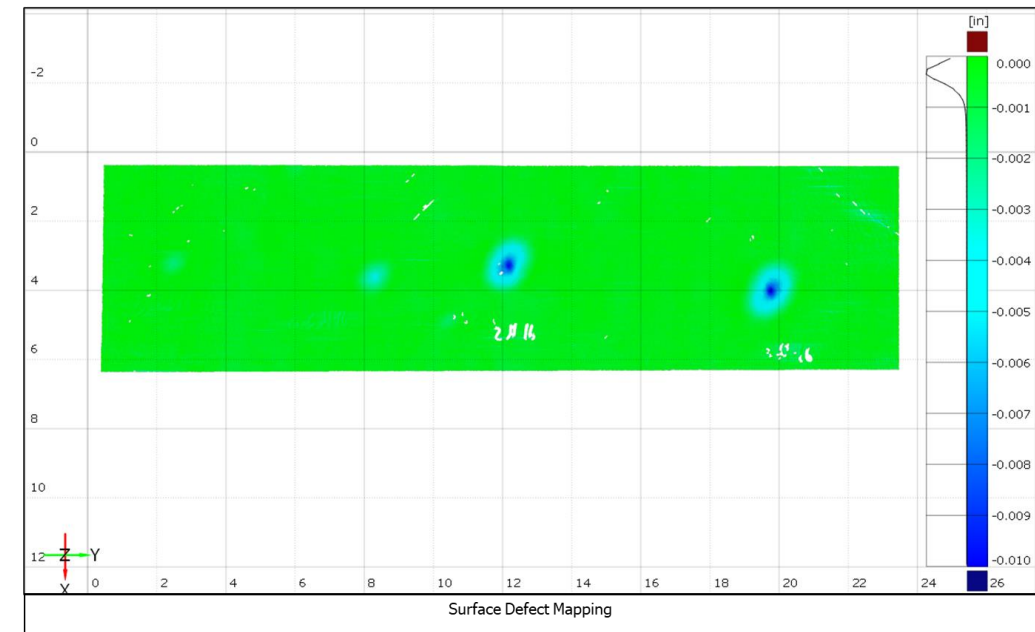
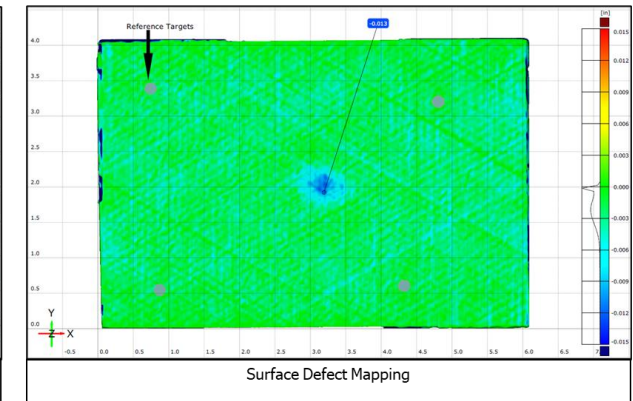
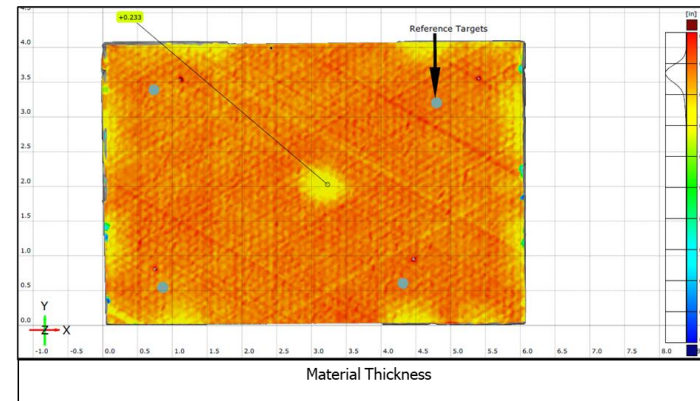
- Measuring material thickness from scan data



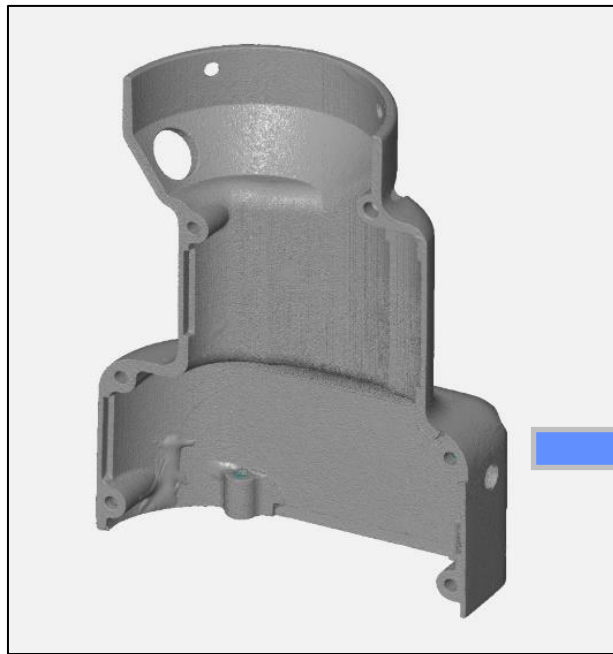
Material thickness color plot of composite barrel

- Using structured light scanning for test data processing
- Example Use Cases:
 - Material Testing
 - Ablative Testing
 - Engine/Component Testing
 - Process V&V
 - Pressure Testing
 - Failure Investigations

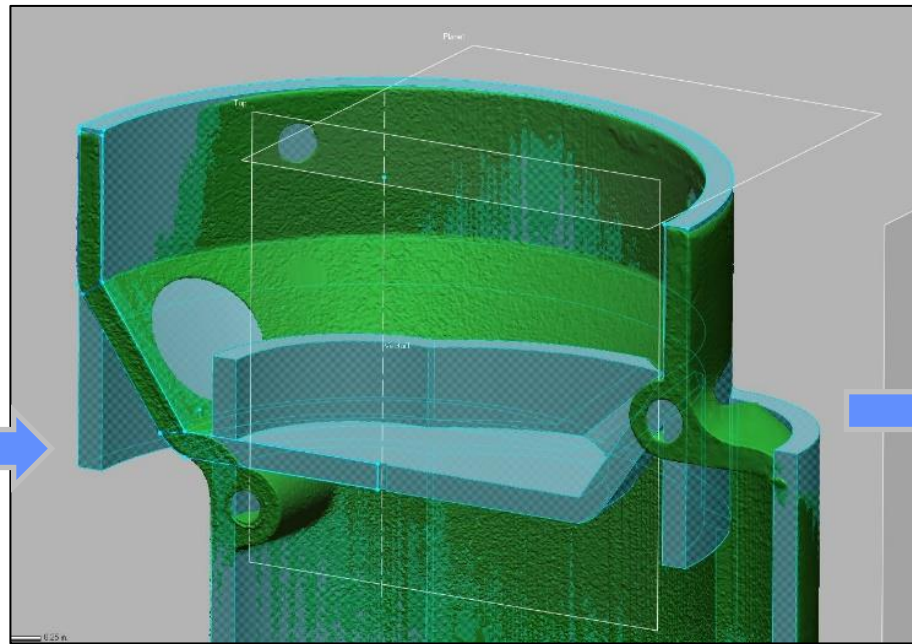
Impact Sample Inspections



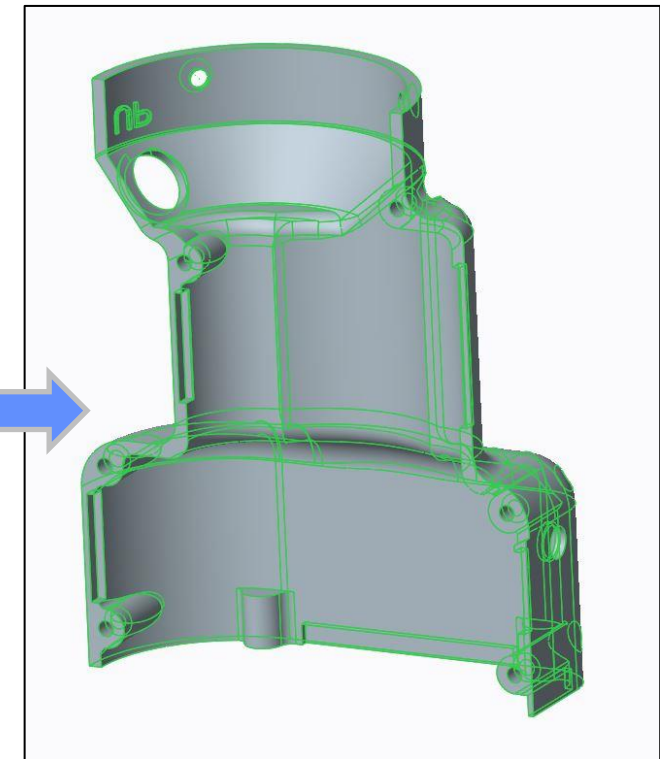
- Fitting of CAD features to different regions of the scan data



Scan Data

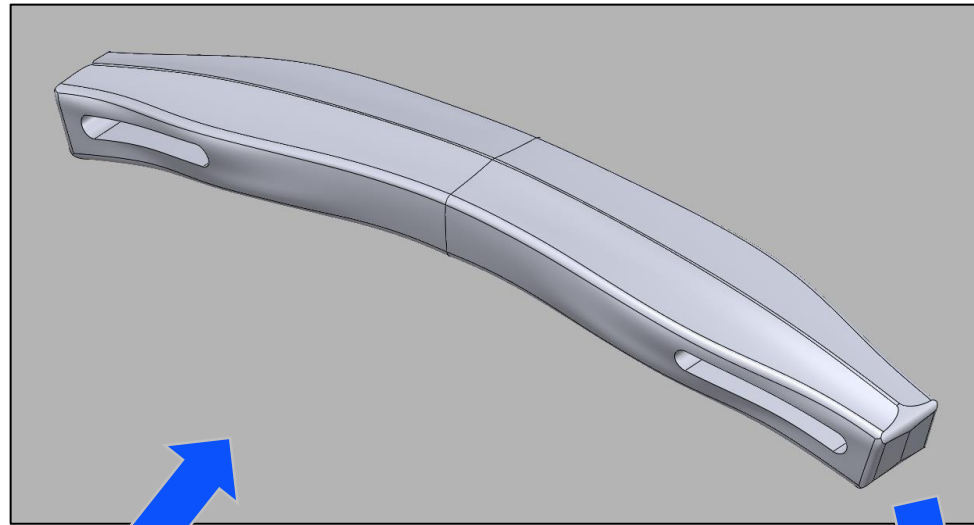


In process

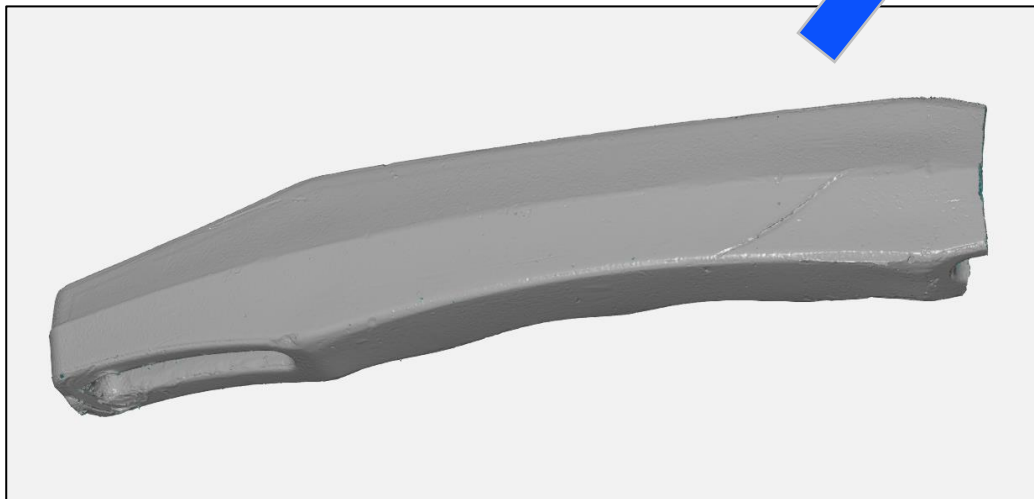


End Product - CAD

- Scan, model and replace broken hardware



Modeled Part from Scan Data

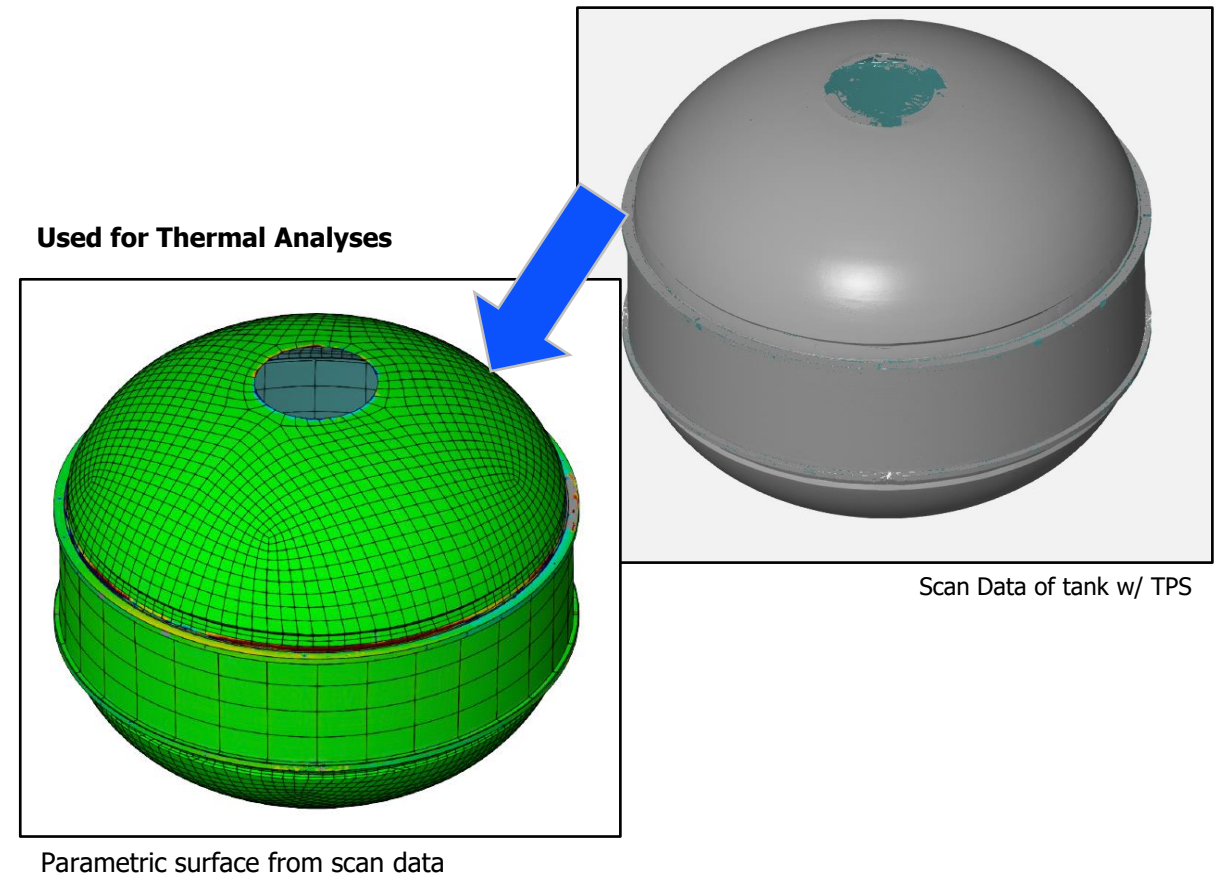
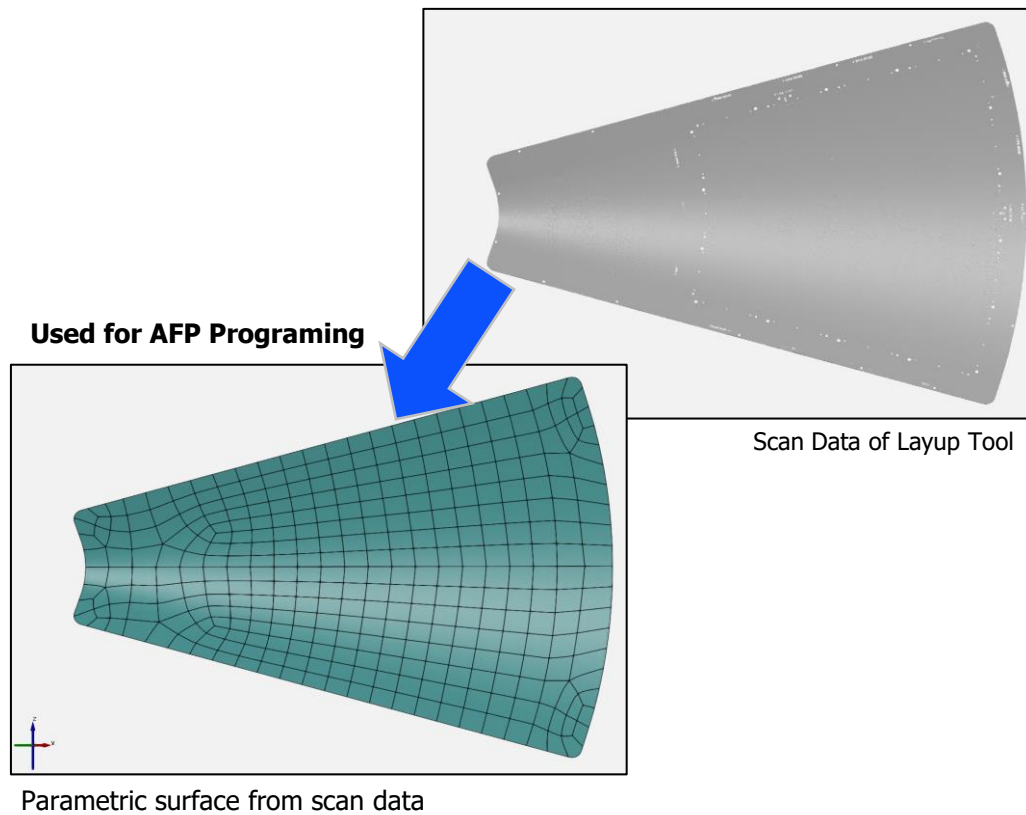


Scan Data of Broken Part

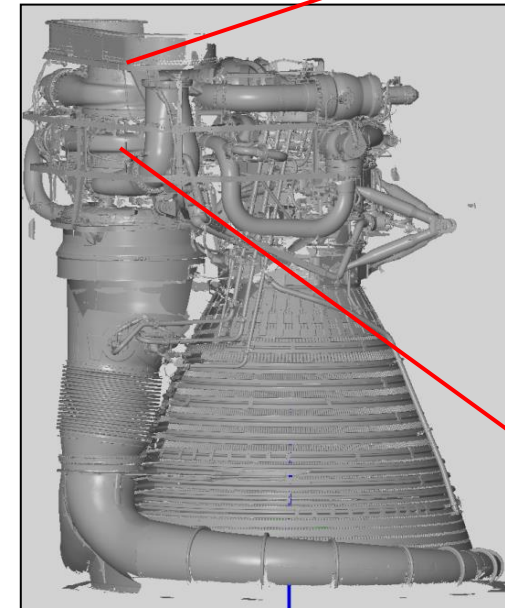
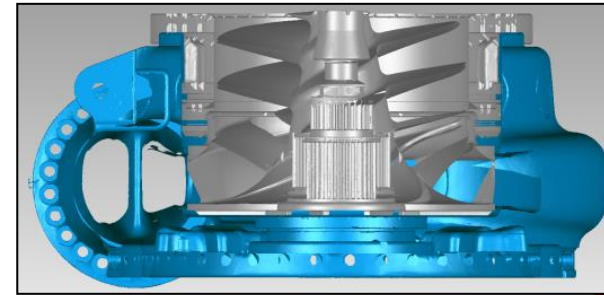
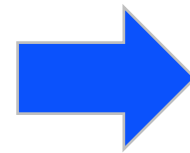
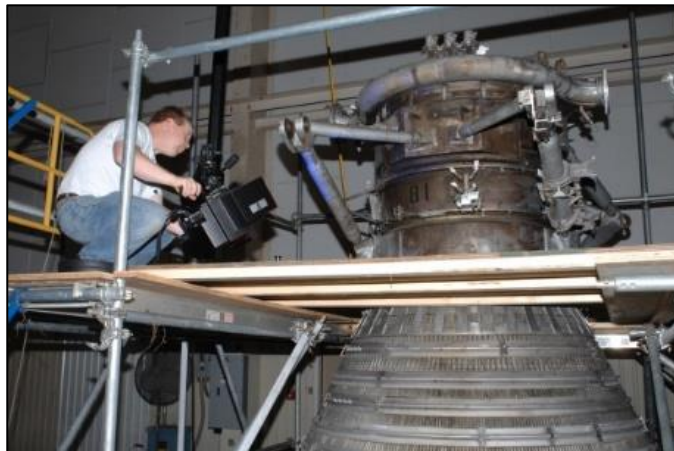


Additive Manufactured Replacement

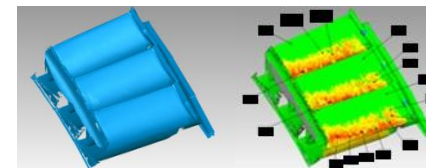
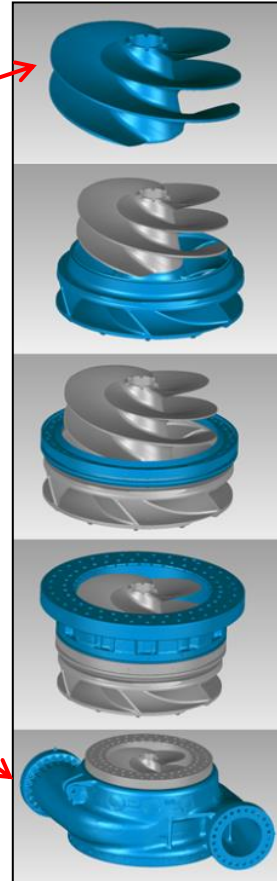
- Produce parametric surfaces from scan data
 - Can be used in CAD, CAM, FEA, CFD



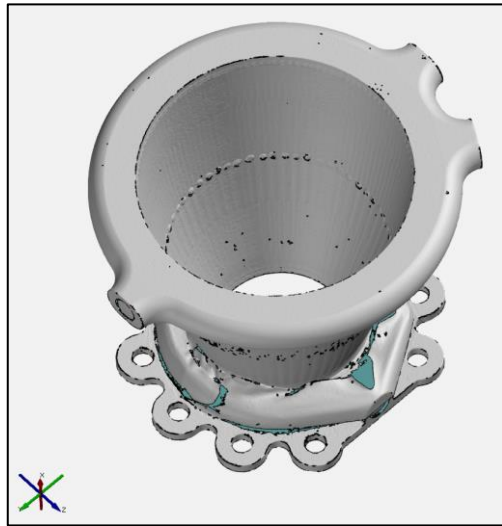
- Digital Assembly of F1 Engine
 - Perform photogrammetry and scan assembled engine
 - Disassemble and scan individual components
 - Digitally reassemble the components into their as-assembled positions
- Internal Geometry can now be measured



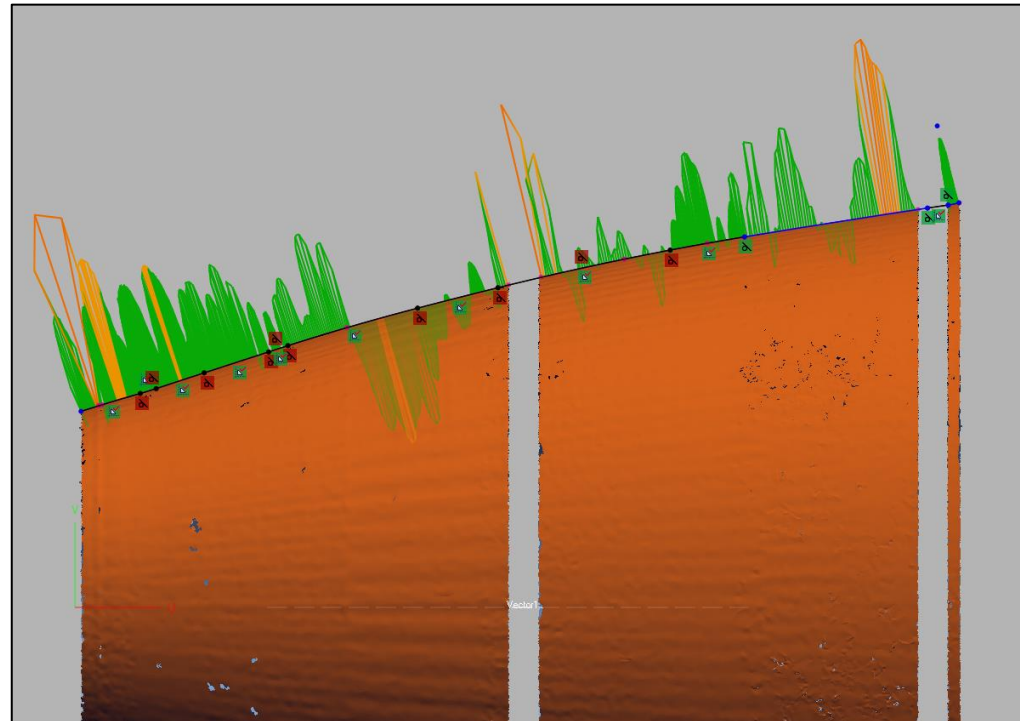
LOX Pump shown below and to the left



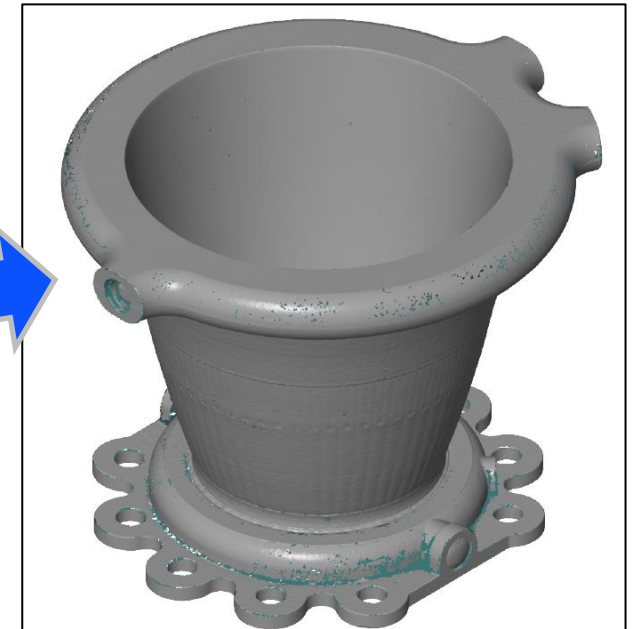
- Match Machining
 - Using structured light data to determine machine paths



Scan Data: Initial State

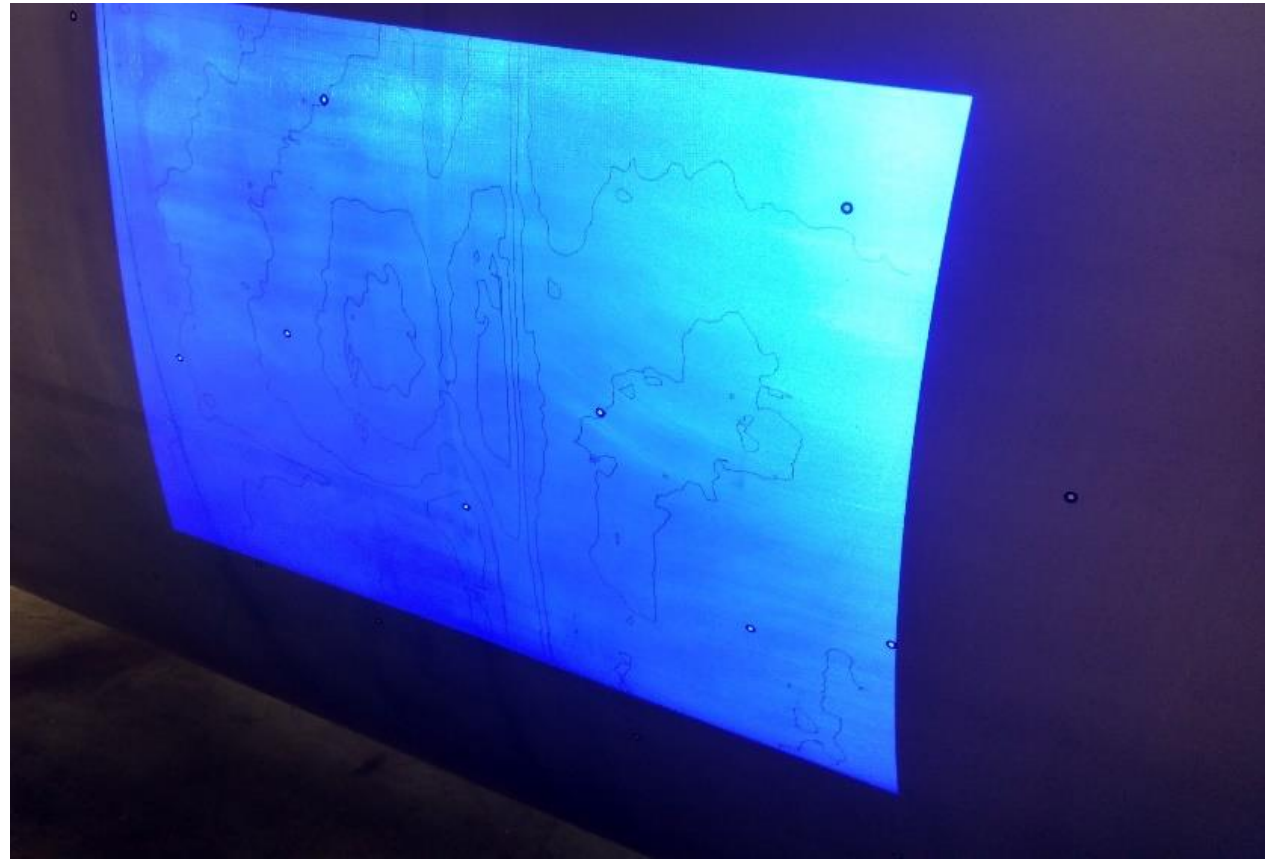


Fitted Machining Profile



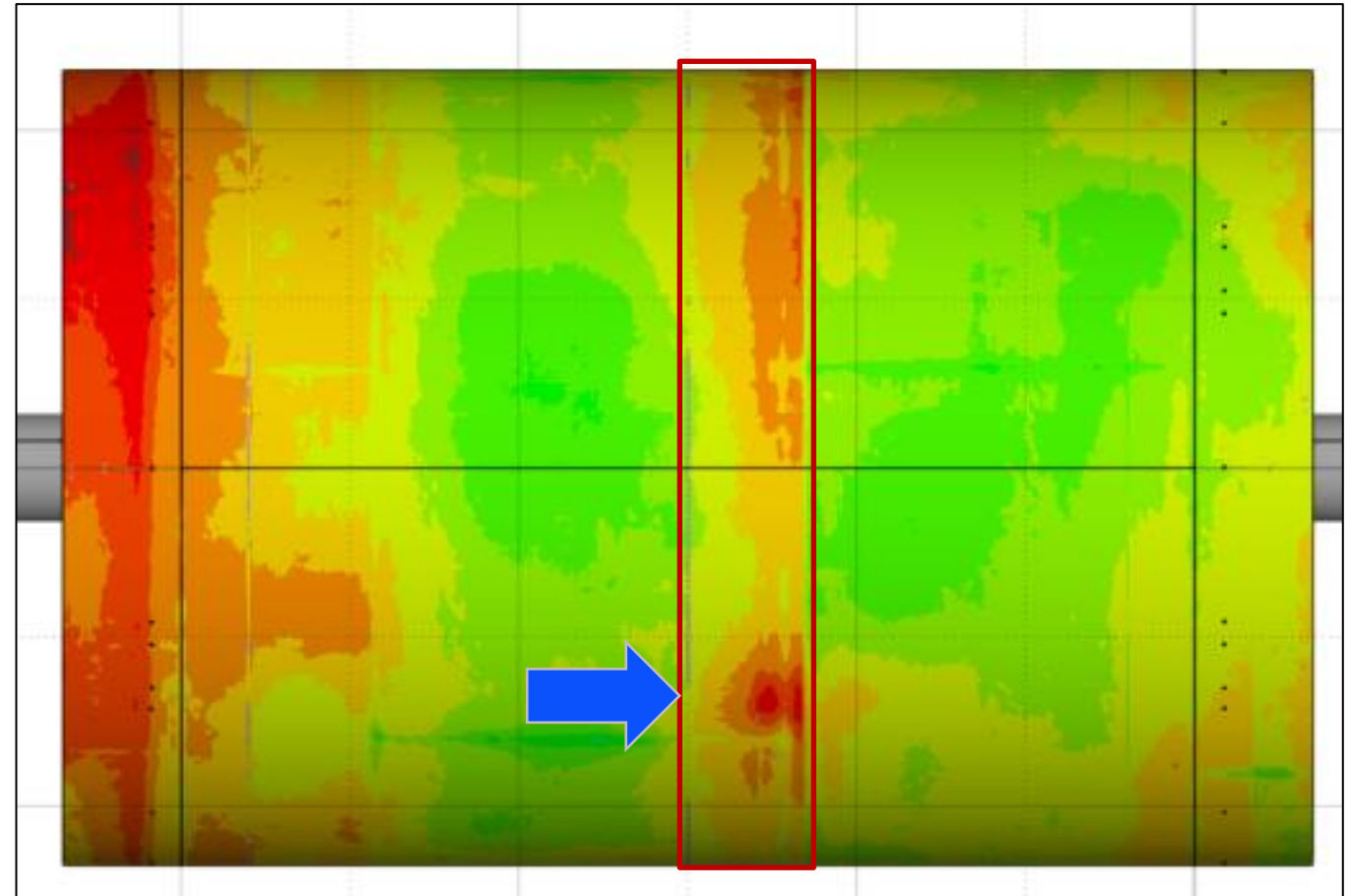
Machined ID

- Reverse projecting objects of interest on to actual hardware
 - Geometric features
 - Topology lines
 - Points
 - Lines
 - Circles
 - Etc.

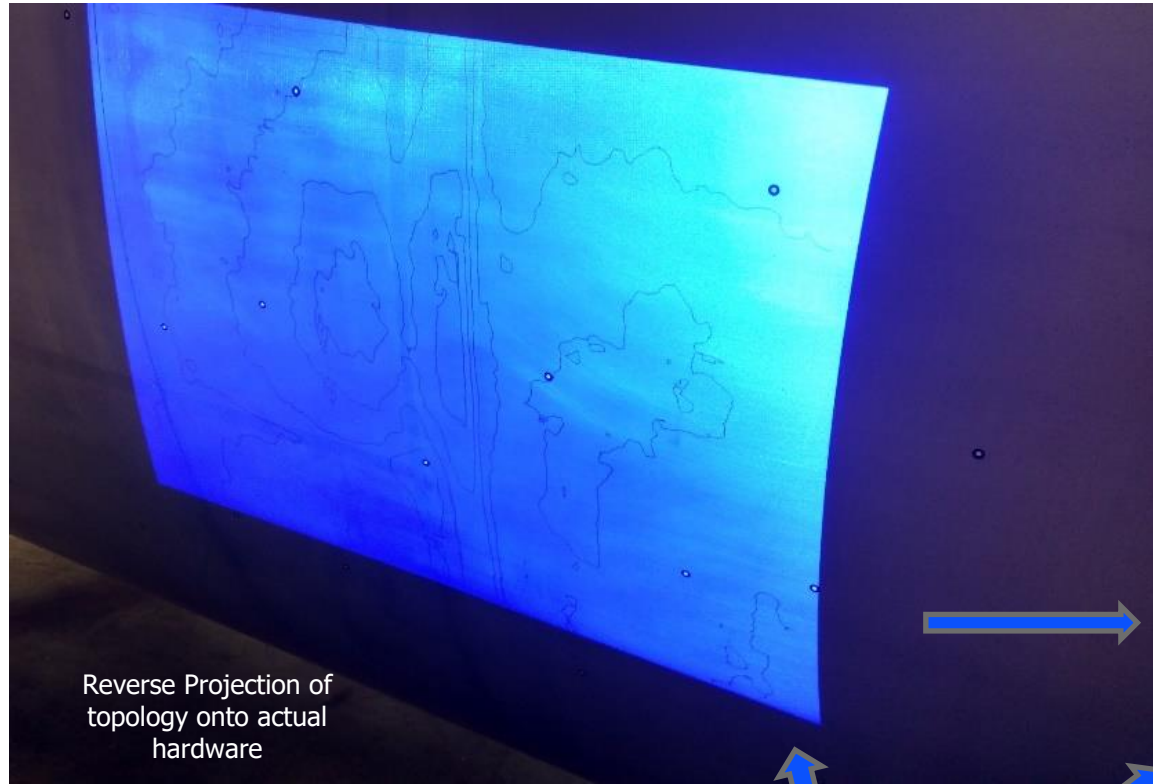


Reverse projection of topology lines on hardware

- Goal: Reduce the gradient within the indicated region
 - Customer request
 - High areas need to be reduced to ≤ 0.010 "



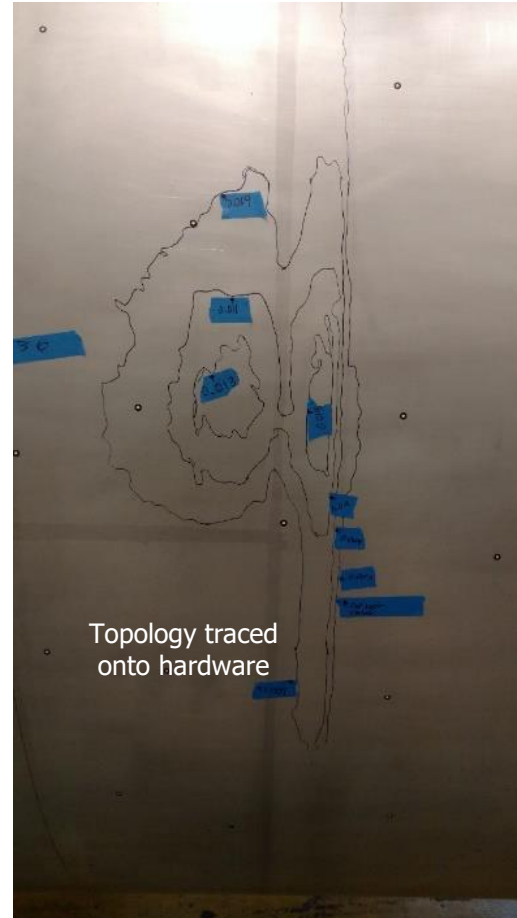
3D Deviation hardware scan data compared to CAD before sanding (+/-0.015")



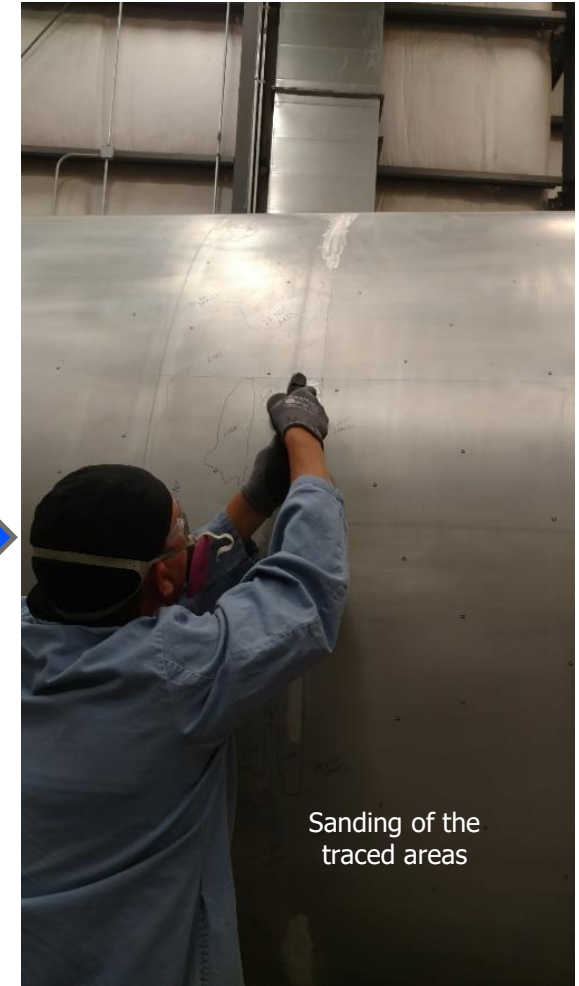
Reverse Projection of topology onto actual hardware



Colored Topology from Surface Comparison

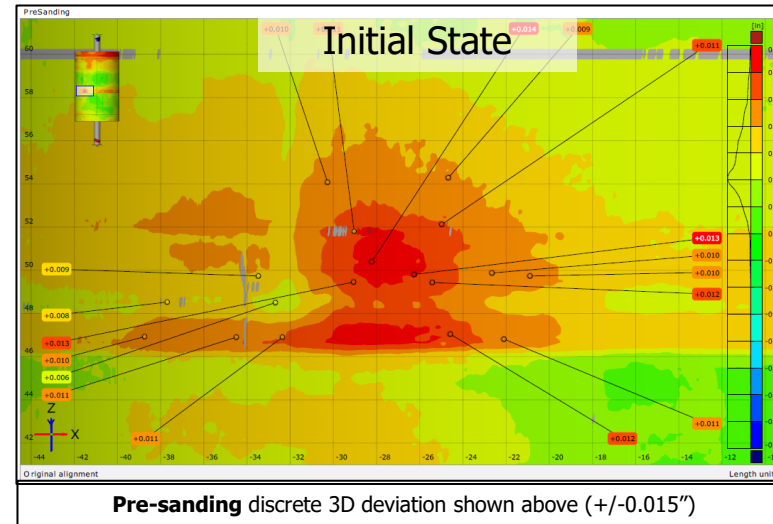


Topology traced onto hardware

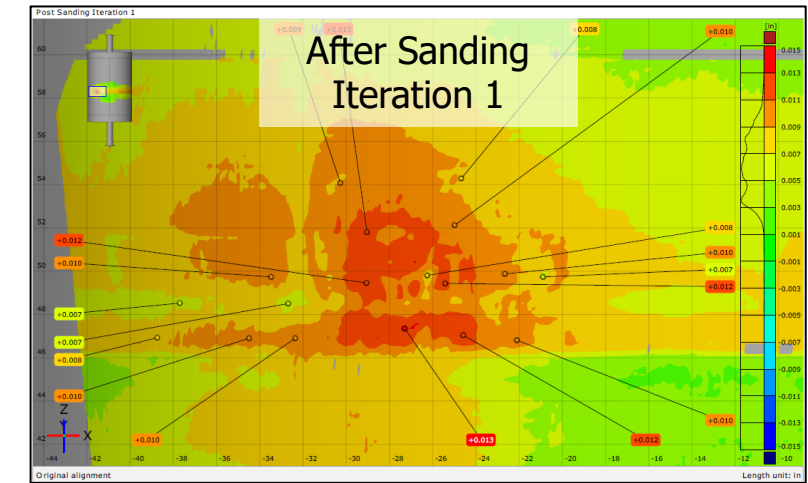


Sanding of the traced areas

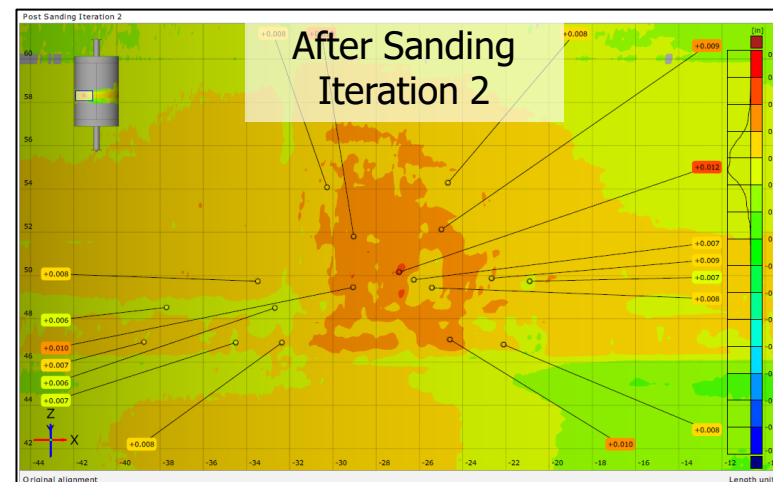
- Sanding Results
 - Structured Light was used to determine the deviation goal was achieved.



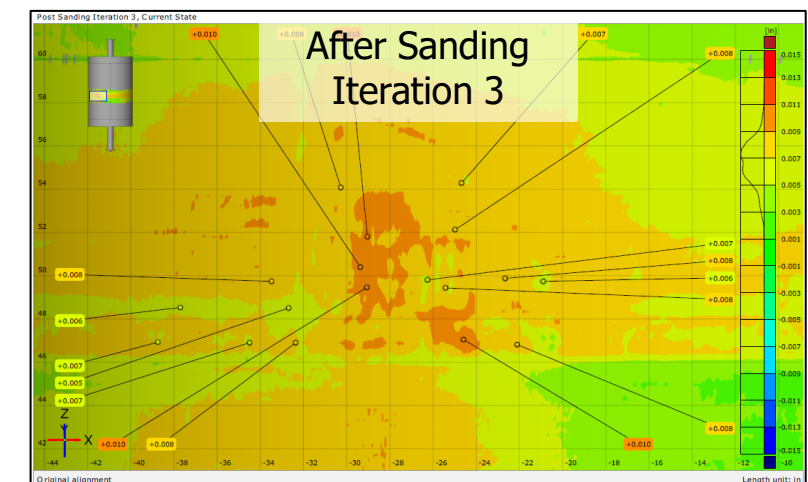
Pre-sanding discrete 3D deviation shown above (+/-0.015")



Post-sanding iteration 1 discrete 3D deviation shown above (+/-0.015")



Post-sanding iteration 2 discrete 3D deviation shown above (+/-0.015")

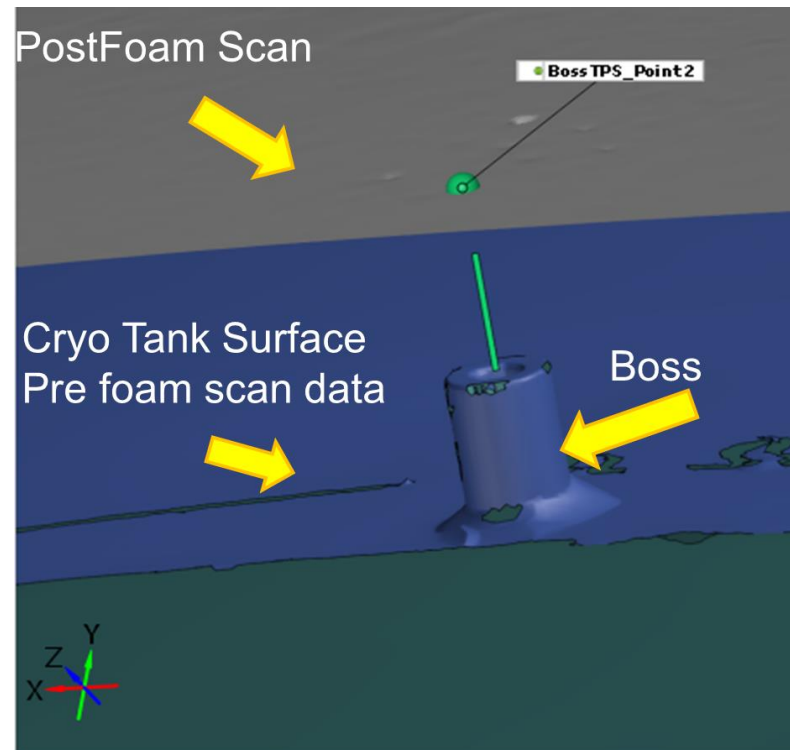


Post-sanding iteration 3, current state, discrete 3D deviation shown above (+/-0.015")

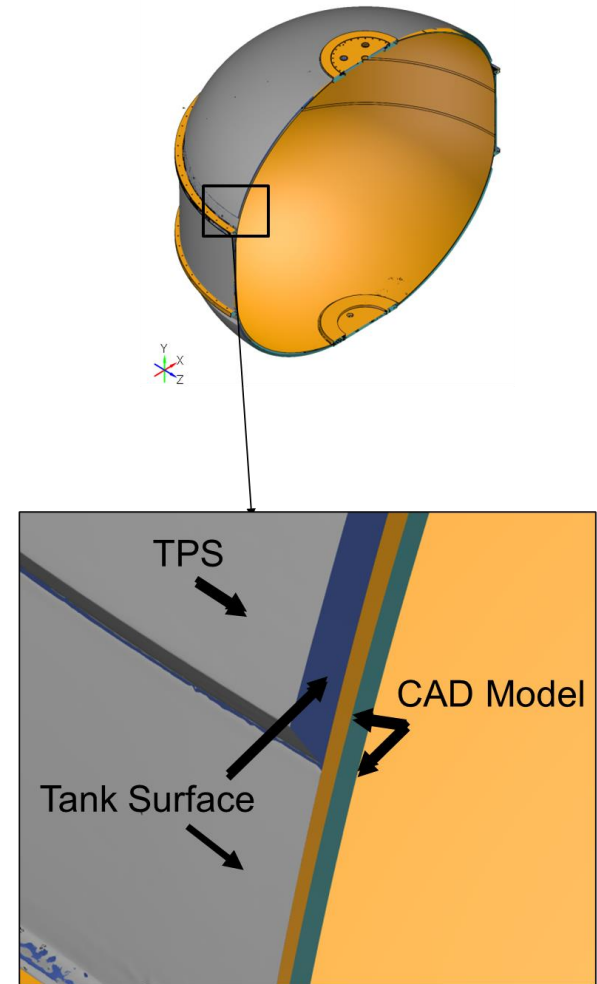
- Locating TPS Covered Bosses for Cryo Tank
 - Multiple scan data sets were aligned and the axial intersection locations of the bosses on the TPS surface were reverse projected and marked.



Pre TPS Data Capture



Pre/Post TPS Scan Data and Geometry used for Reverse Projection



Multiple Scan Data Sets & CAD Model

- Please contact
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 - Teams
 - Email- john.c.ivester@nasa.gov
 - Office Phone- 256-544-8597
 - Cell Phone- 864-723-7769

