

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



ERA23FA174

COMPUTED TOMOGRAPHY

Specialist's Factual Report

August 15, 2023

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A. ACCIDENT

Location: Gulf of Mexico
Date: March 30, 2023
Time: 1816 eastern daylight time
2216 coordinated universal time (UTC)
Airplane: Cessna 525B; Registration: N869AC

B. COMPUTED TOMOGRAPHY SPECIALIST

Specialist John Flynn
National Transportation Safety Board
Washington, DC

C. DETAILS OF THE INVESTIGATION

1.0 General

The left Tamarack Active Camber Surface (TACS) Control Unit (TCU) from the accident airplane was subjected to x-ray radiograph and computed tomography (CT) scanning to document its internal condition. The scanning was conducted from April 25 to May 02, 2023, in Chicago, Illinois by Varex Imaging, Inc under the direction of the NTSB using the CST 9MV 4343 HE DRZ+ CT system and Actis 225/500 microfocus CT system.

For the CT scans, the component was loaded into the imaging unit and placed on a turntable. The component was then rotated in front of the x-ray source, and the x-rays were captured by a detector after they went through the part. The x-ray source produced a cone shaped beam of x-rays, and the portion of the part imaged was adjusted slightly after each scan was completed until the entire assembly (or region of interest of the part) was scanned. The x-ray energy levels measured by the detector were recorded at several thousand different points during each rotation, and this information was converted into slice images using reconstruction algorithms.

The component was scanned using a total of 4,666 slices, and the total size of the combined data sets was approximately 17.3 GB. The complete scan protocols are given in table 1. The digital radiograph and CT axial slice images were provided by Varex to the NTSB where they were examined, processed, and analyzed to evaluate the component.

Table 1. Scan Protocol

CT System	9 MeV (Megavolt)	225 kV (microfocus)
Number of Slices	2000	2666
Voxel ¹ Size - X Direction (millimeter(mm))	0.15	0.14
Voxel Size - Y Direction (mm)	0.15	0.14
Voxel Size - Z Direction (mm)	0.15	0.14
Image Projections per Revolution	2880	1800
Exposure Time (milliseconds)	1000	285.607
Frames to Avg (frames per projection)	1	2
X-ray Source Voltage (kilovolts)	9,000	222
X-ray Source Current (mA) (microfocus system)	320 hz	575 μ A
Source Filter Thickness (mm)	9.5	1
Source Filter Material	copper	brass
Image Matrix Size (pixels)	1800 x 1800	1024 x 1024

The data sets of slice images were examined, processed, and analyzed by the NTSB using the VGStudioMax software package to convert the axial slice data into orthogonal slice images and a three-dimensional reconstructed image of the component. As part of the evaluation, some sections of the components were digitally removed or rendered transparent to allow closer observation of interior parts. In all the images, the higher density areas were shown as brighter shades of gray and lower density areas were shown as darker shades of gray. Each 2-D quadrant within the images shows a scale at the bottom of that quadrant - note that the scales in each quadrant may be different. The pointers shown in some of the images denote specific areas of interest within that image. The numbers associated with the pointer are the gray value at the pointer location and the three positional coordinates of the pointer.

Some of the TCU internal components were “virtually unrolled” using the CT image visualization software. This process required the identification of a path for the software to use when unrolling the data set, and it resulted in a cylindrical structure being “unrolled” to show a round surface as a flat planar image.

The images of the components were examined for any signs of missing or damaged parts, contamination, or any other anomalies. Specific results (including example images) are presented in subsequent sections of this report.

¹ A voxel is a three-dimensional picture element (pixel).
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2.0 Computed Tomography Results

The CT results for the left TCU are shown in Figures 1 through 44. Review of the images indicated that, when the scans were conducted, there were no indications of missing or broken components. The Linear Variable Differential Transformers (LVDTs) 1 and 2 had some wire anomalies. The LVDT anomalies are being noted as points of interest, but it is not definitive from the scan results alone whether the noted anomalies are due to physical abnormalities or image resolution effects.

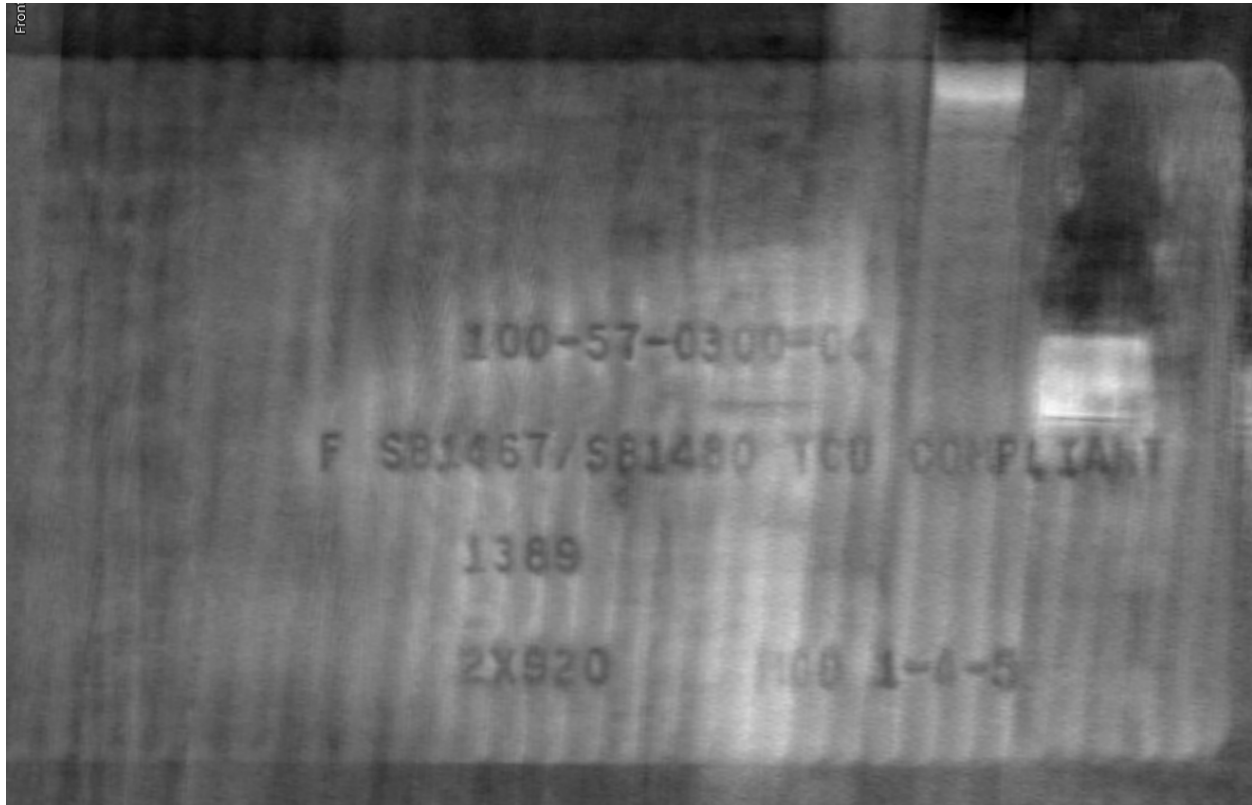


Figure 1. Left TACS control unit - nameplate.

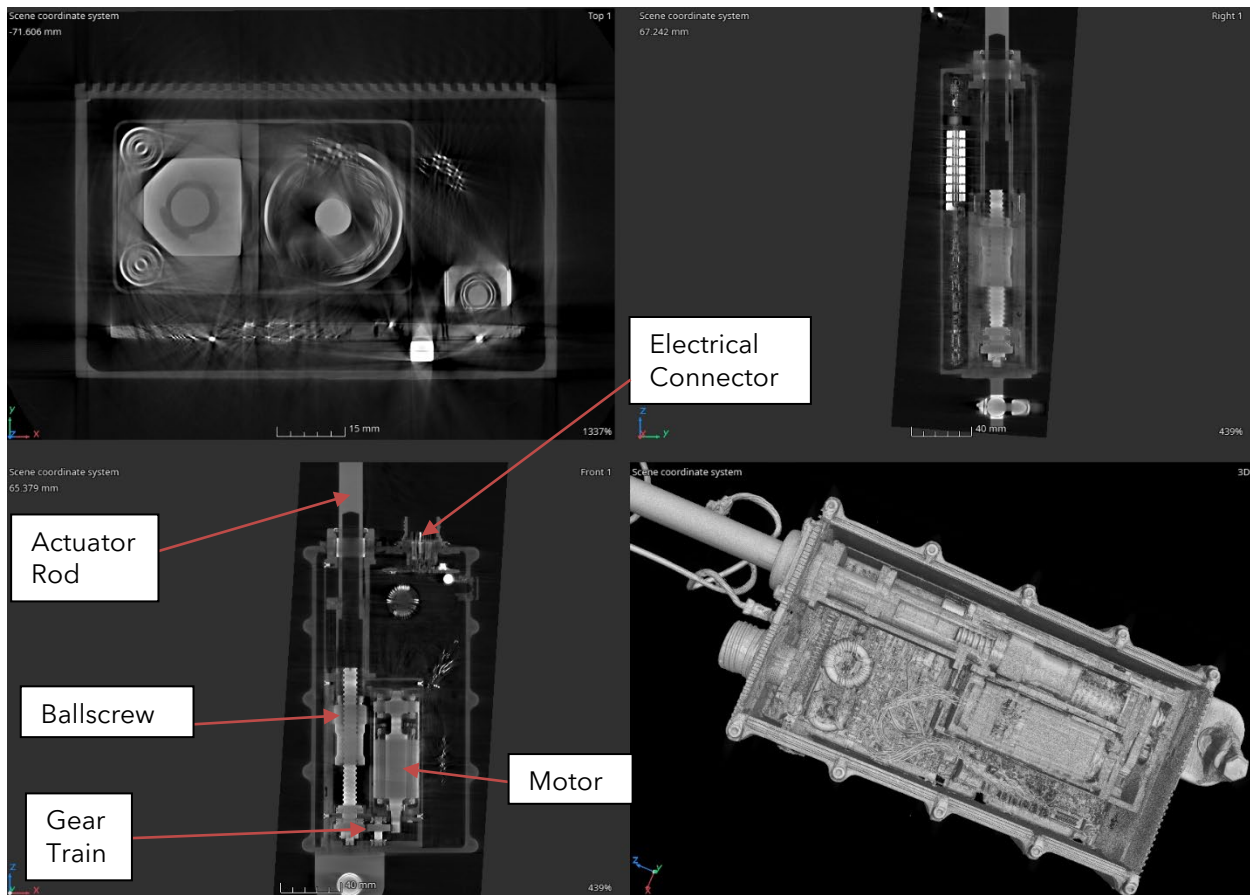


Figure 2. Left TACS control unit - overview.

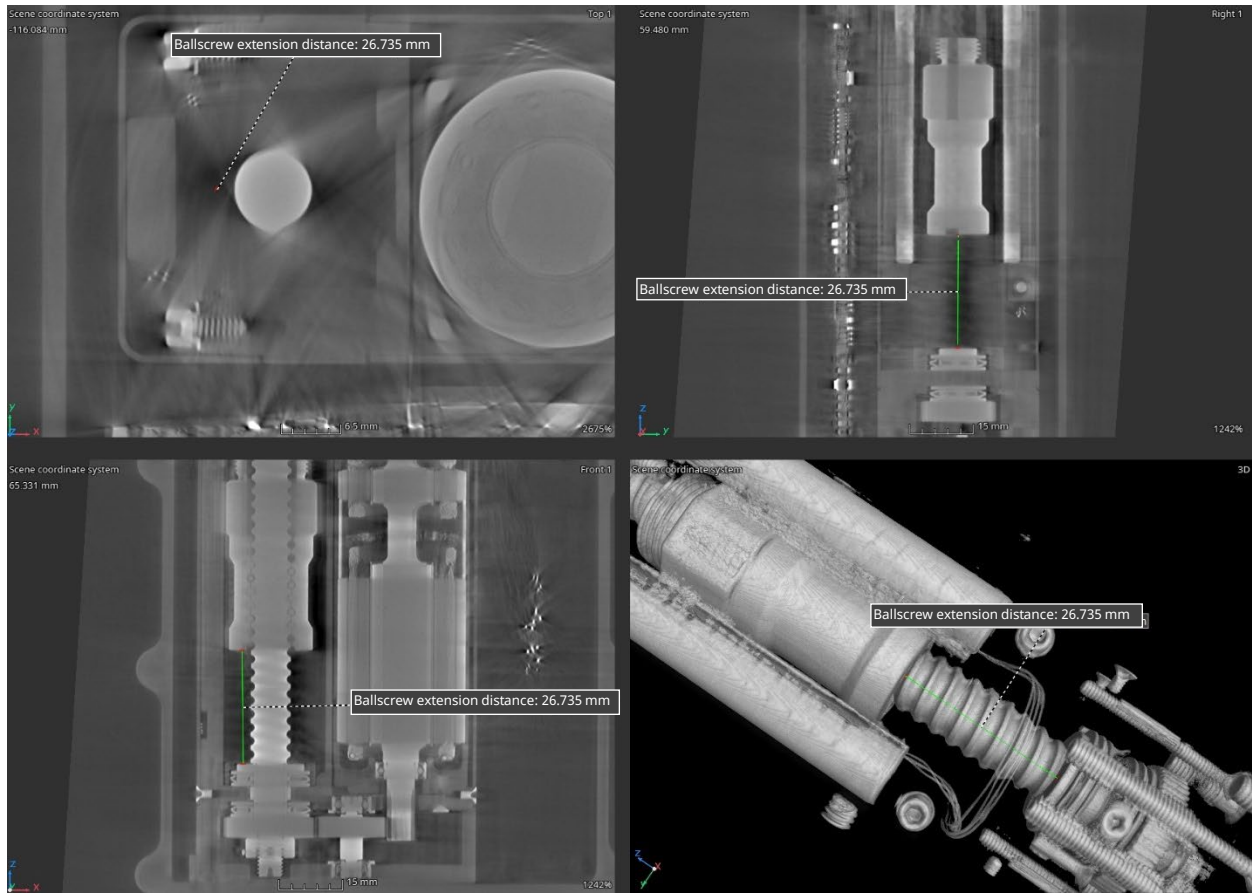


Figure 4. Left TACS control unit – ballscrew extension distance.

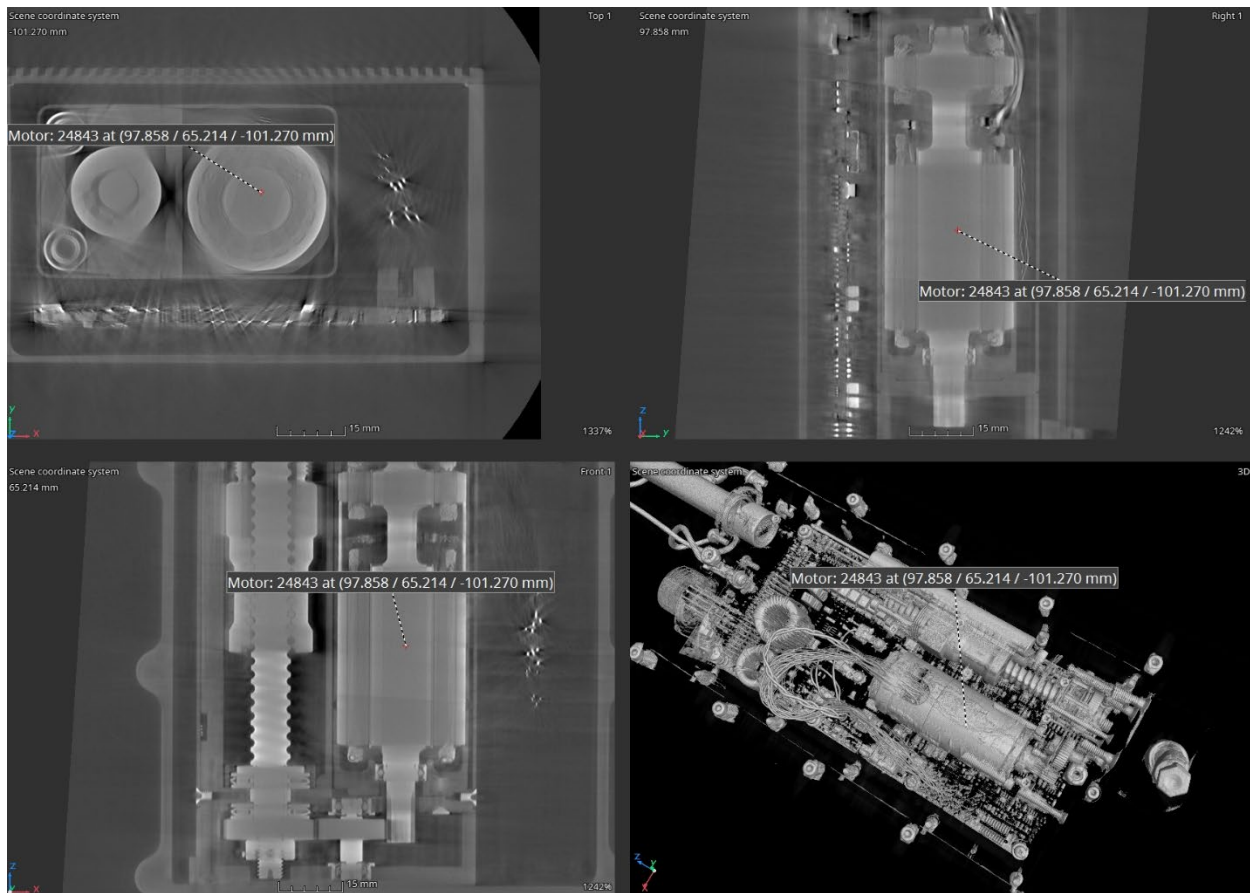


Figure 5. Left TACS control unit – motor.

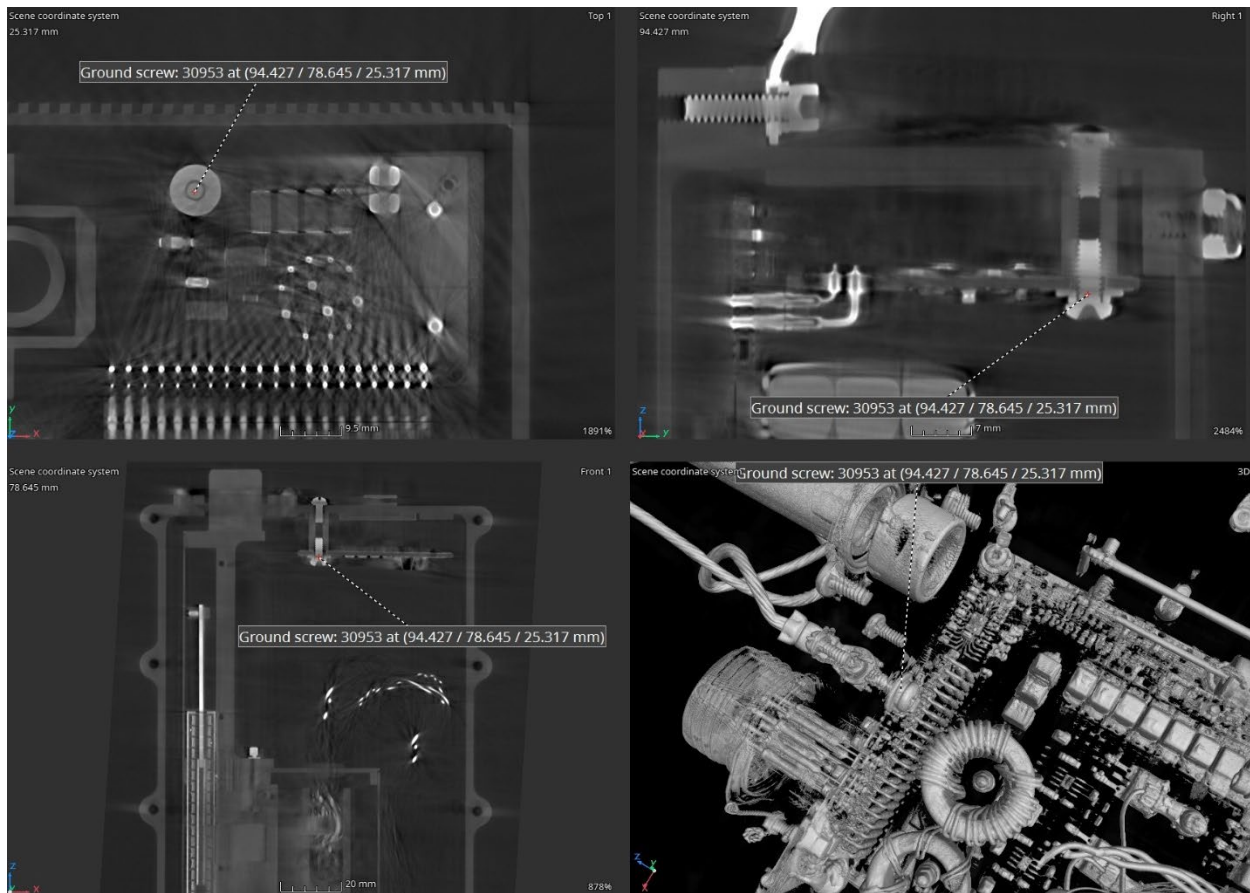


Figure 6. Left TACS control unit – ground screw.

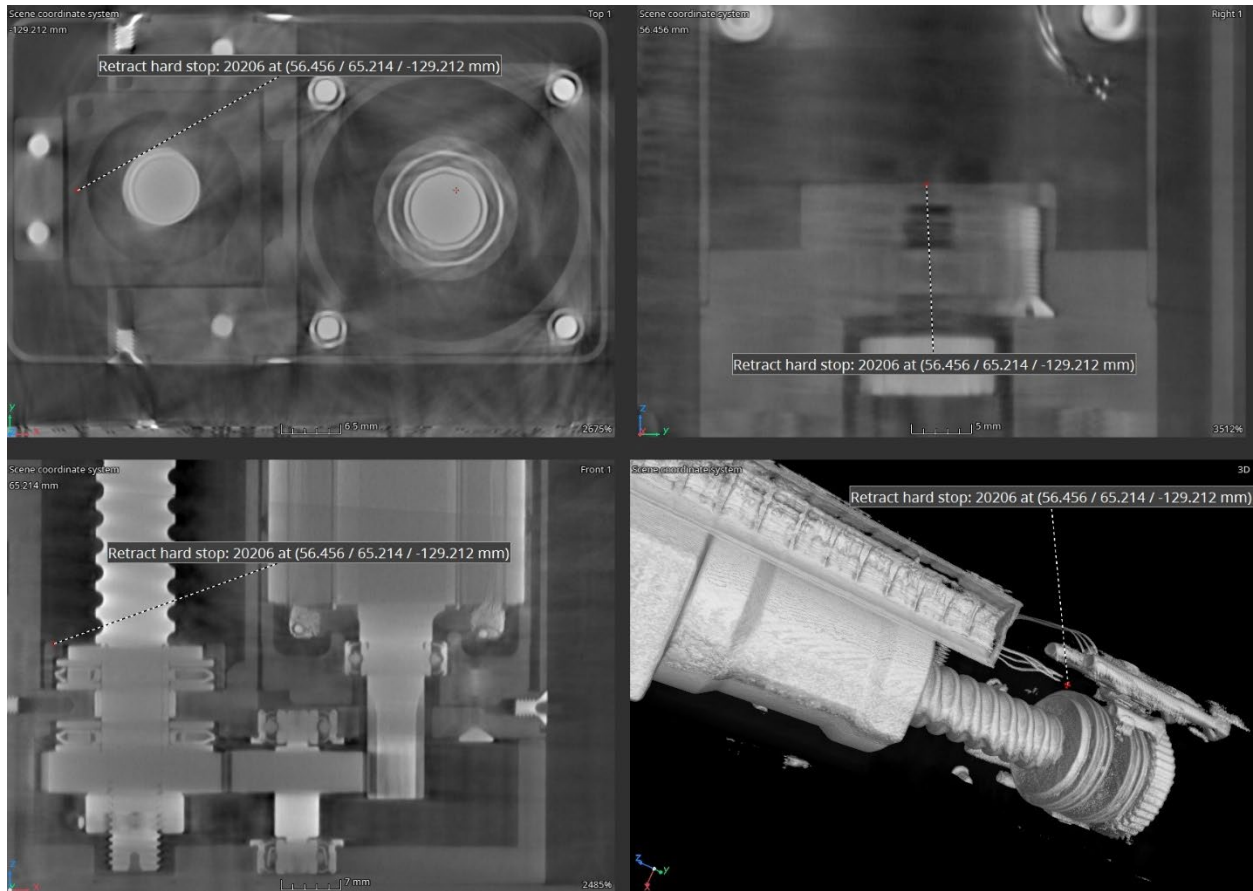


Figure 7. Left TACS control unit - retract hard stop.

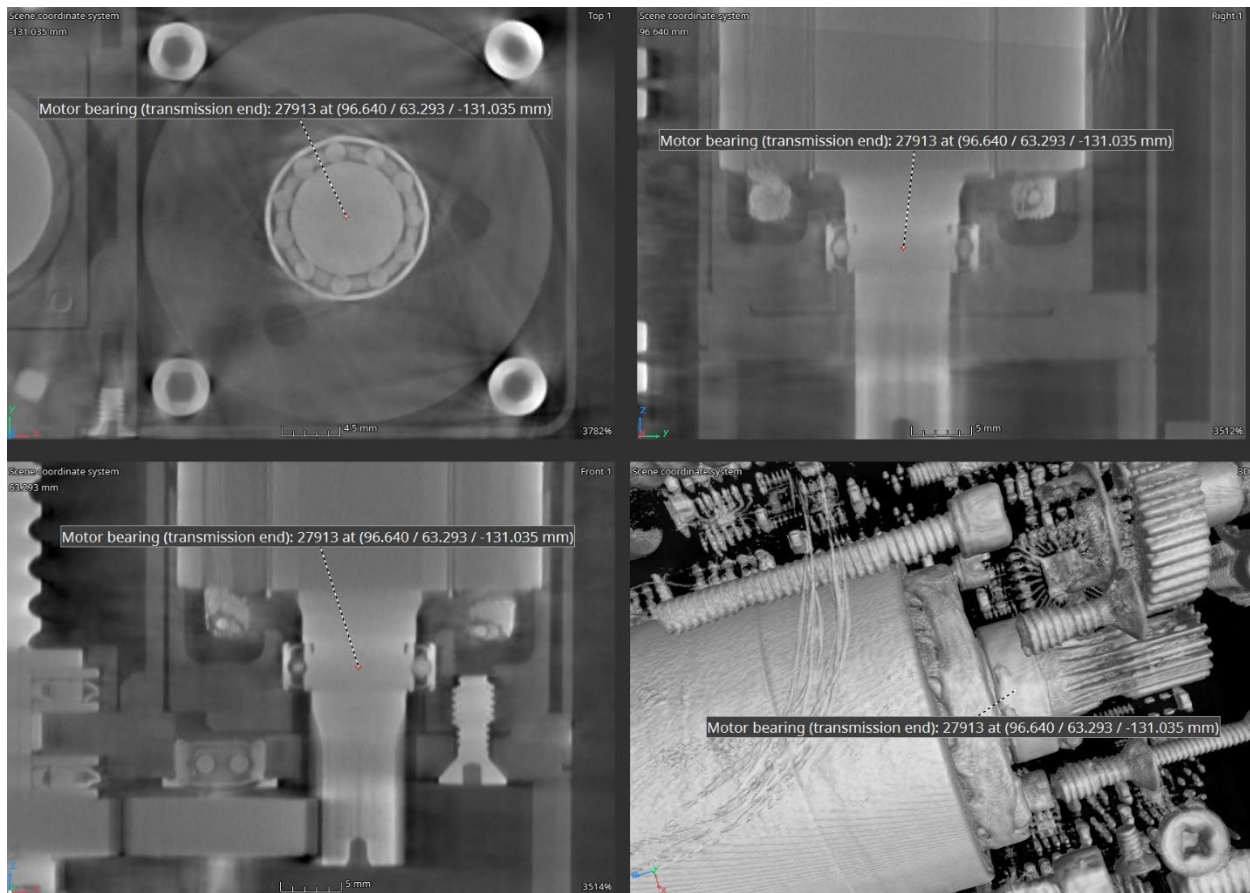


Figure 8. Left TACS control unit – motor bearing transmission end.

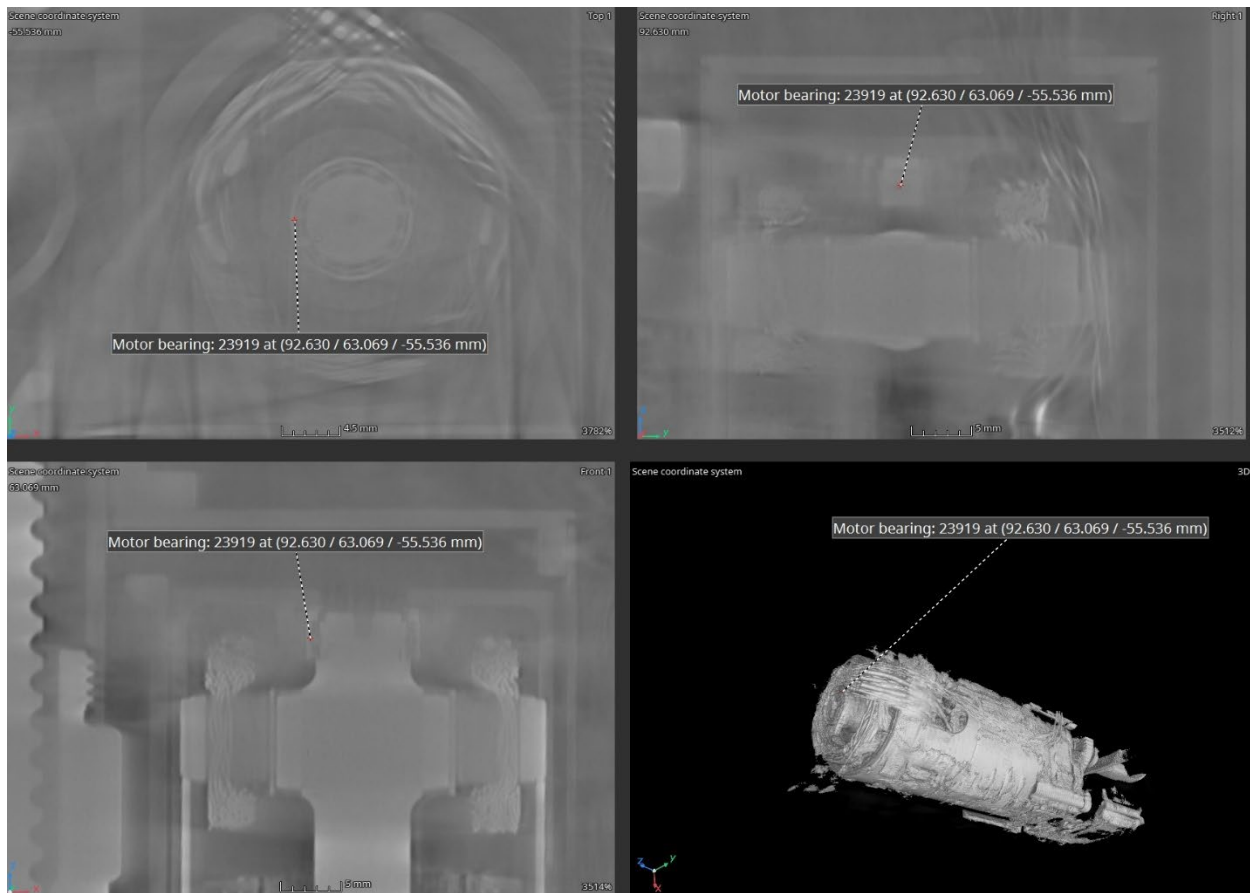


Figure 9. Left TACS control unit – motor bearing non-drive end.

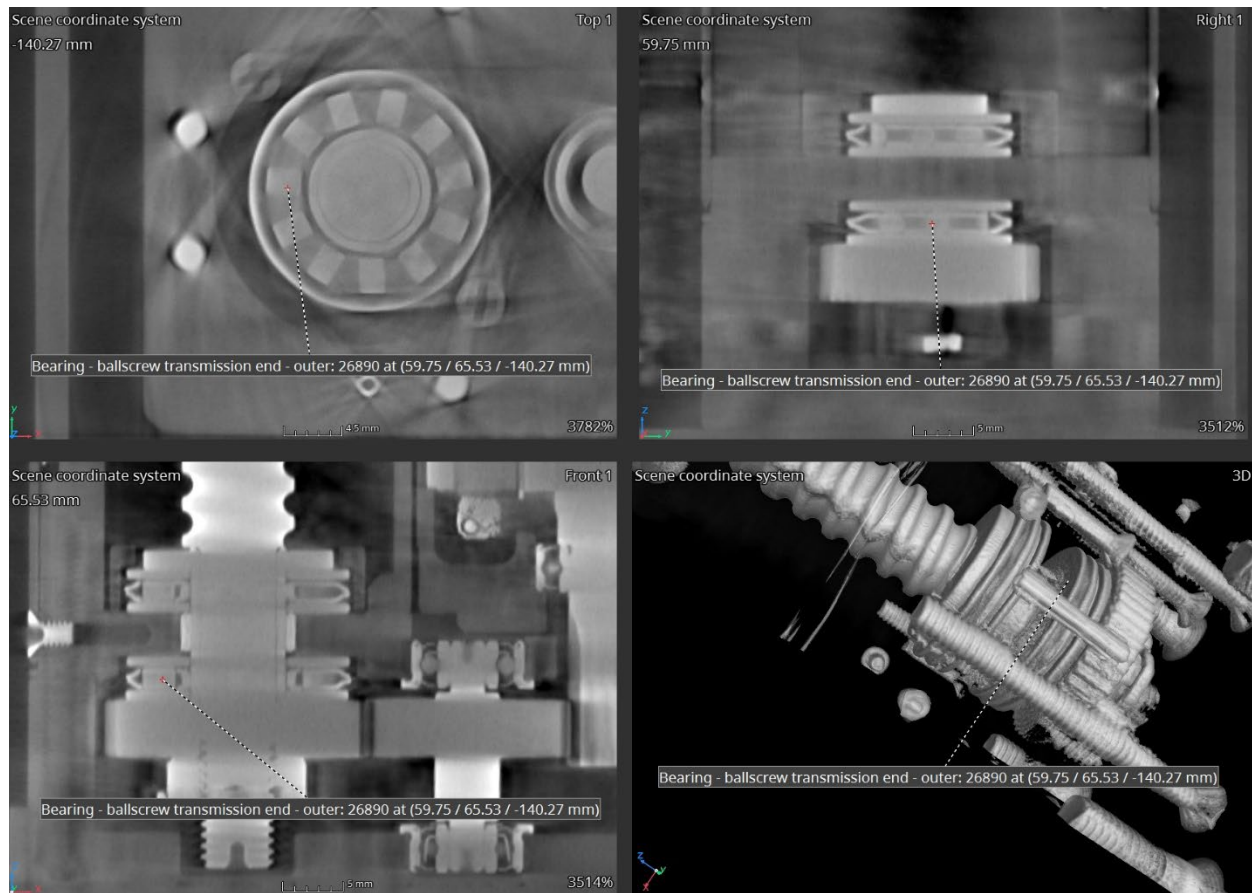


Figure 10. Left TACS control unit – ballscrew transmission end outer bearing.

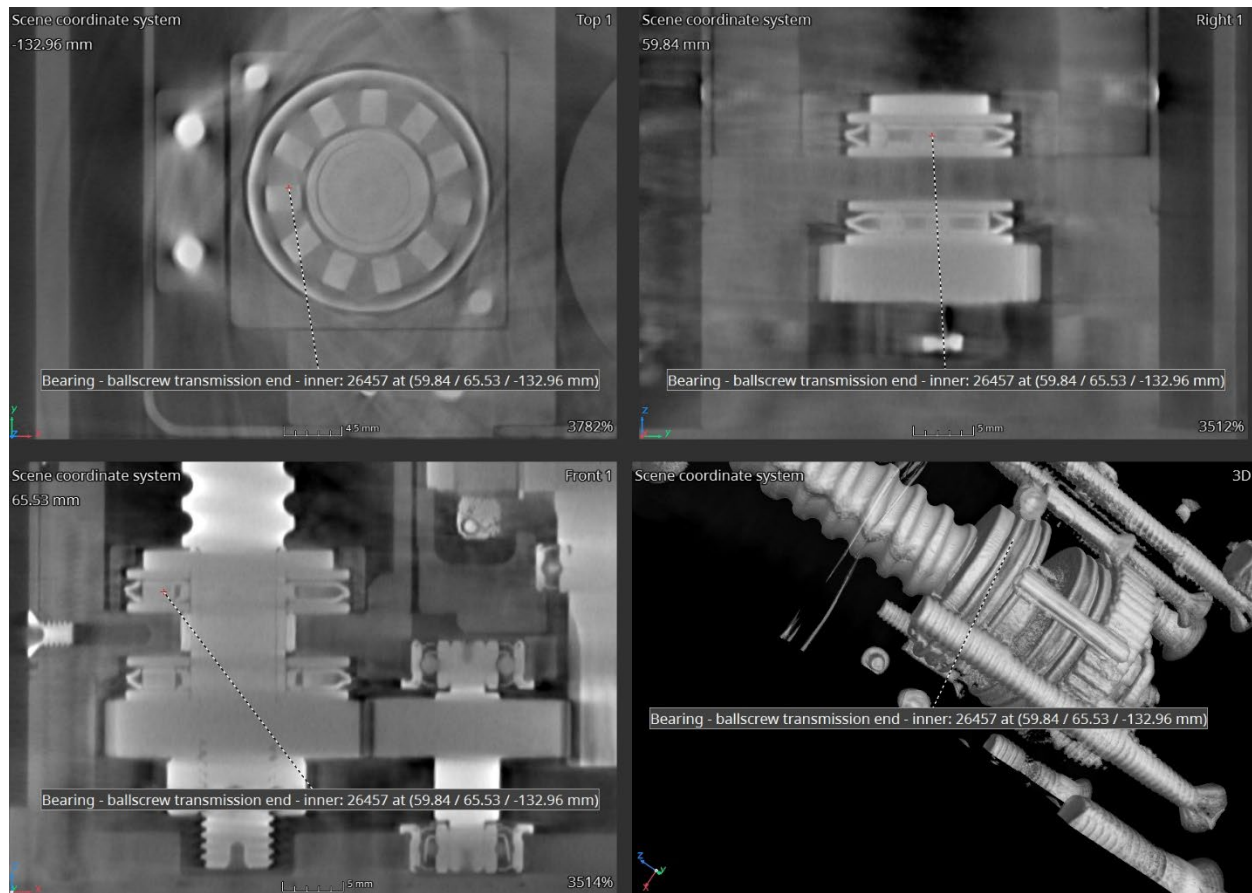


Figure 11. Left TACS control unit – ballscrew transmission end inner bearing.

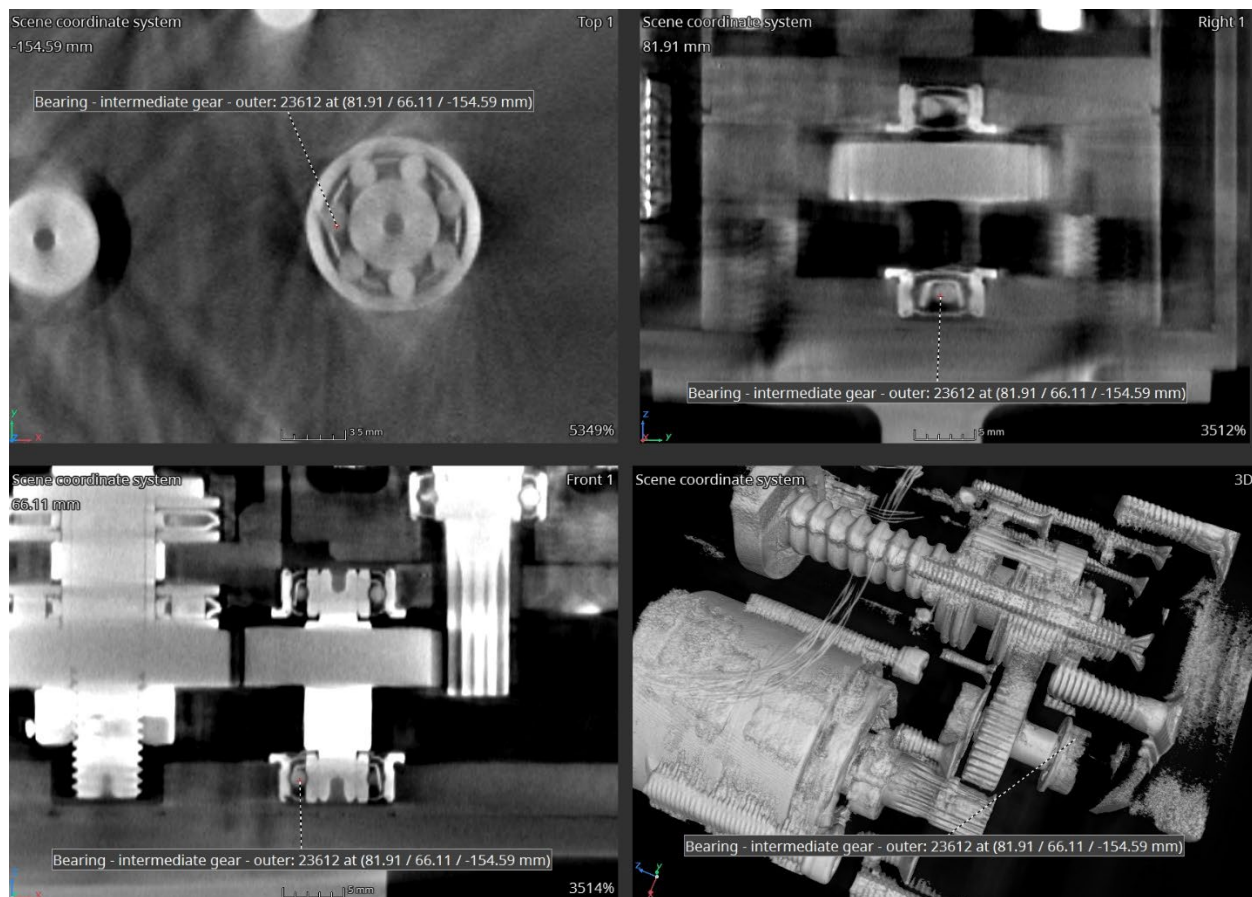


Figure 12. Left TACS control unit - intermediate gear outer bearing.

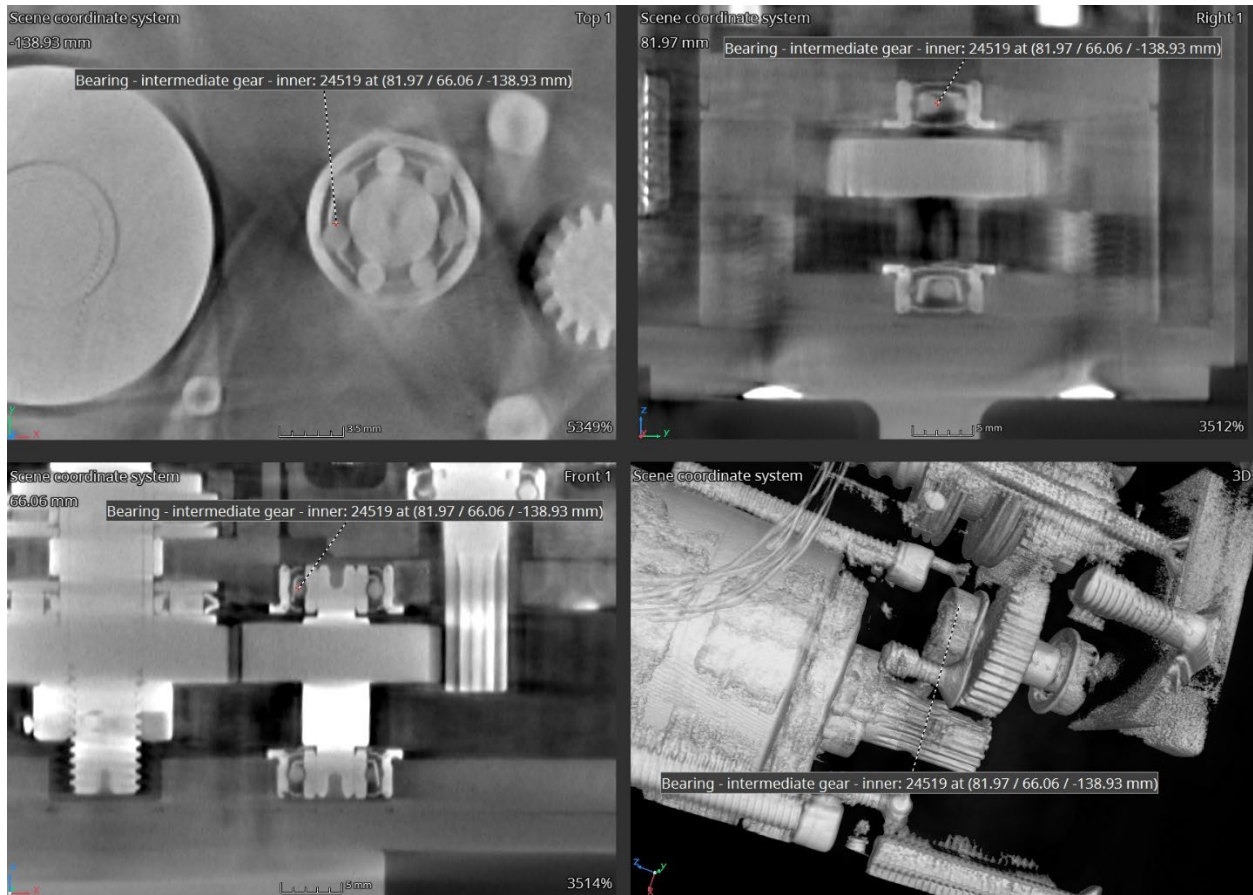


Figure 13. Left TACS control unit - intermediate gear inner bearing.

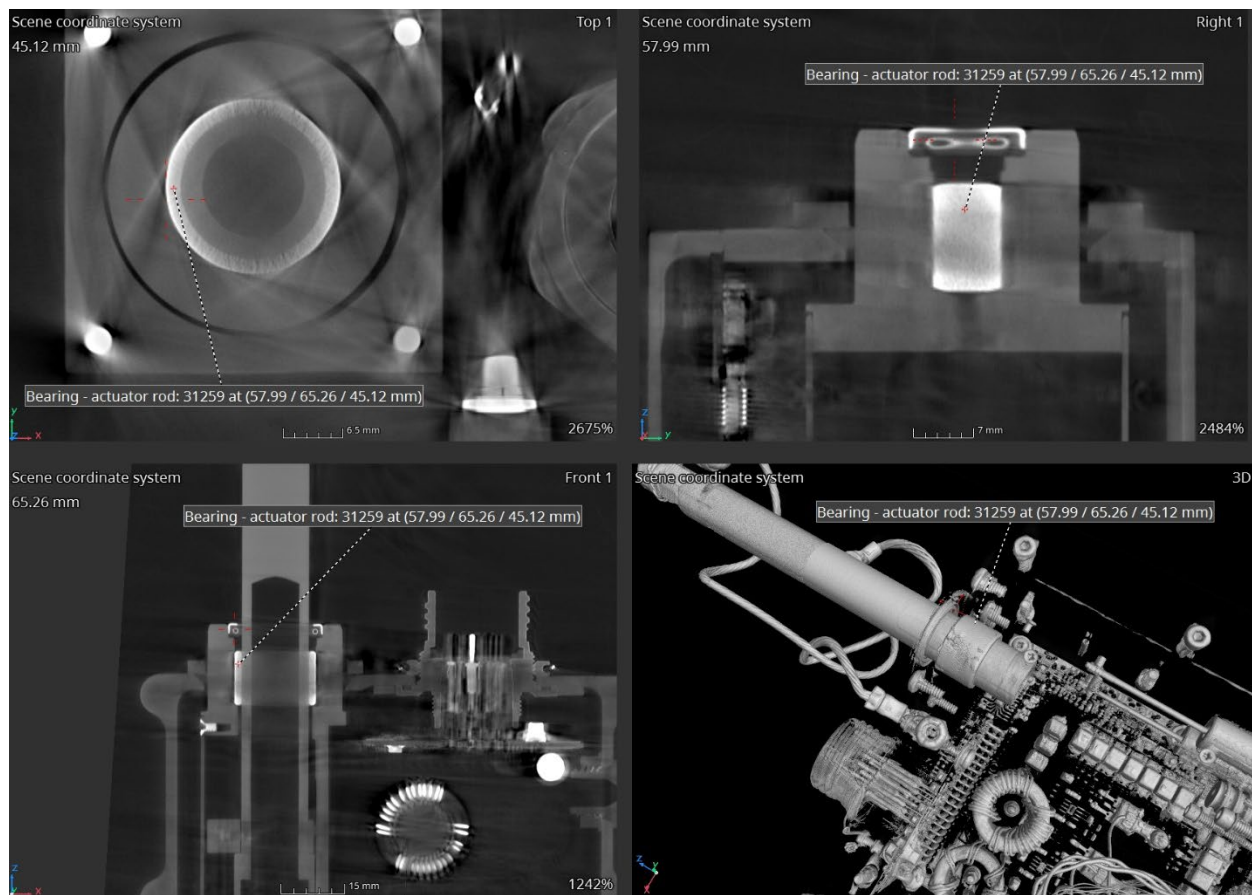


Figure 14. Left TACS control unit - actuator rod bearing.

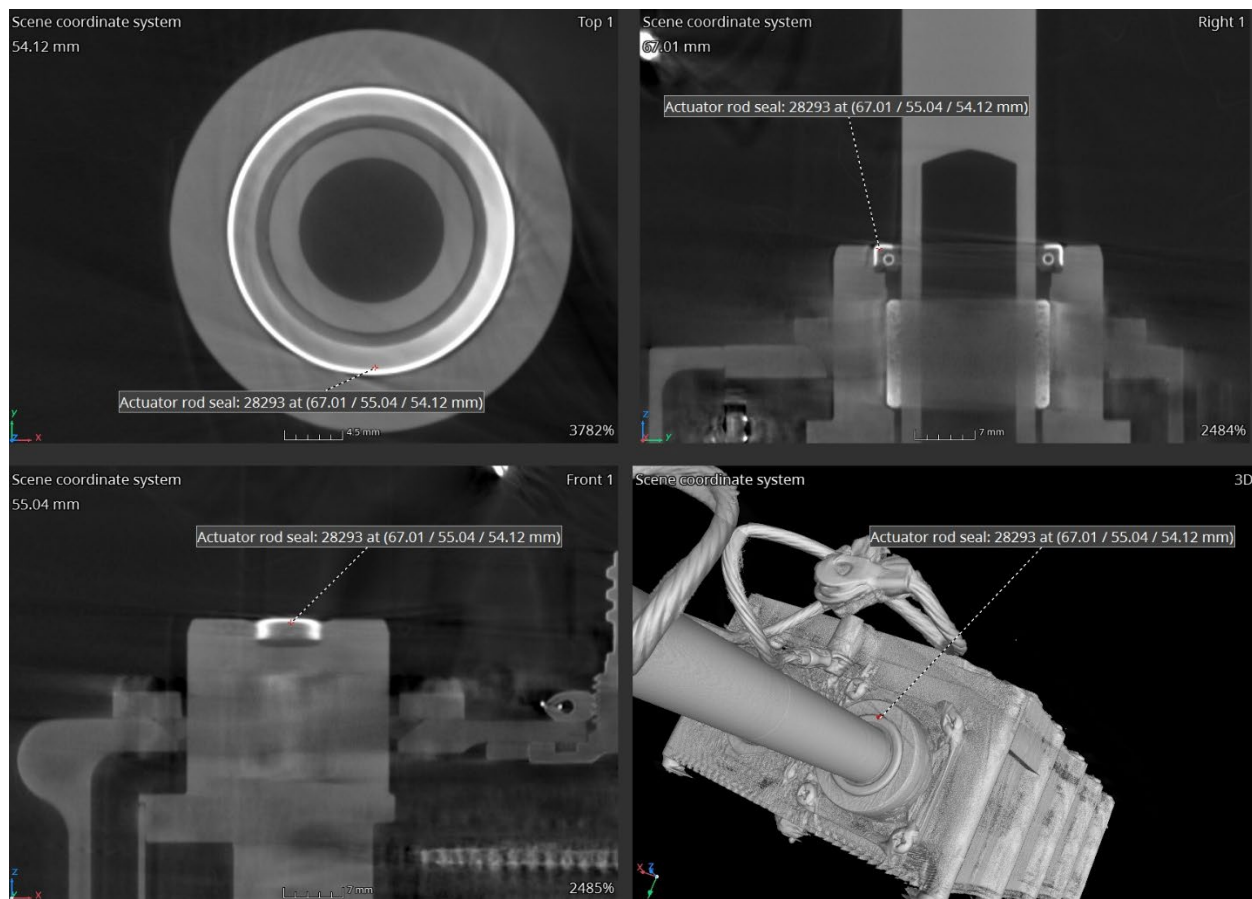


Figure 15. Left TACS control unit - actuator rod seal.

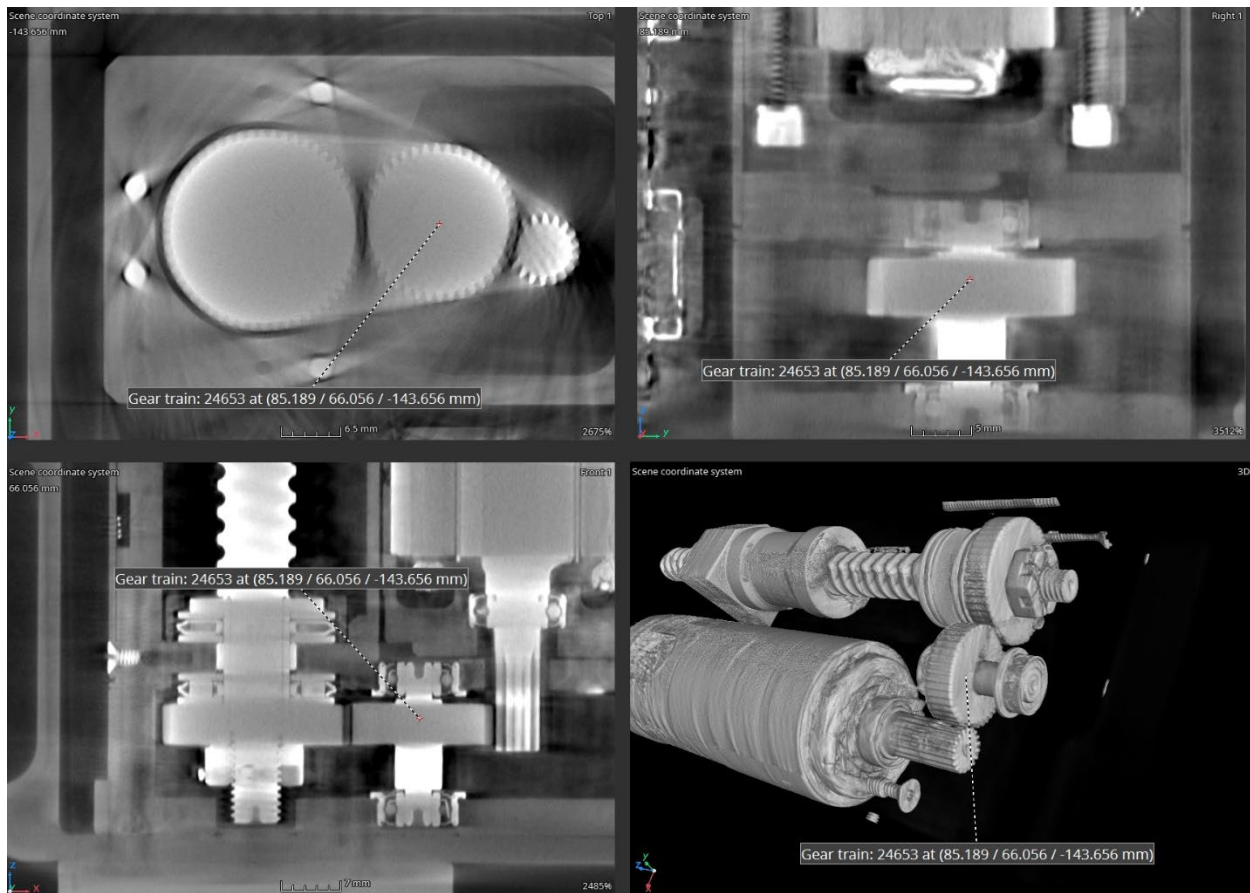


Figure 16. Left TACS control unit – gear train.

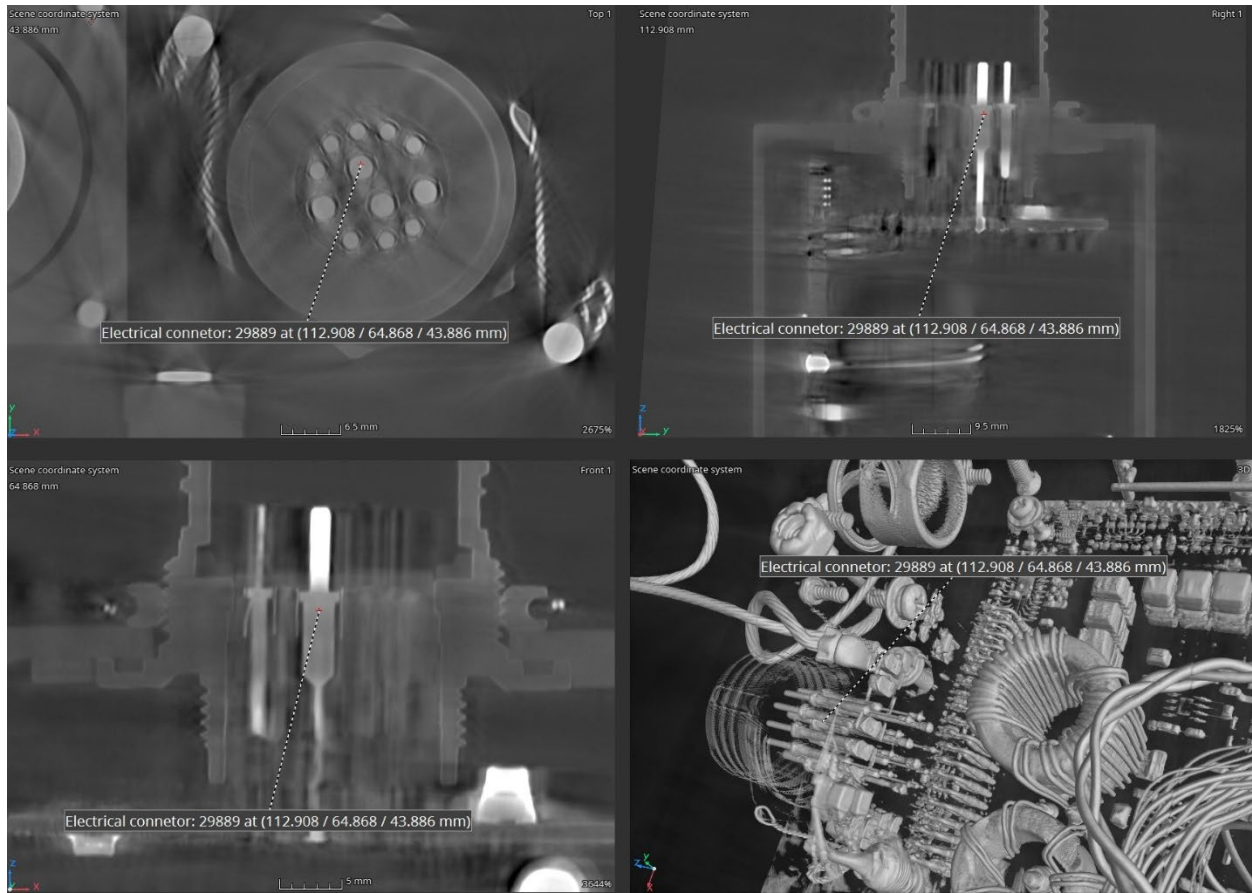


Figure 17. Left TACS control unit – electrical connector.

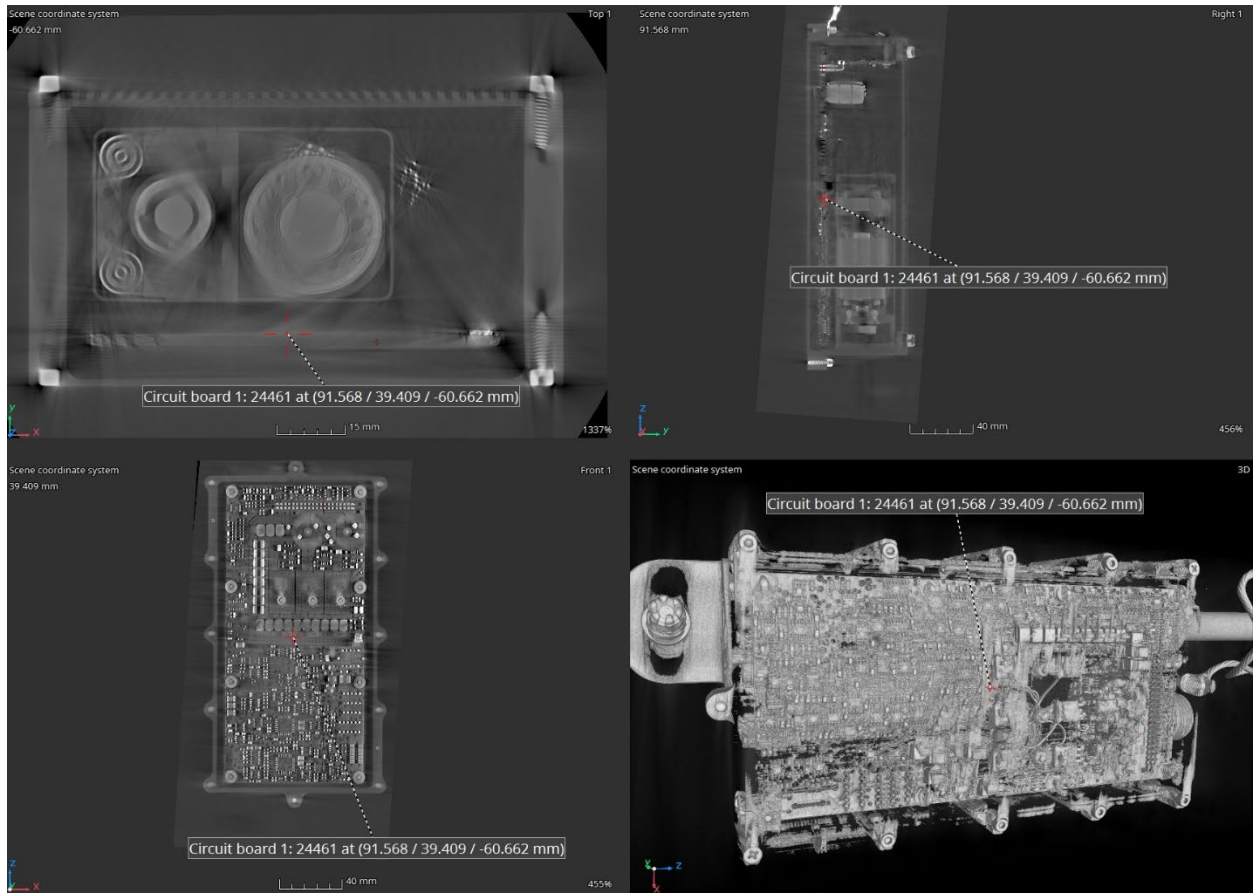


Figure 18. Left TACS control unit – circuit board 1.



Figure 19. Left TACS control unit – printed circuit board (PCB) connections row 1.

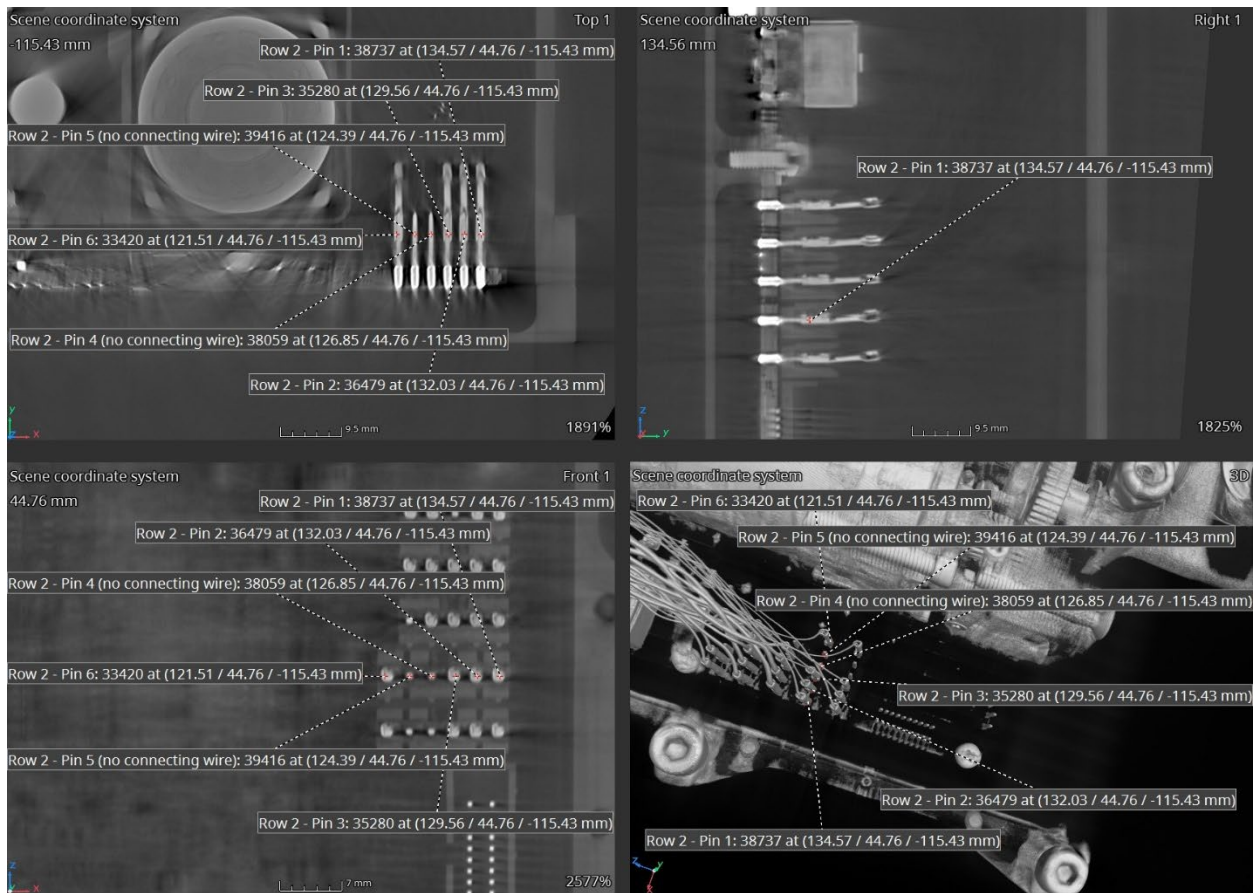


Figure 20. Left TACS control unit – PCB connections row 2.



Figure 21. Left TACS control unit – PCB connections row 3.

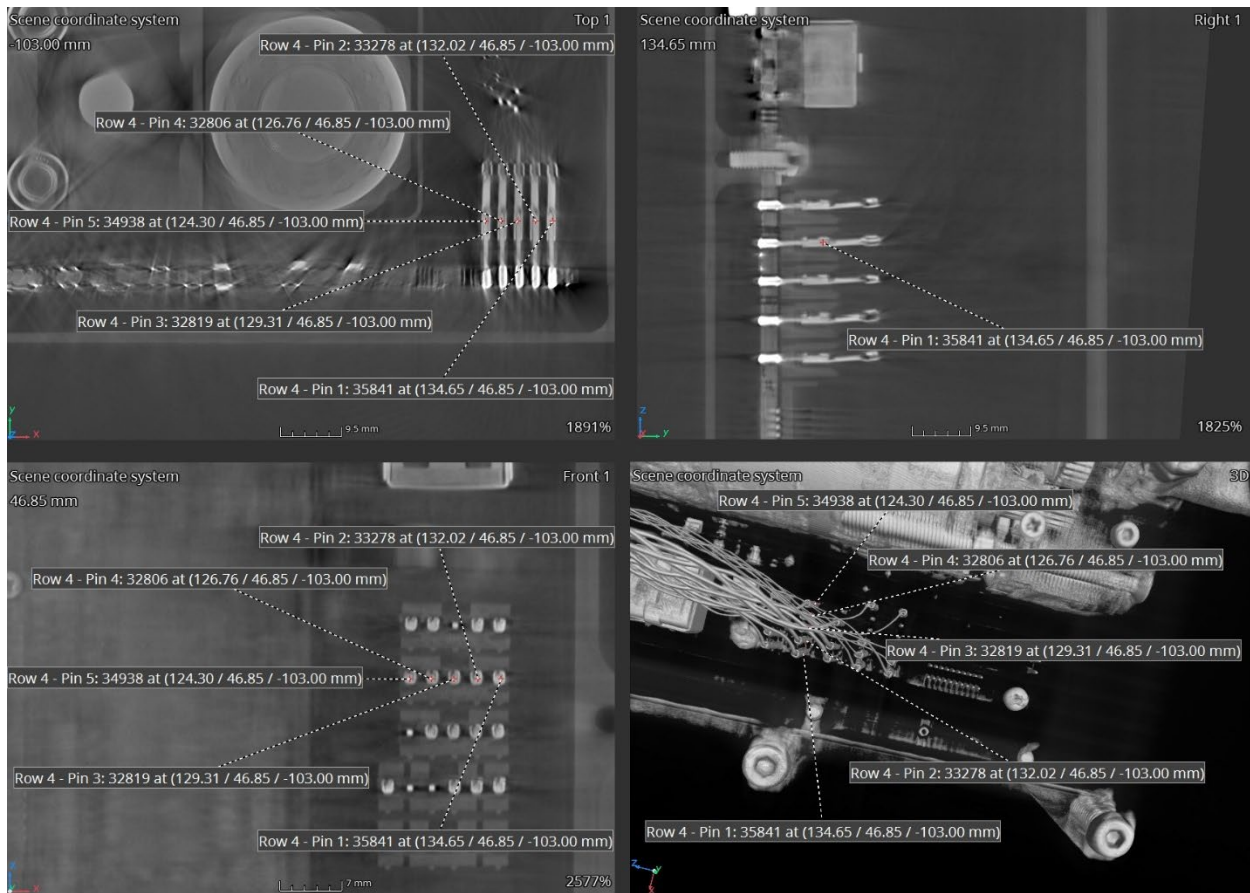


Figure 22. Left TACS control unit – PCB connections row 4.



Figure 23. Left TACS control unit – PCB connections row 5.

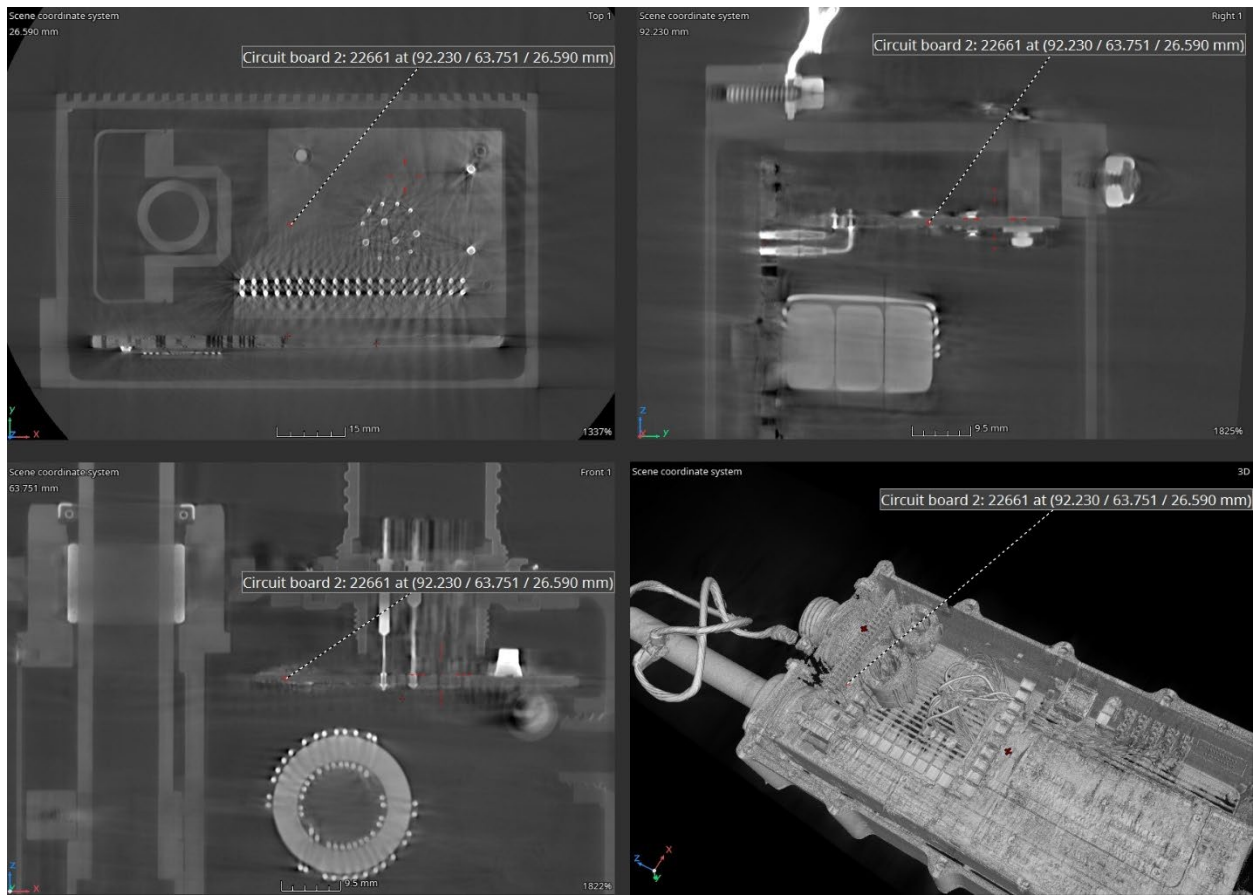


Figure 24. Left TACS control unit – circuit board 2.

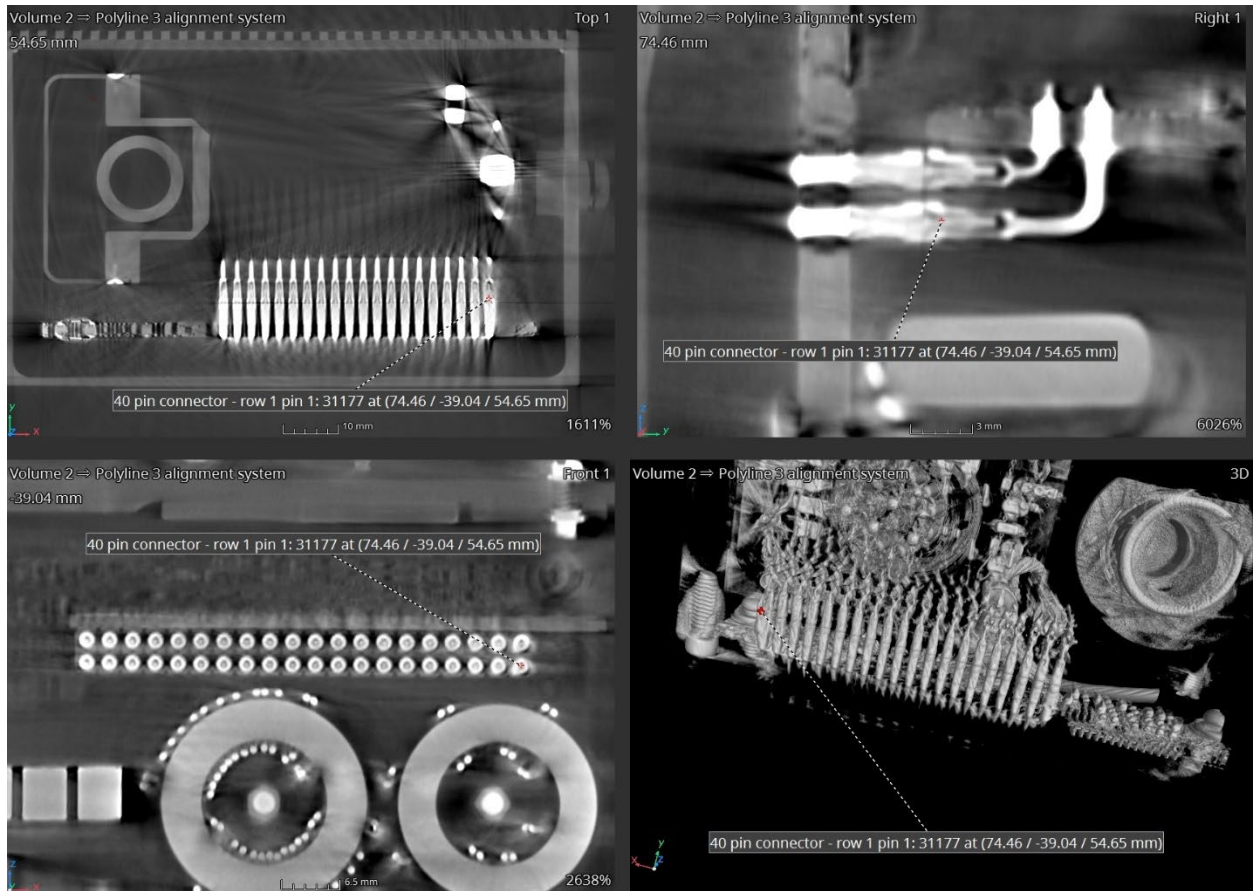


Figure 25. Left TACS control unit - 40 pin connector row 1.

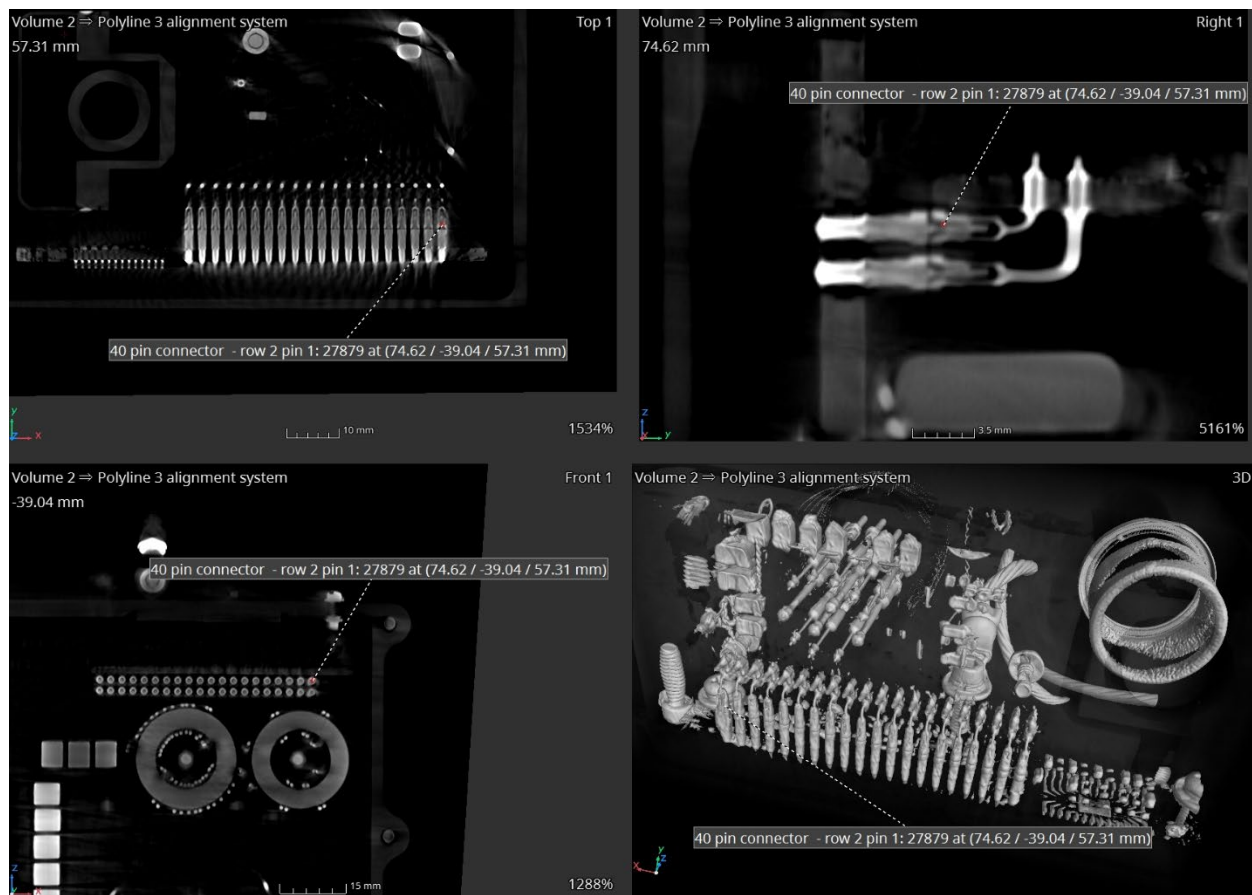


Figure 26. Left TACS control unit - 40 pin connector row. 2

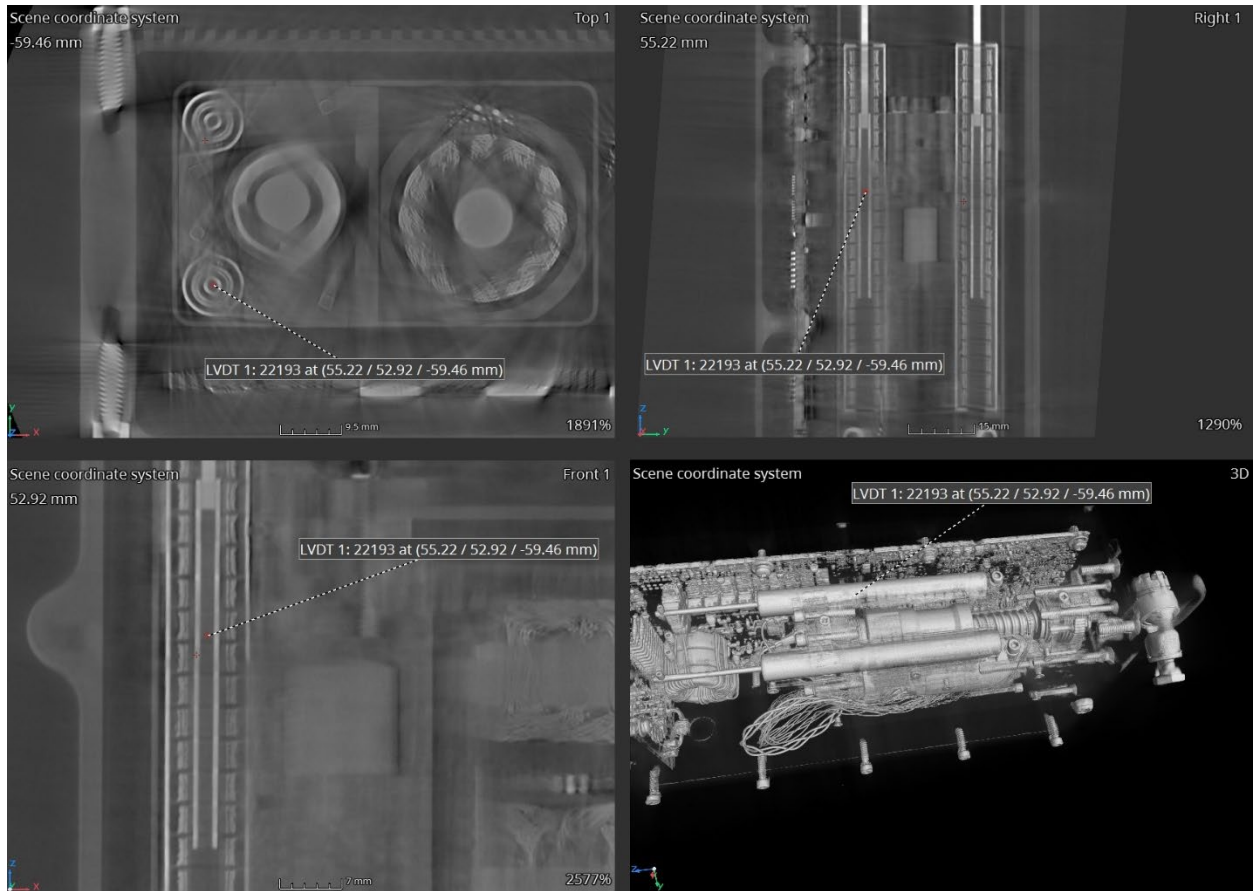


Figure 27. Left TACS control unit - LVDT 1.

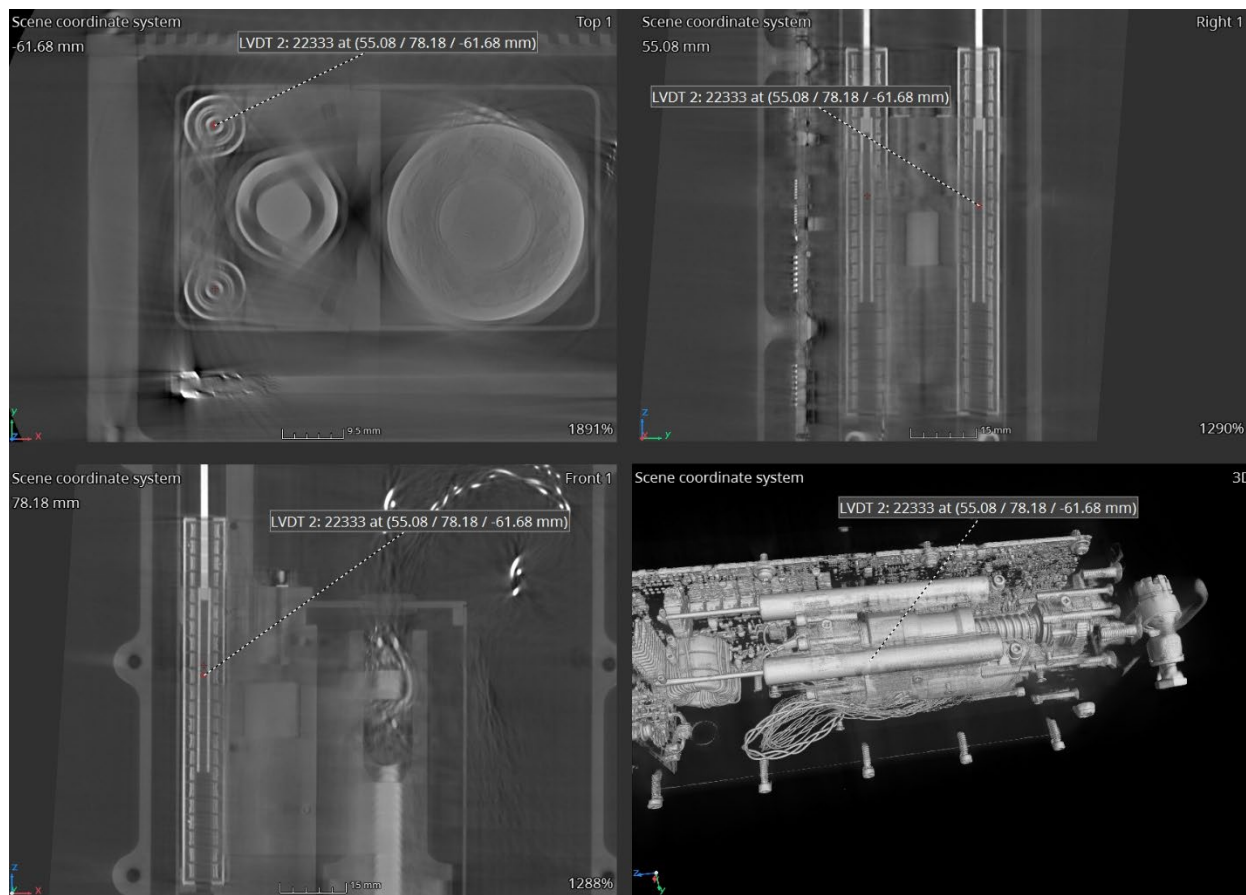


Figure 28. Left TACS control unit - LVDT 2.

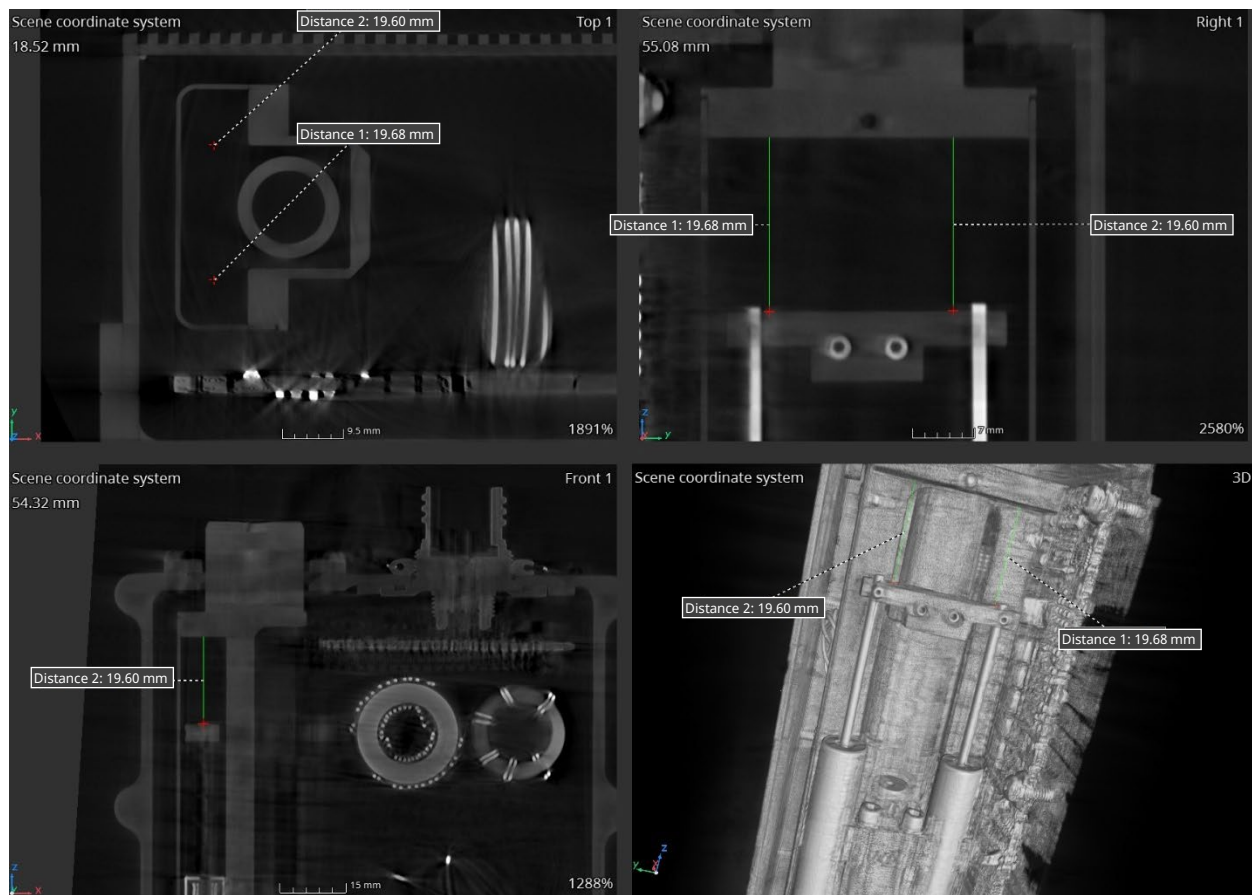


Figure 29. Left TACS control unit - LVDT to housing distance.



Figure 30. Left TACS control unit - LVDT 1 set screw.

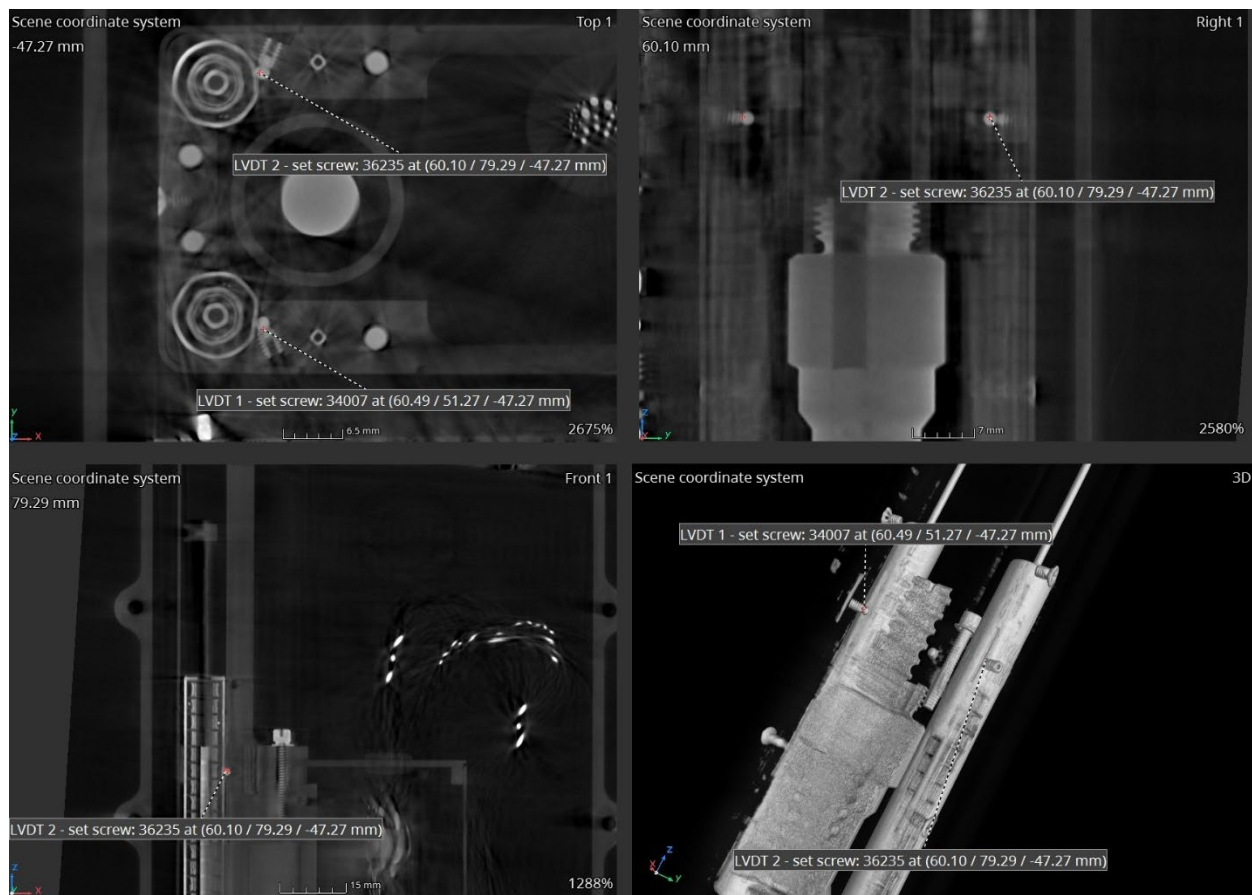


Figure 31. Left TACS control unit – LVDT 2 set screw.

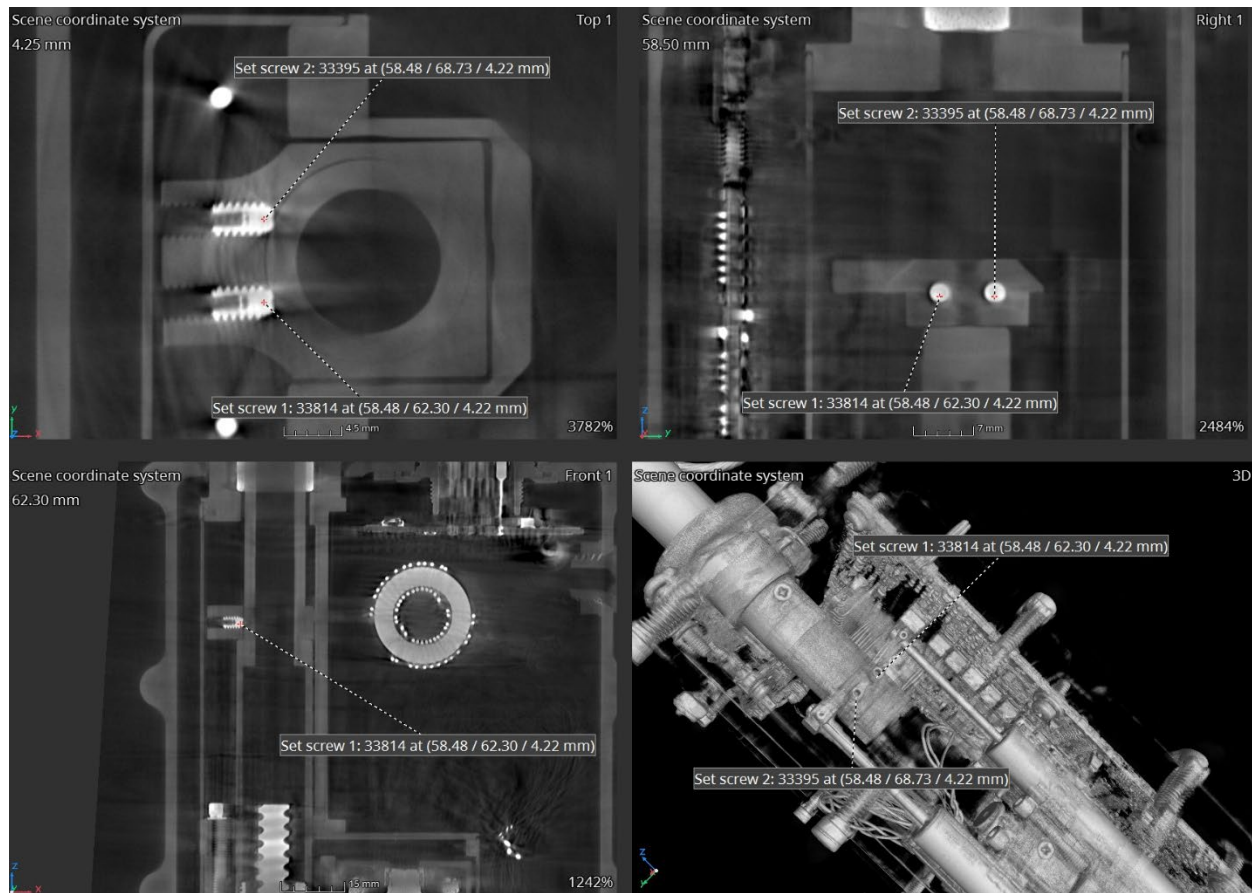


Figure 32. Left TACS control unit - LVDT attachment set screws 1 and 2.

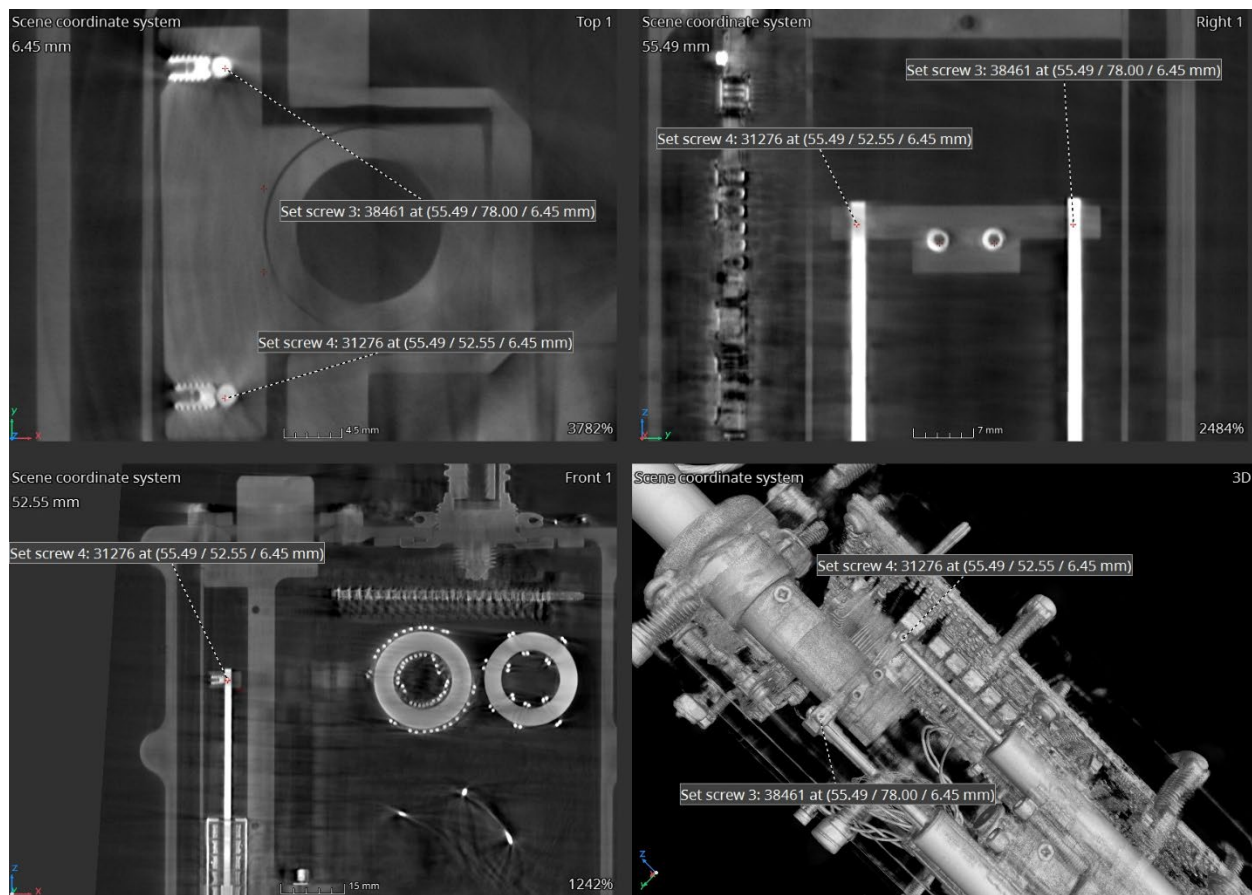


Figure 33. Left TACS control unit - LVDT attachment set screws 3 and 4.

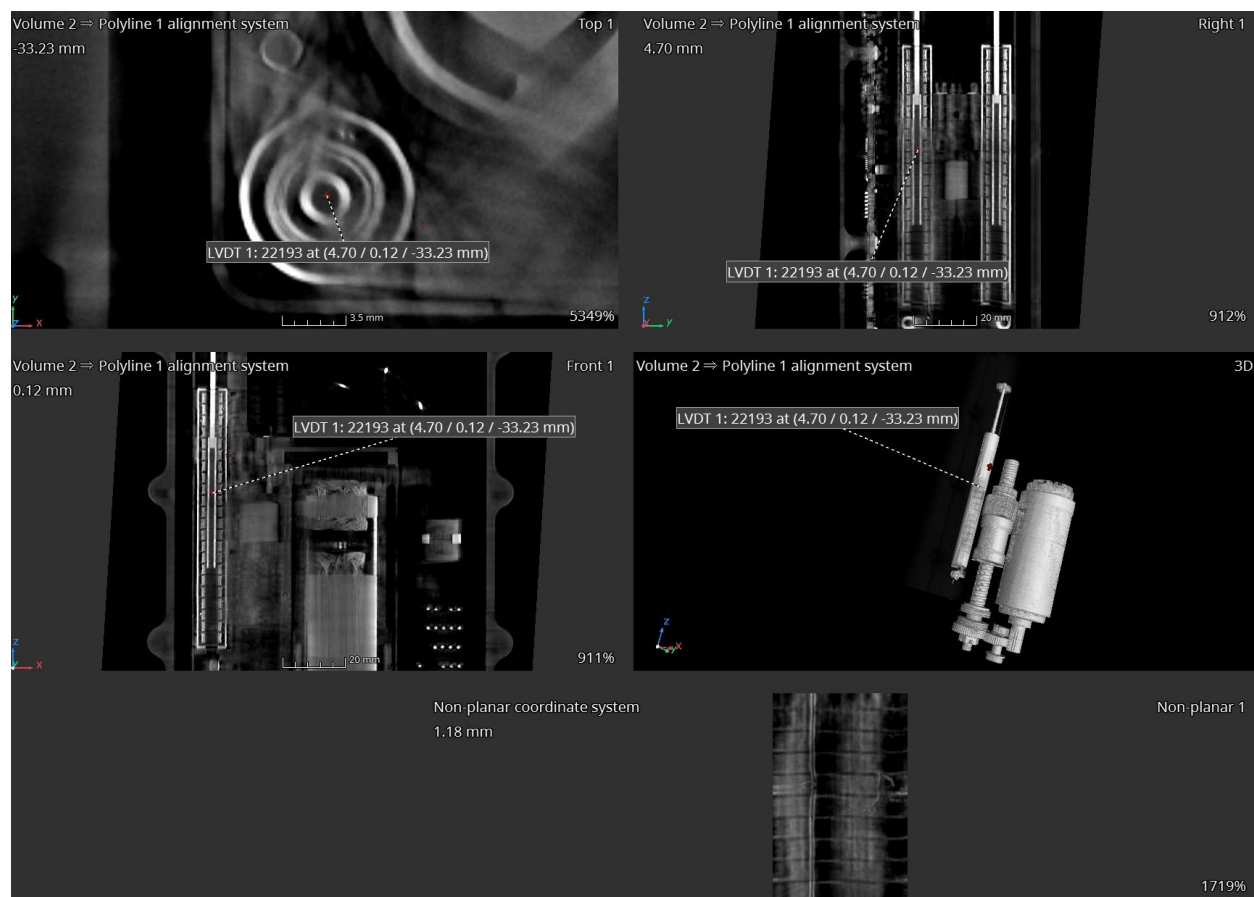


Figure 34. Left TACS control unit - LVDT 1.

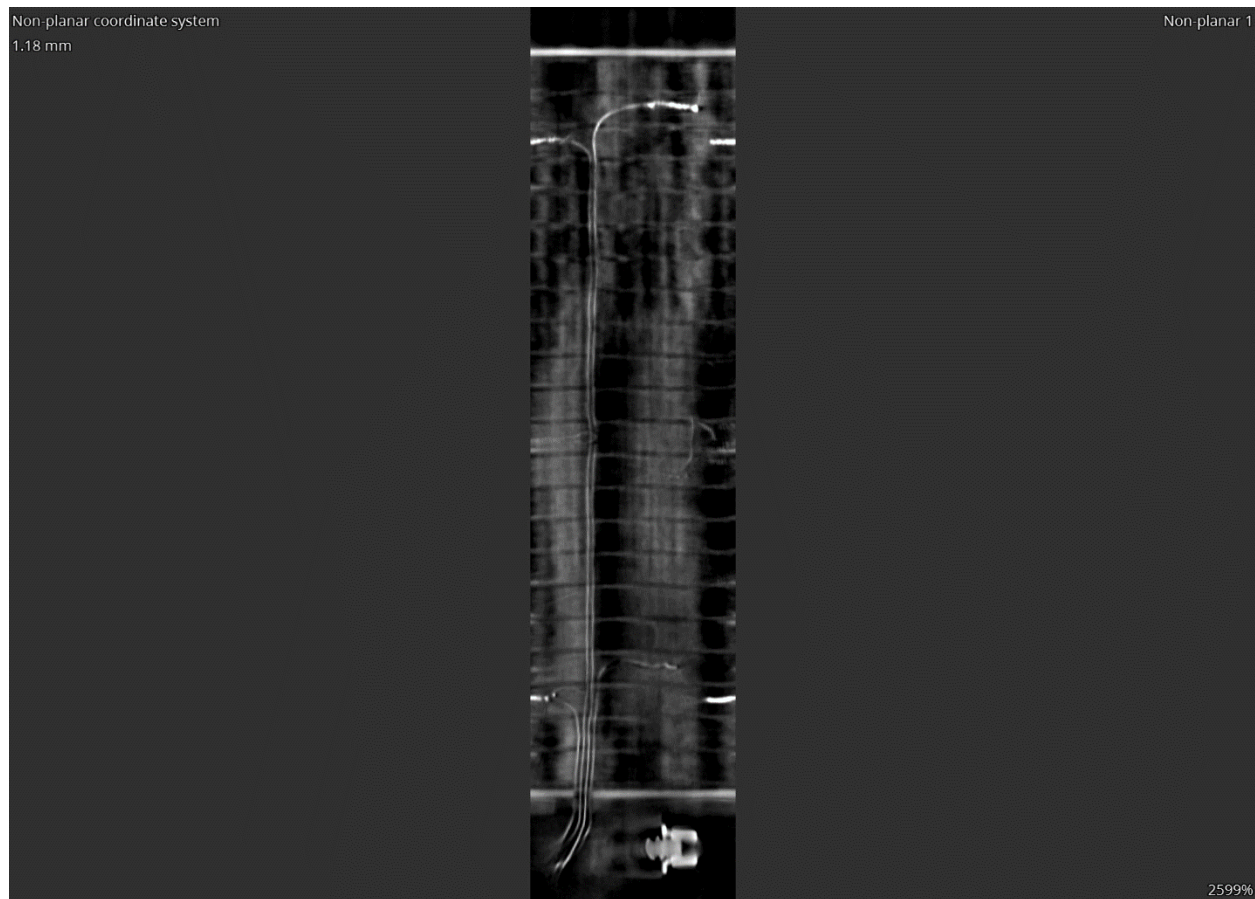


Figure 35. Left TACS control unit - LVDT 1 unrolled.



Figure 36. Left TACS control unit – LVDT 1 – wire anomaly 1.



Figure 37. Left TACS control unit - LVDT 1 wire anomaly 2.

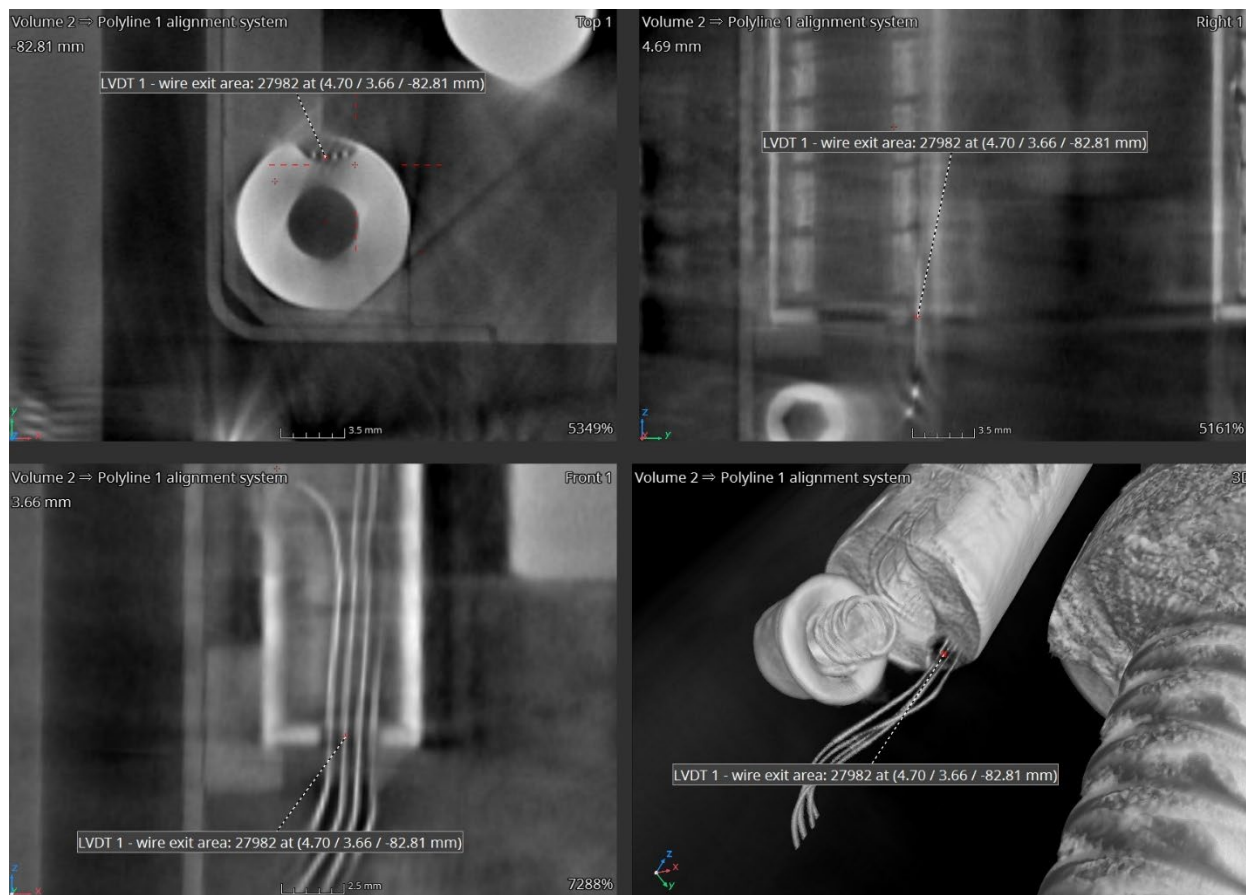


Figure 38. Left TACS control unit - LVDT 1 wire exit area.

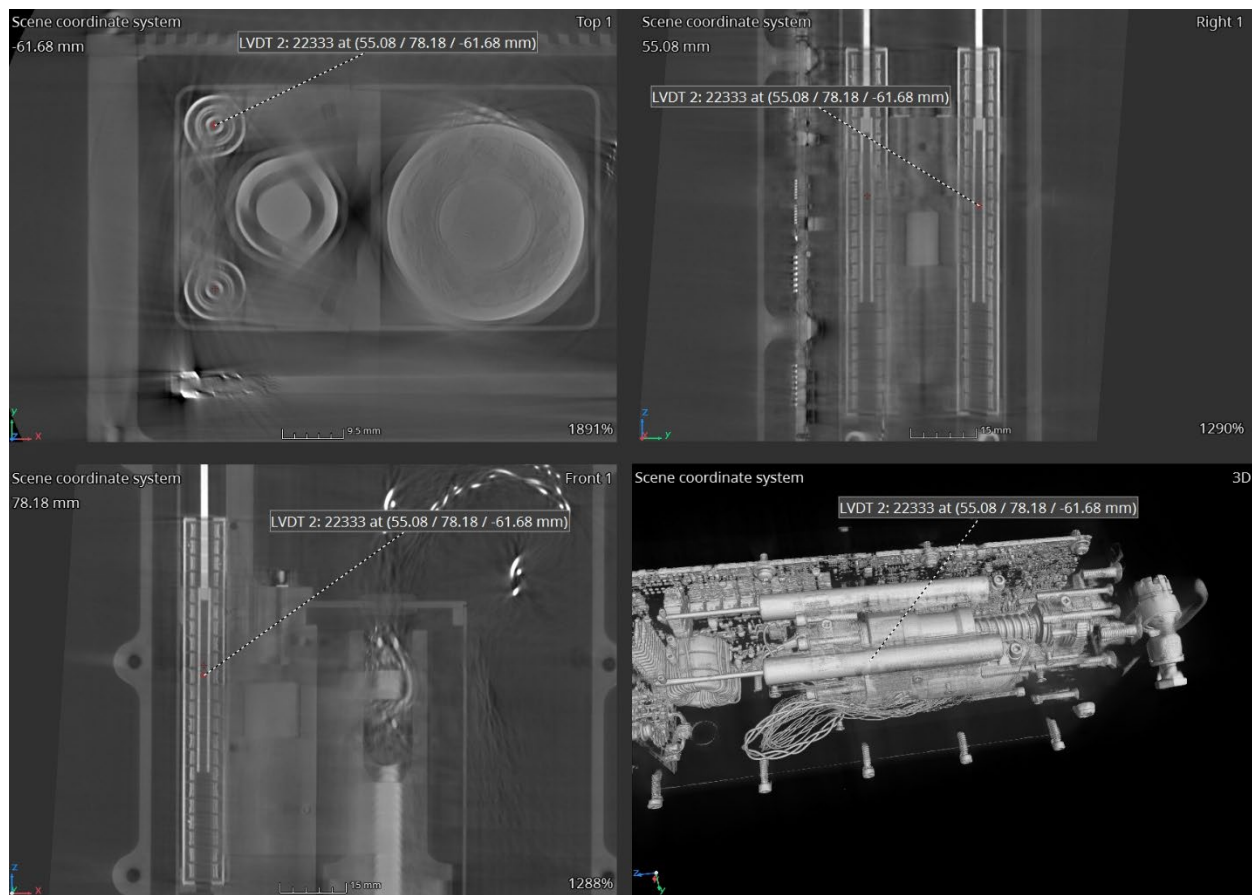


Figure 39. Left TACS control unit - LVDT 2.

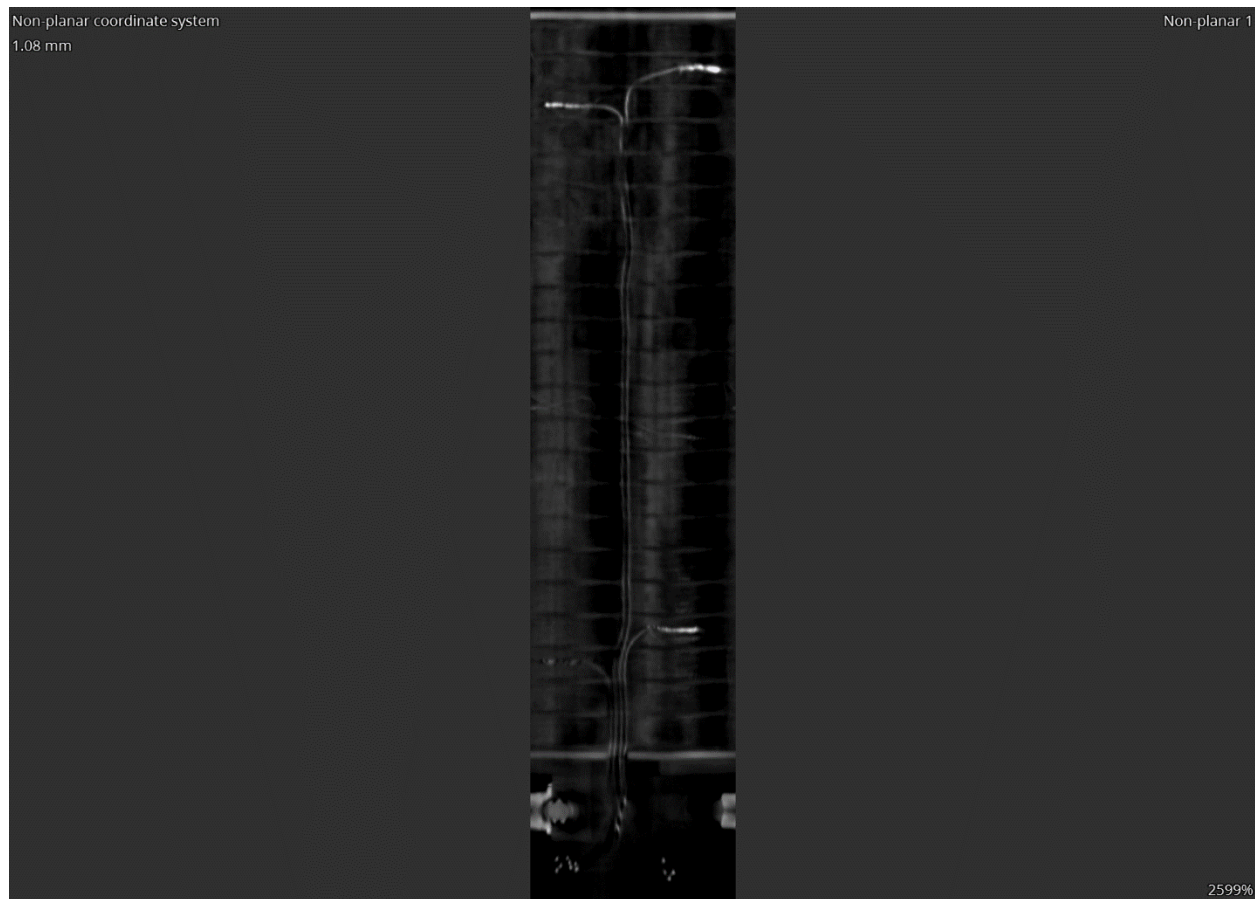


Figure 40. Left TACS control unit - LVDT 2 unrolled.

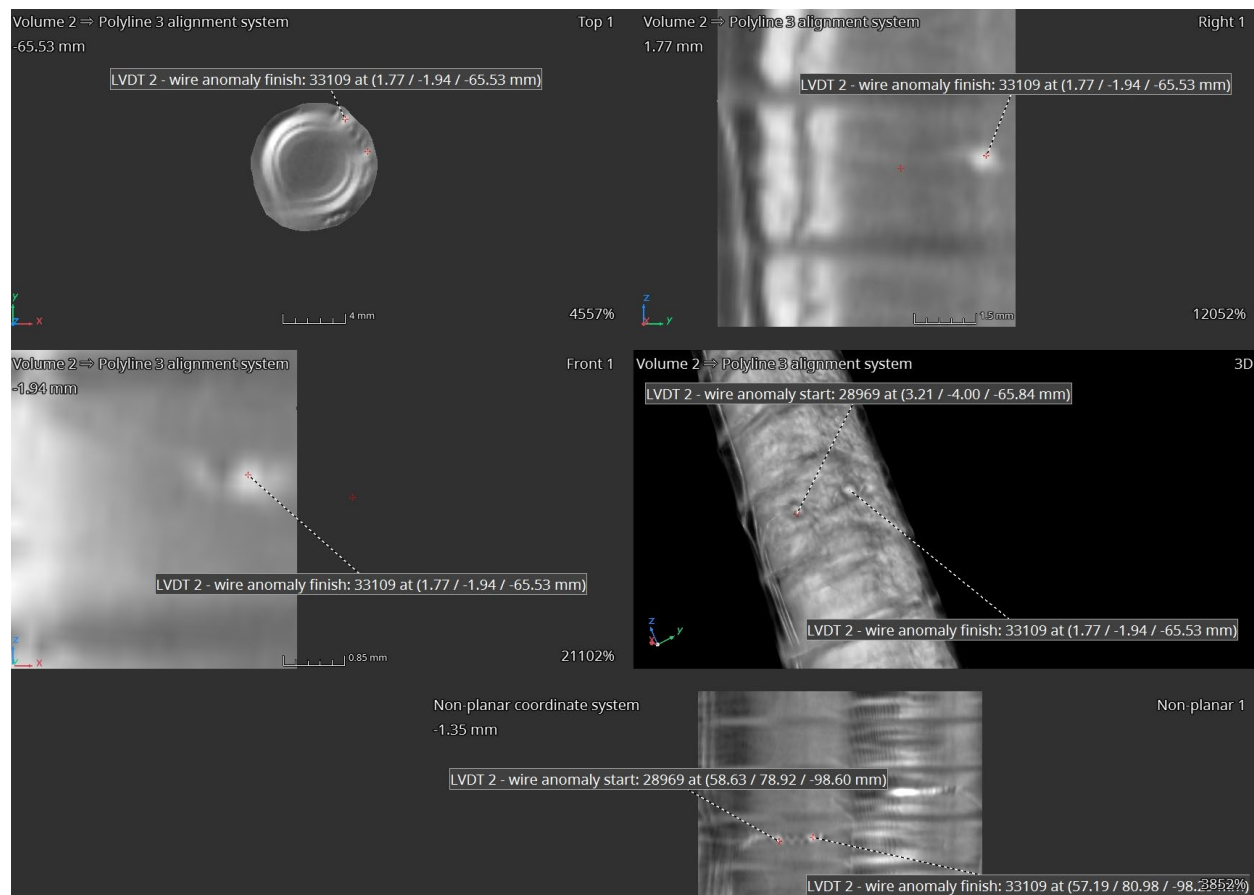


Figure 41. Left TACS control unit - LVDT 2 wire anomaly 1.

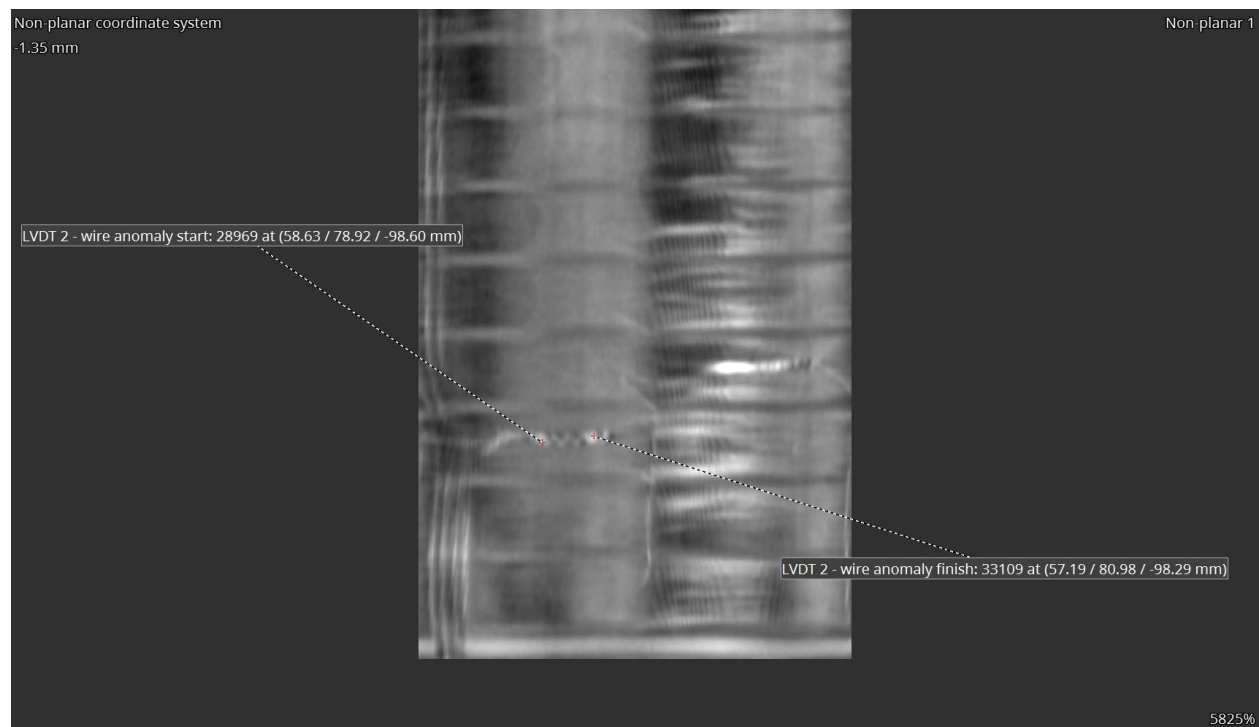


Figure 42. Left TACS control unit - LVDT 2 wire anomaly 1 unrolled.



Figure 43. Left TACS control unit - LVDT 2 wire anomaly 2.



Figure 44. Left TACS control unit – LVDT 2 wire exit area.

Submitted by:

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