

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

November 17, 2016

Computed Tomography Specialist's Factual Report

ERA-16-FA-043

A. ACCIDENT

Operator: Kavak Aviation, LLC
Location: Clear Lake, Orlando, Florida
Date: November 20, 2015
Time: 1127 eastern standard time
Airplane: Beech A36TC, N7FG

B. GROUP

Computed
Tomography
Specialist: Scott Warren
National Transportation Safety Board
Washington, D.C.

C. SUMMARY

On November 20, 2015, about 1127 eastern standard time, a Beech A36TC, N7FG, descended into Clear Lake, Orlando, Florida. The private pilot and one passenger were fatally injured, and the airplane was destroyed. The airplane was registered to and operated by Kavak Aviation, LLC, under the provisions of 14 Code of Federal Regulations (CFR) Part 91 as a personal flight. Visual meteorological conditions prevailed at the time, and a visual flight rules flight plan was filed. The flight originated from Orlando Executive Airport (ORL), Orlando, Florida, about 1115 eastern standard time, and was destined for Gainesville Municipal Airport (GLE), Gainesville, Texas.

The internal configurations of the autopilot disconnect relay, the autopilot disconnect/trim interrupt switch and the autopilot trim switch assembly¹ were documented using radiographic images that were collected from August 10-18, 2016 in Chicago, Illinois. A total of 8,495 computed tomography (CT) slice images were examined, processed, and analyzed by the NTSB to evaluate the components.

Review of the autopilot disconnect relay images showed that only pins 4, 12, 13, and 14 had external connections; there was a potential low clearance point between the power lead from pin 13 and the relay coil; and there were no indications of broken components, interference between components, welded contacts, or other anomalies within the relay.

Review of the autopilot disconnect/trim interrupt switch images indicated that there were cracks in the switch insulator; there was an indentation in one of the contacts; there were no indications of welded contacts within the component; there were grooves in the moving contact body consistent with wear patterns from the springs; and there was one terminal lug with a solder fill pattern that appeared to be different from the other lugs.

Review of the autopilot trim switch assembly images indicated that there were cracks in the switch housing; rocker switch 01 was displaced from the vertical position; there were deformation indications on some corners of both switch rocker 01 and 03; the stop plates for both rocker switch 01 and 03 were deformed; there were no indications of broken components, welded contacts, or foreign materials within the microswitches; and the wire spring for rocker switch 01 appeared to be interfering with the movement of the switch 101 actuator.

D. DETAILS OF THE INVESTIGATION

1.0 General

The autopilot disconnect relay, the autopilot disconnect/trim interrupt switch and the autopilot trim switch assembly were subjected to x-ray computed tomography

¹ The autopilot trim switch assembly is also referred to in various publications as the “elevator trim switch”, “pitch trim switch”, or “manual electric trim switch”.

(CT) scanning to document their internal conditions. The scanning was conducted from August 10-18, 2016. The scans were performed by Varian Medical Systems, Inc under the direction of the NTSB using the Varian Actis 500/225 microfocus CT system.

For the CT scans, the components were each individually loaded into the imaging unit and placed on a turntable. Each 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 fan or cone 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 captured 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 components were scanned using a total of 8,495 slices, and the total size of the combined data sets was 55.76 Gb. A target CT scan of the autopilot disconnect/trim interrupt switch was conducted to provide better resolution within the solder joint areas of the autopilot disconnect/trim interrupt switch. The complete scan protocols are given in table 1. The CT axial slice images were provided to the NTSB where they were examined, processed, and analyzed to evaluate the components.

Table 1
Scan Protocol

Component	Autopilot disconnect relay	Autopilot disconnect/trim interrupt switch (full scan)	Autopilot disconnect/trim interrupt switch (target CT)	Autopilot trim switch assembly
Number of slices	2092	2701	601	3101
Voxel Size - X Direction (mm)	0.022	0.011	0.011	0.015
Voxel Size - Y Direction (mm)	0.022	0.011	0.011	0.015
Voxel Size - Z Direction (mm)	0.02	0.01	0.01	0.01
Image Projections per Revolution	1800	1800	1800	2160
Exposure time (ms)	285.58	285.58	285.58	285.58
Frames to Avg (frames per projection)	2	2	2	2
X-ray Source Voltage (kV)	222	200	200	223
X-ray Source Current (mA)	0.490	0.400	0.400	0.450
Source Filter Thickness (mm)	1.0	2.0	2.0	2.0 1.0
Source Filter Material	Brass	Brass	Brass	Brass Copper
Image Maxtrix Size	2048 x 2048	2048 x 2048	2048 x 2048	2048 x 2048

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 the images, the high density areas were shown as brighter shades of gray and lower density areas were shown as darker shades of gray. The pointers shown in some of the images denote specific areas of interest within that 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.

2.0 Computed Tomography Results

2.1 Autopilot disconnect relay

The computed tomography (CT) results for the autopilot disconnect relay are shown in figures 1 through 17. Review of the images showed that only pins 4, 12, 13, and 14 had external connections; there was a potential low clearance point between the power lead from pin 13 and the relay coil; and there were no indications of broken components, interference between components, welded contacts or other anomalies within the relay.

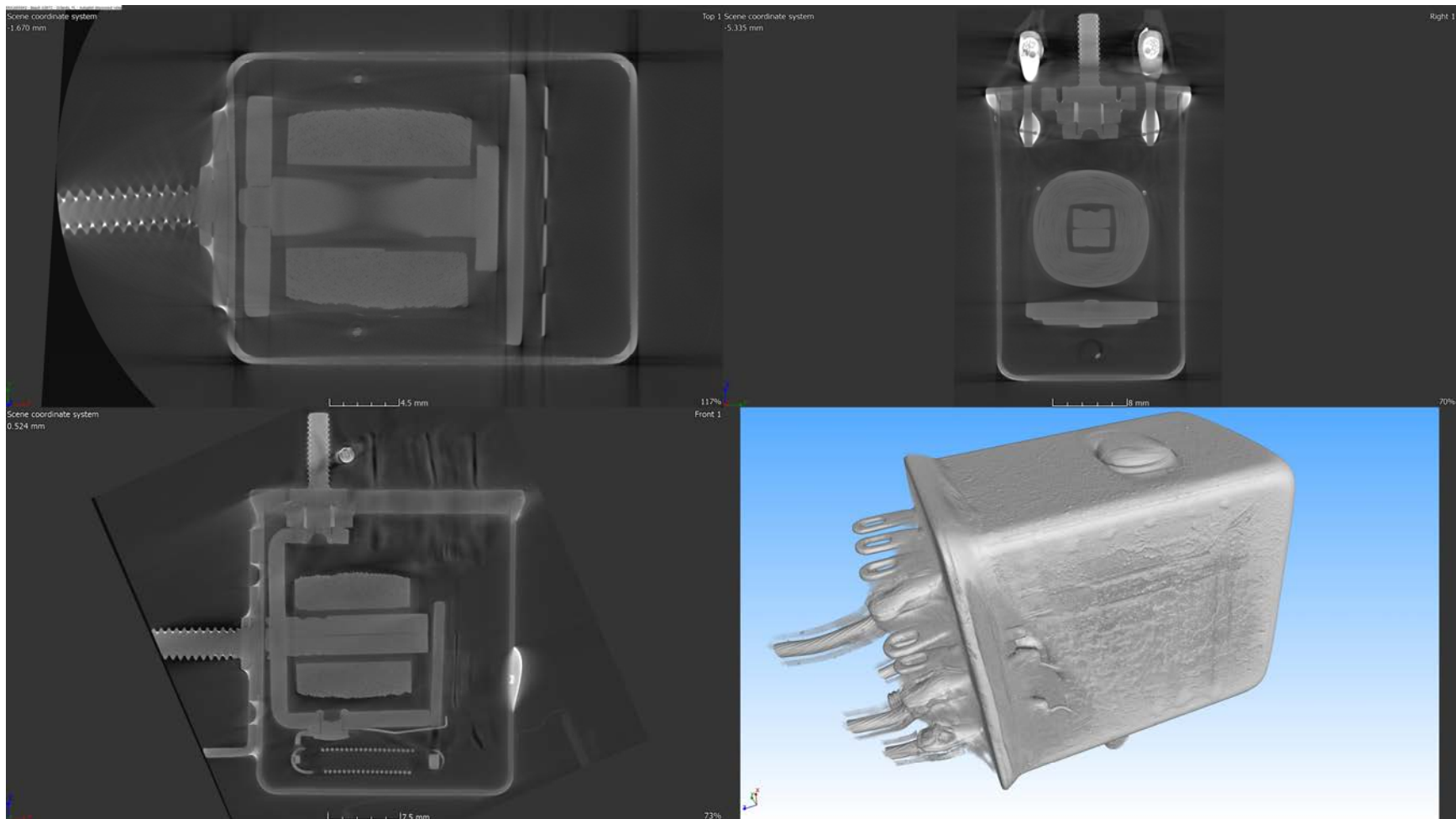


Figure 1
Autopilot disconnect relay – Overall view

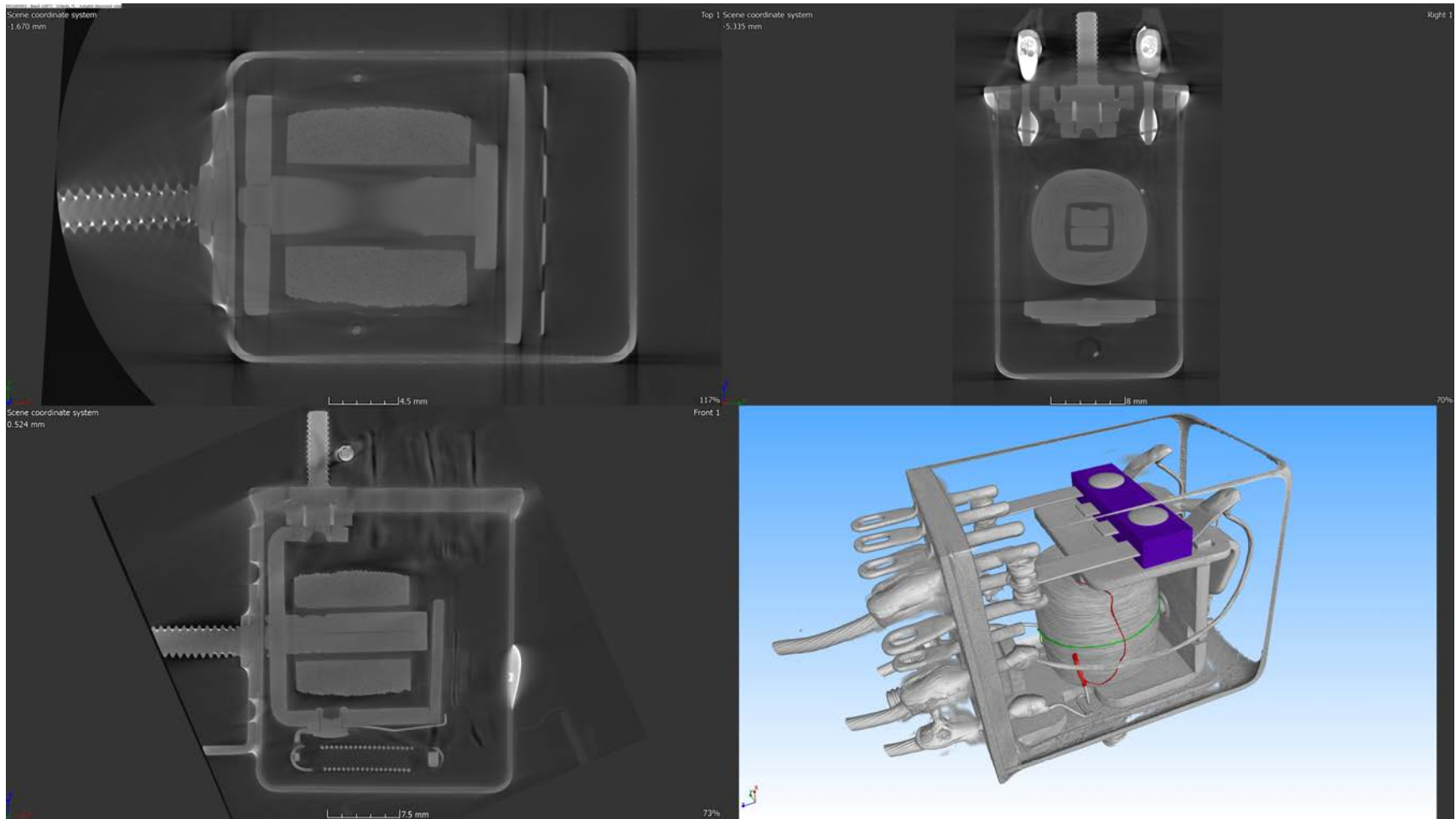


Figure 2
Autopilot disconnect relay – Overall view with cover digitally removed

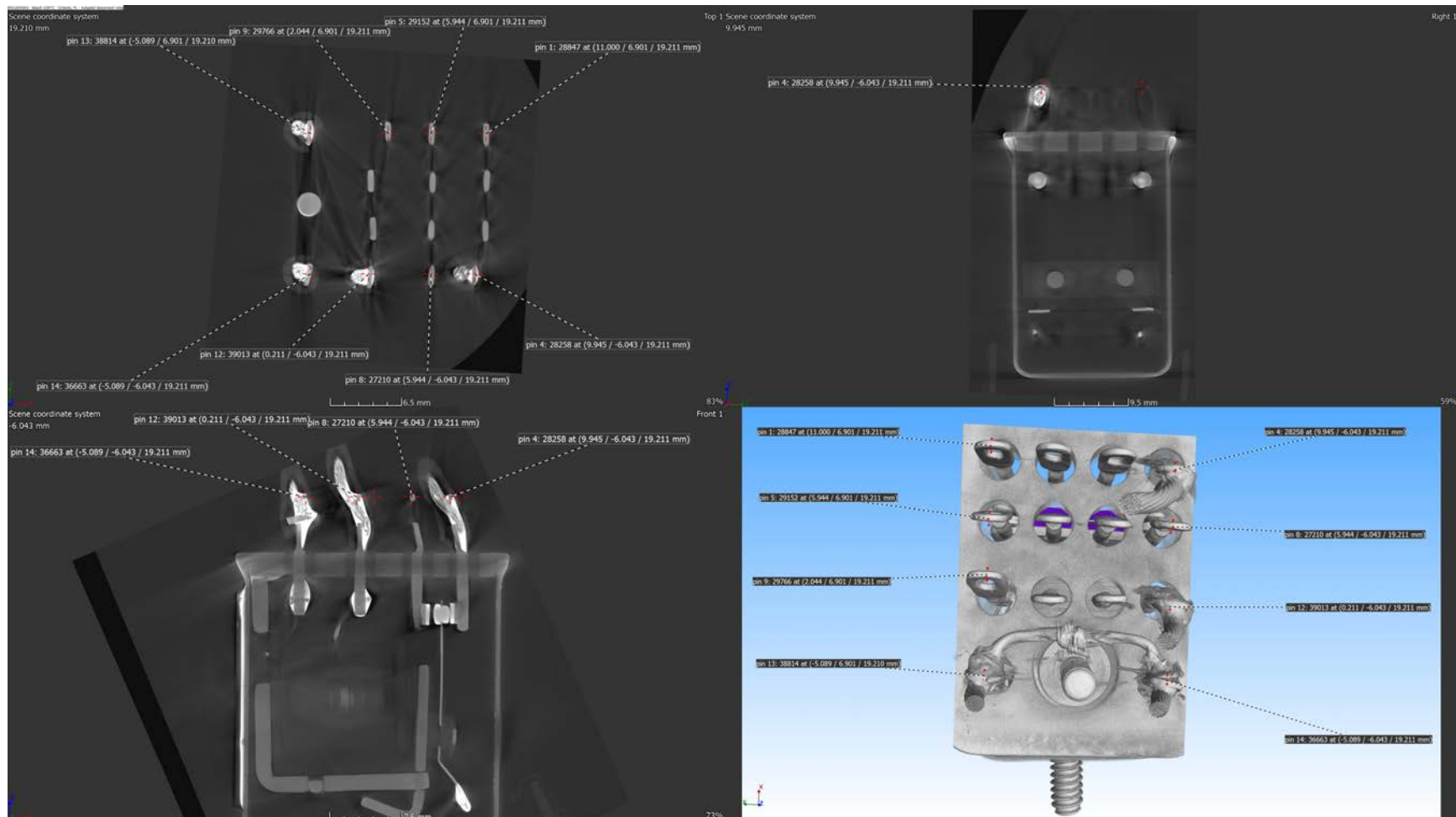


Figure 3
Autopilot disconnect relay – Pin locations

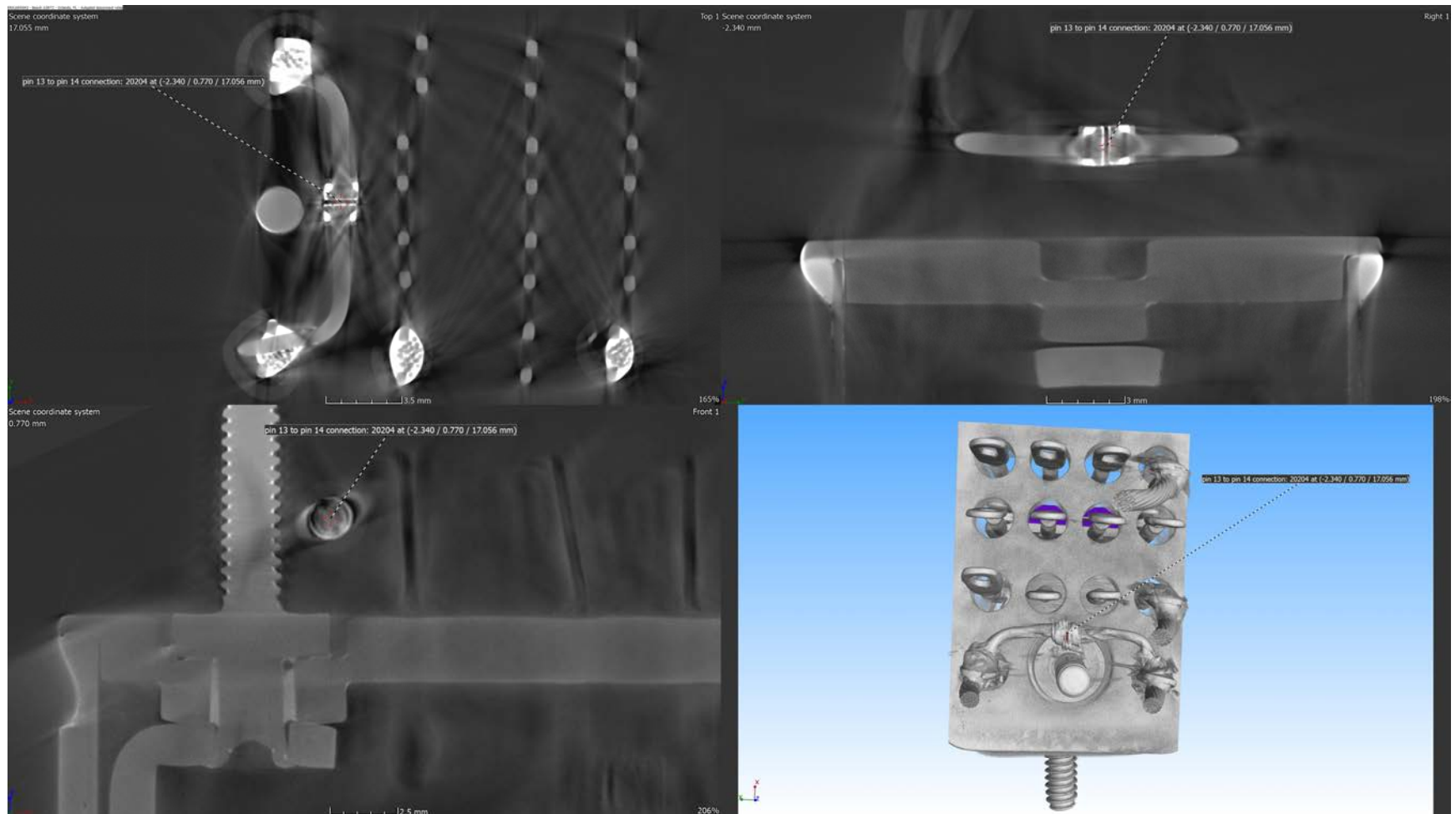


Figure 4
Autopilot disconnect relay – Pin 13 to pin 14 connection

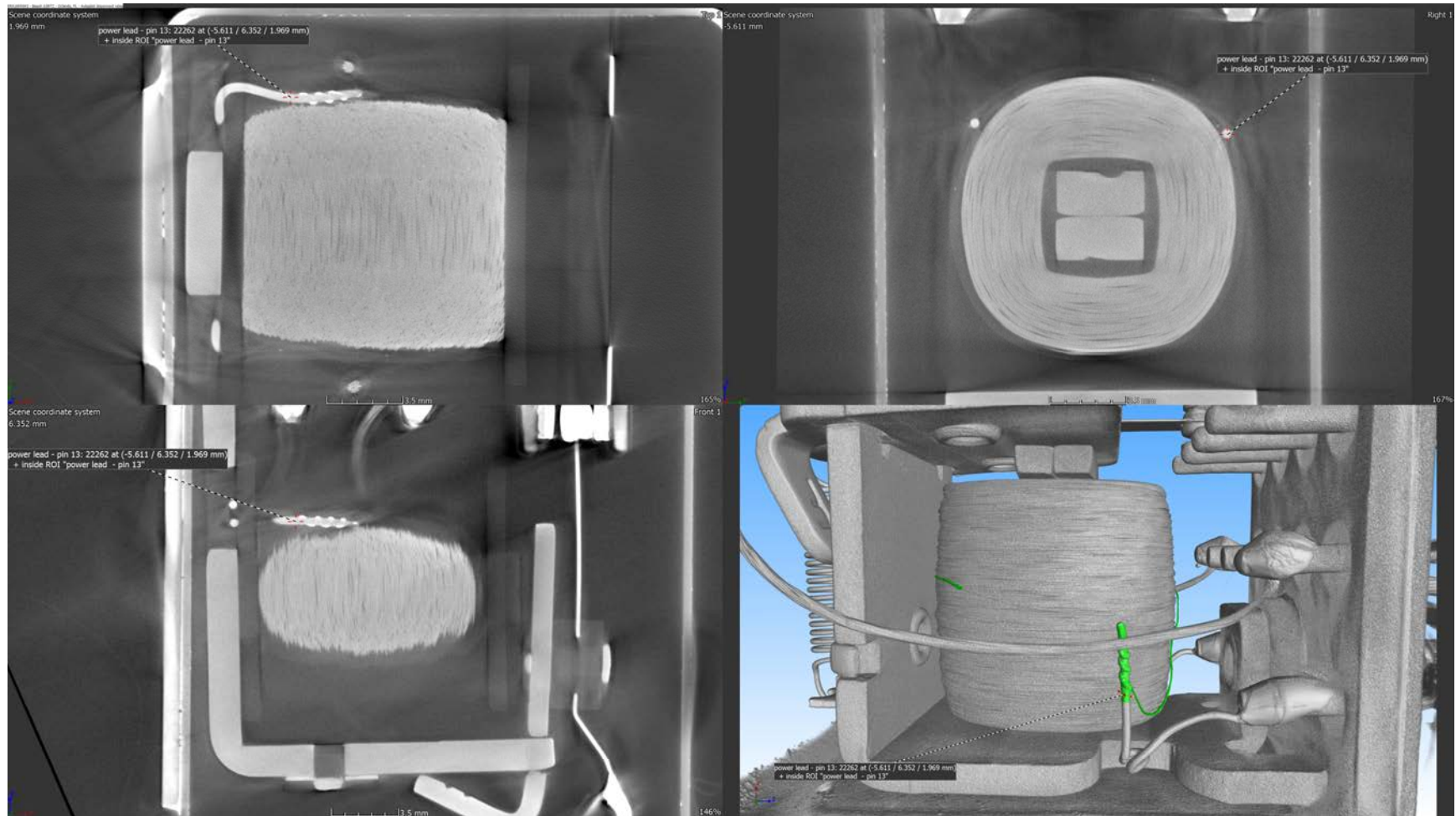


Figure 5
Autopilot disconnect relay – Power lead – pin 13

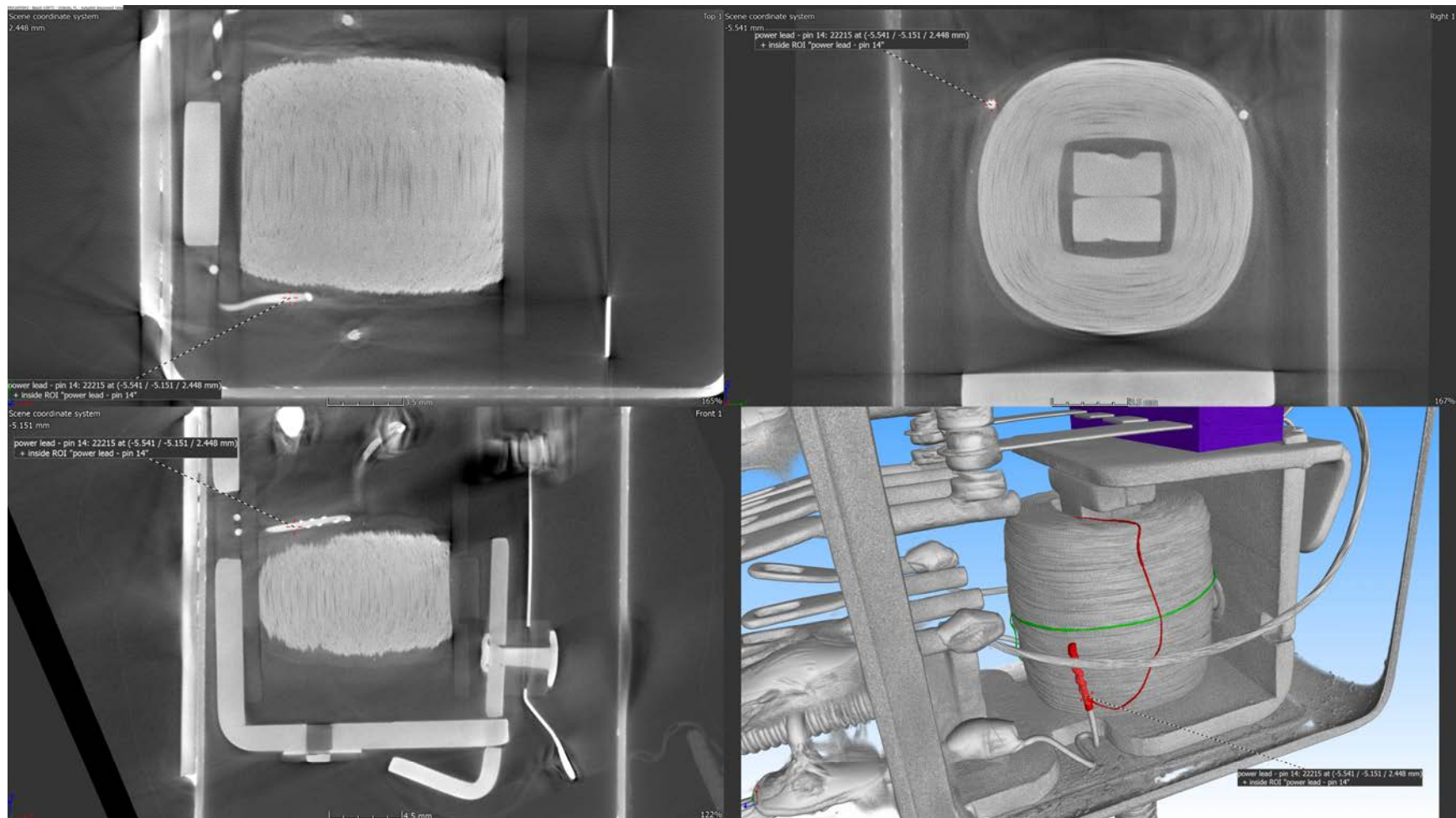


Figure 6
Autopilot disconnect relay – Power lead – pin 14

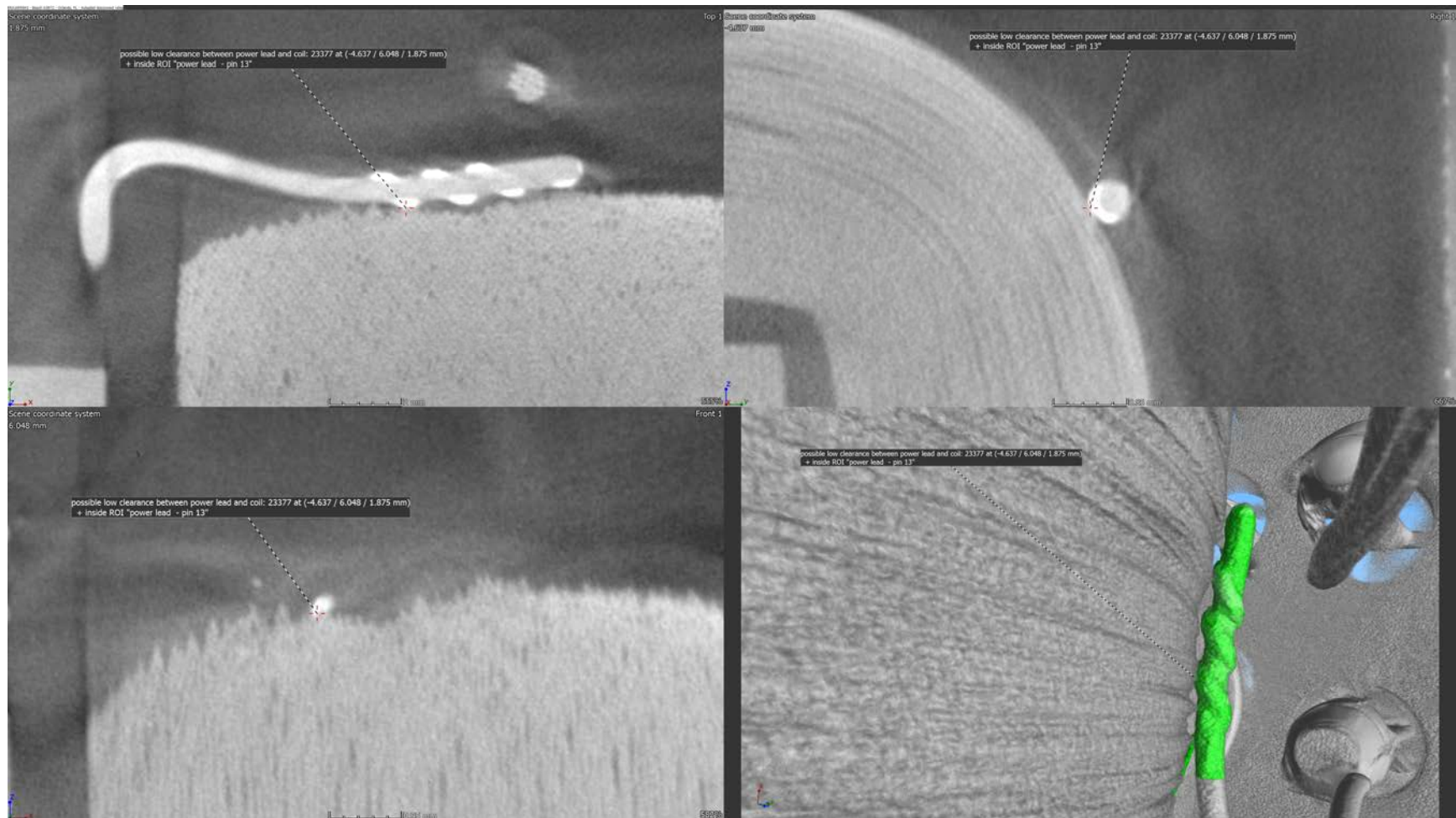


Figure 7
Autopilot disconnect relay – Possible low clearance between power lead and coil

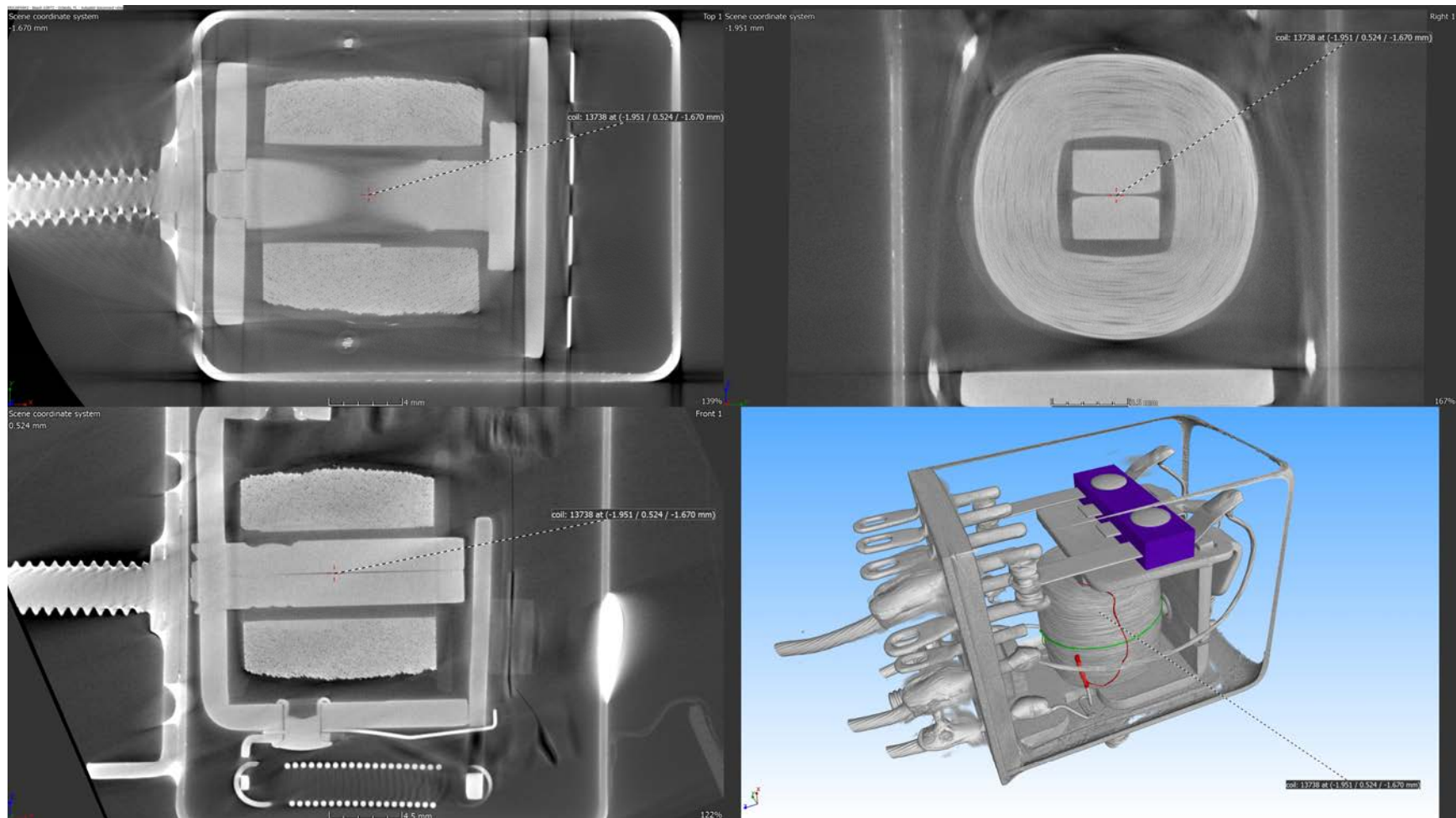


Figure 8
Autopilot disconnect relay – Coil

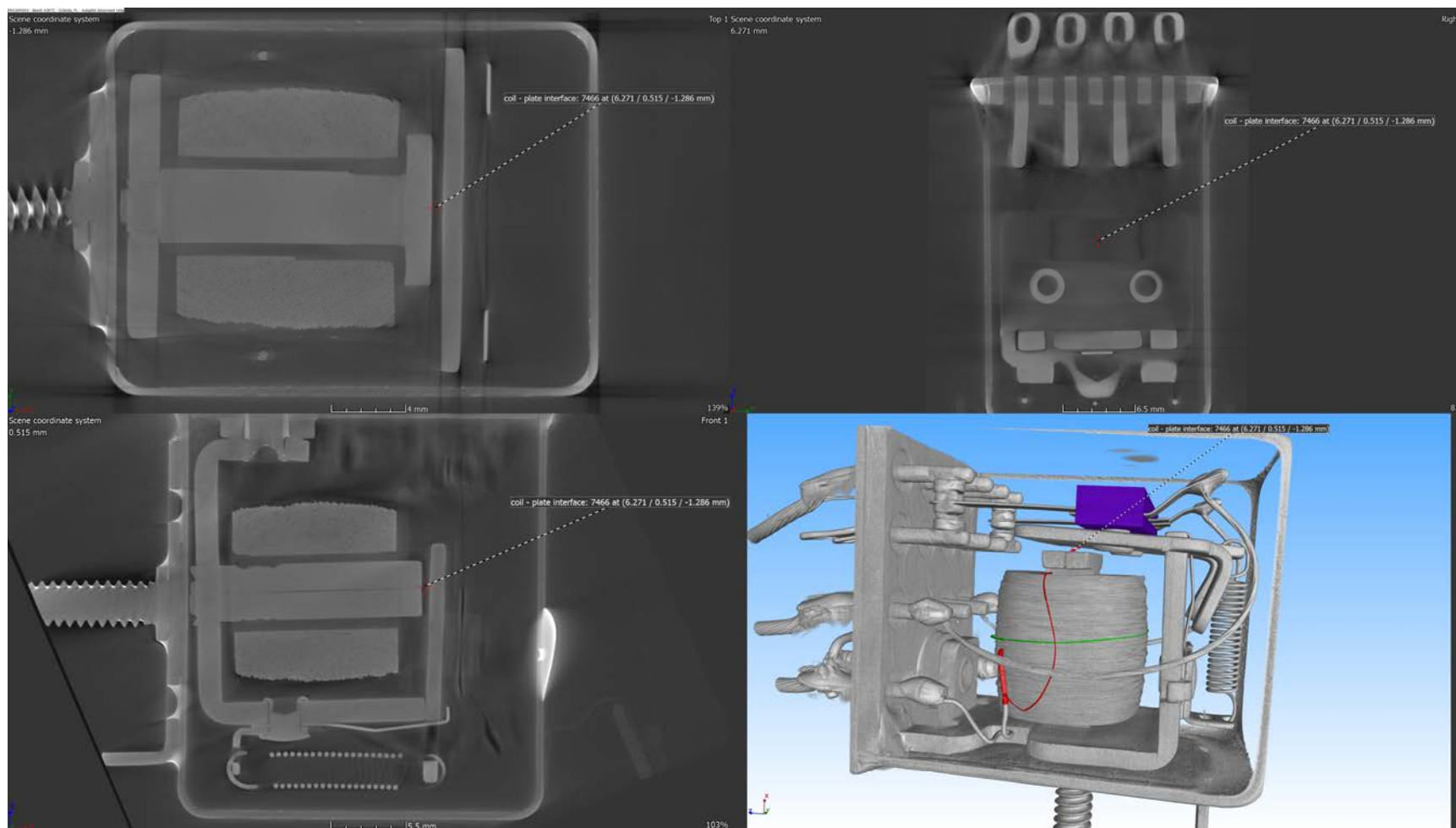


Figure 9
Autopilot disconnect relay – Coil-plate interface

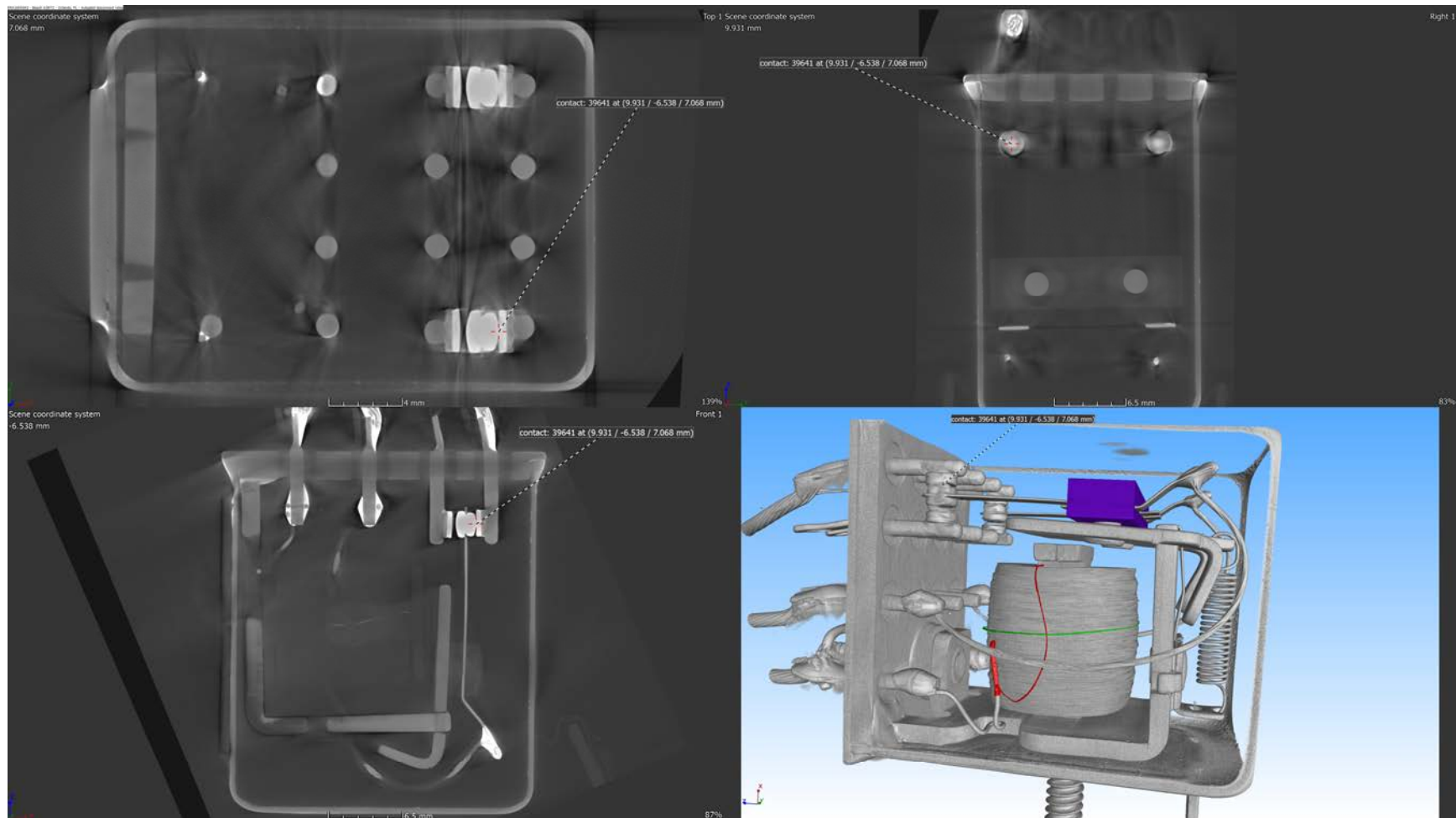


Figure 10
Autopilot disconnect relay – Contact

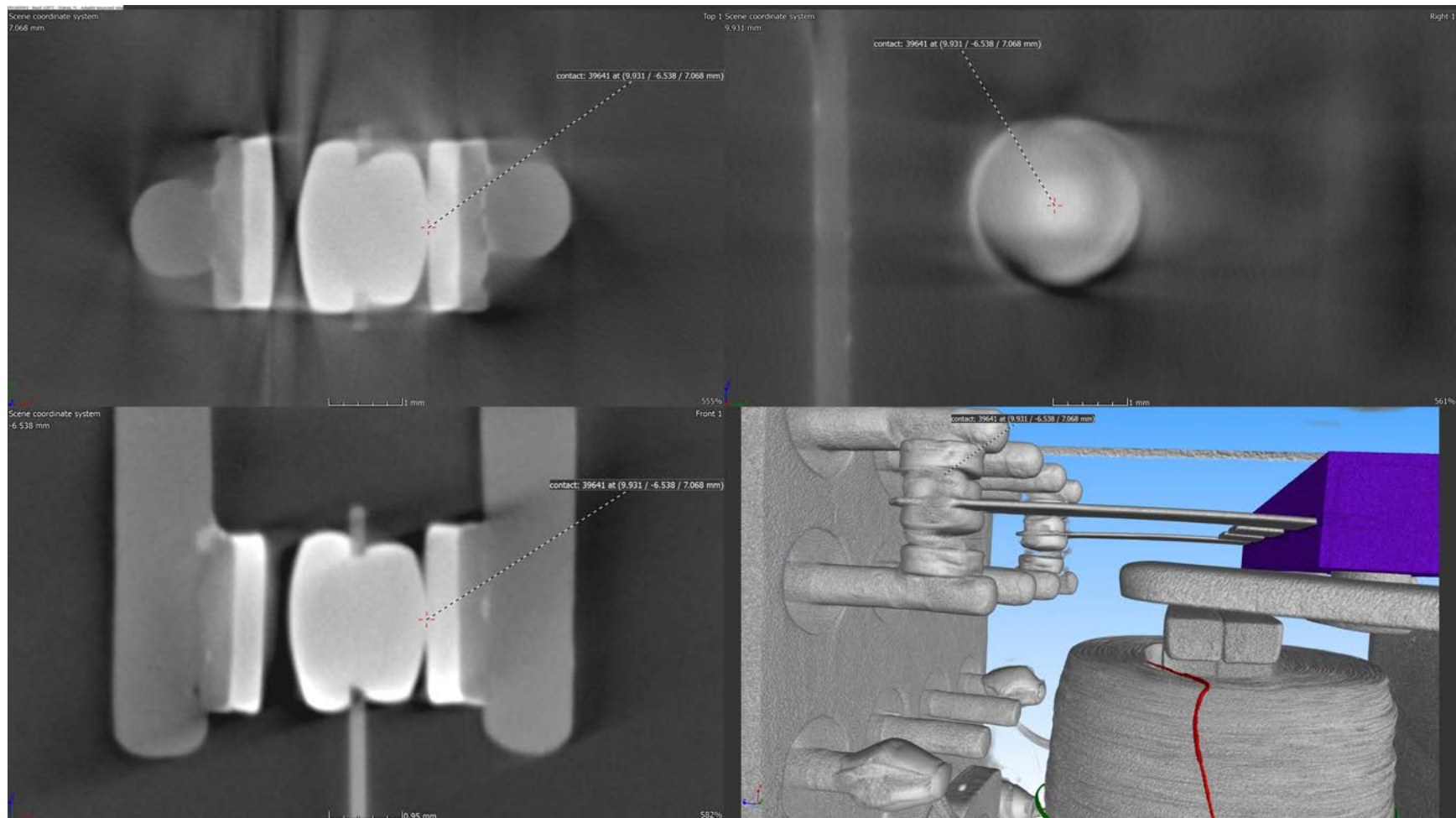


Figure 11
Autopilot disconnect relay – Contact – close up view

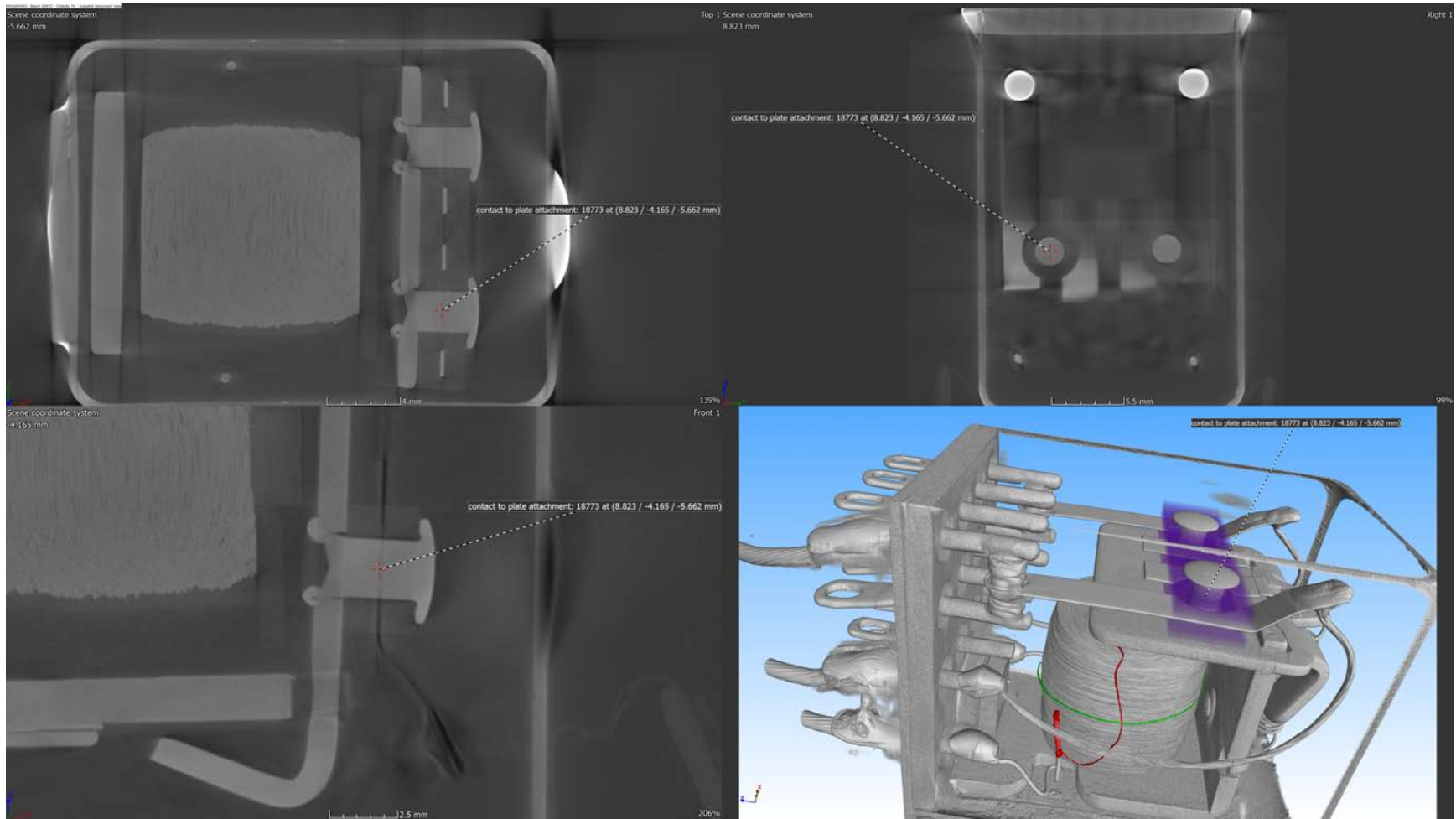


Figure 12
Autopilot disconnect relay – Contact to plate attachment

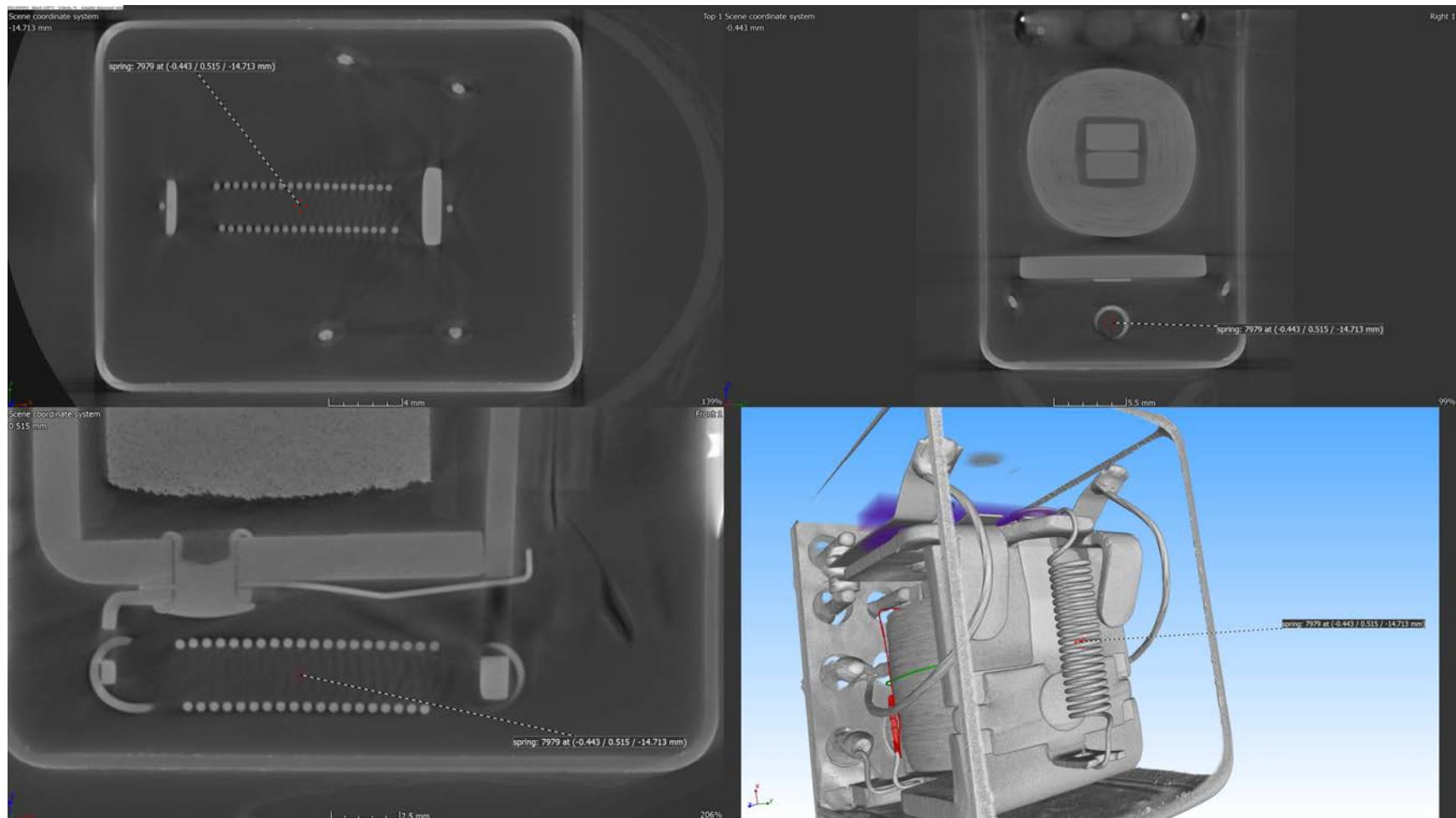


Figure 13
Autopilot disconnect relay – Spring

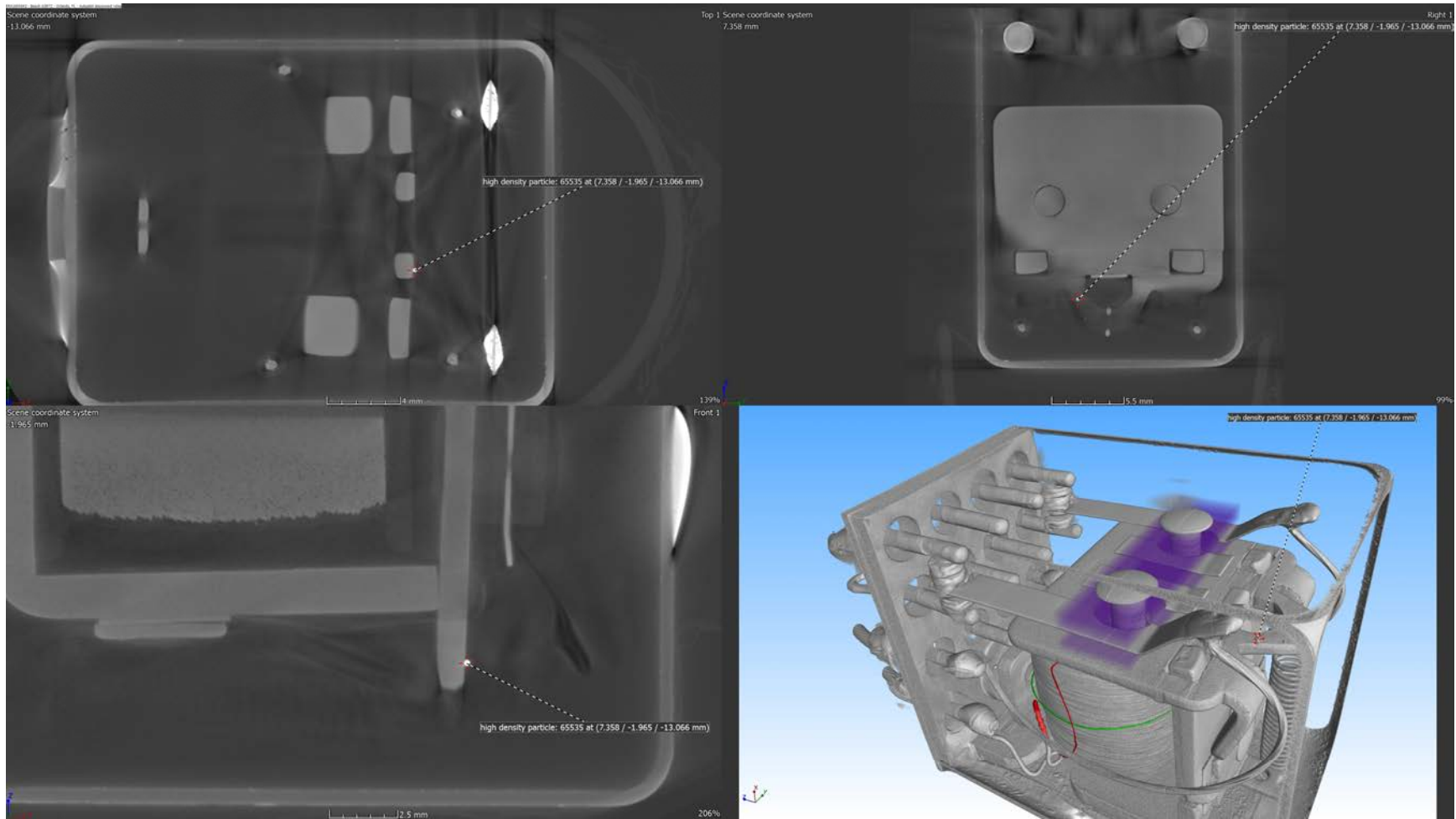


Figure 14
Autopilot disconnect relay – High density particle

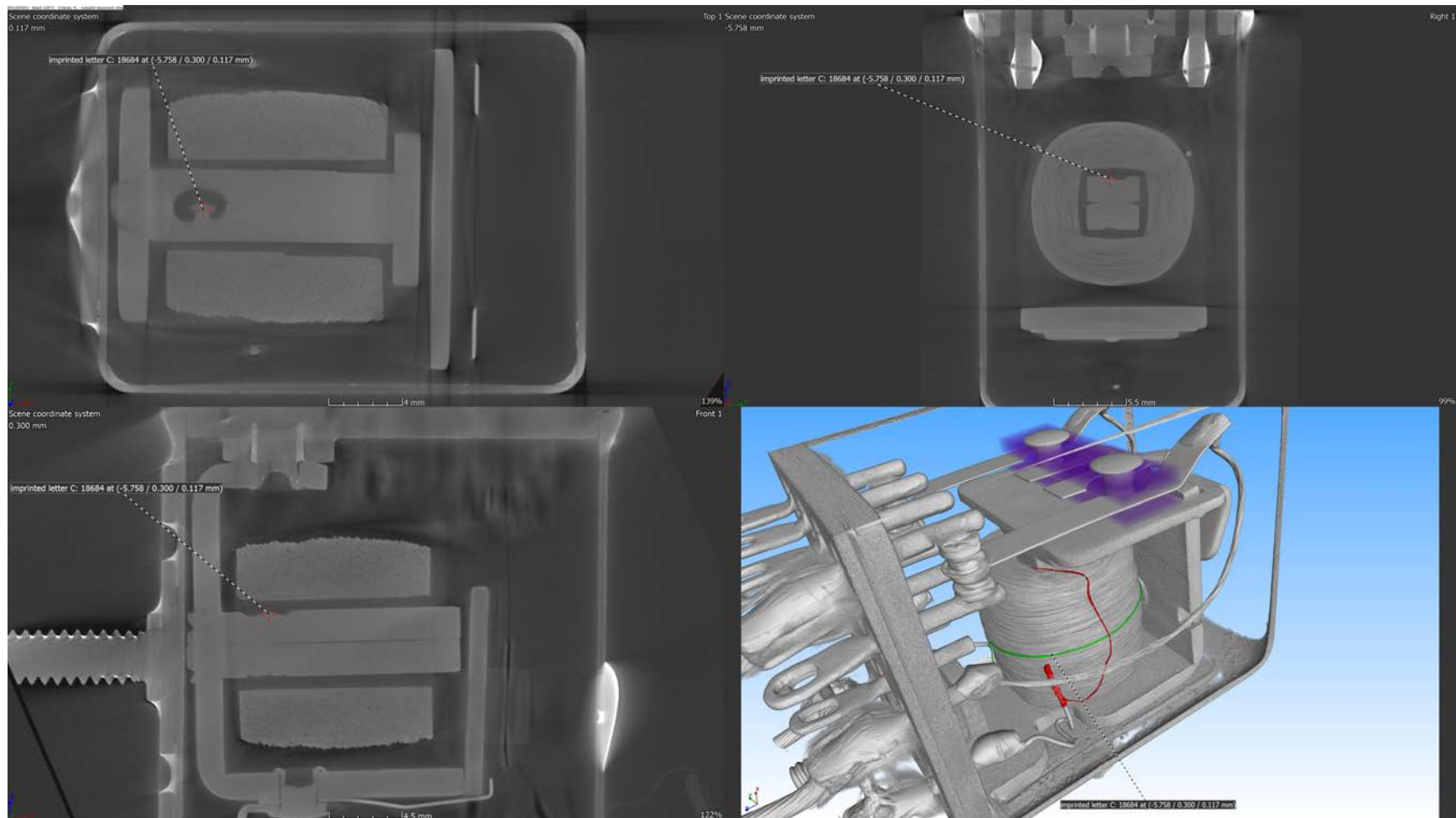


Figure 15
Autopilot disconnect relay – Imprinted letter C

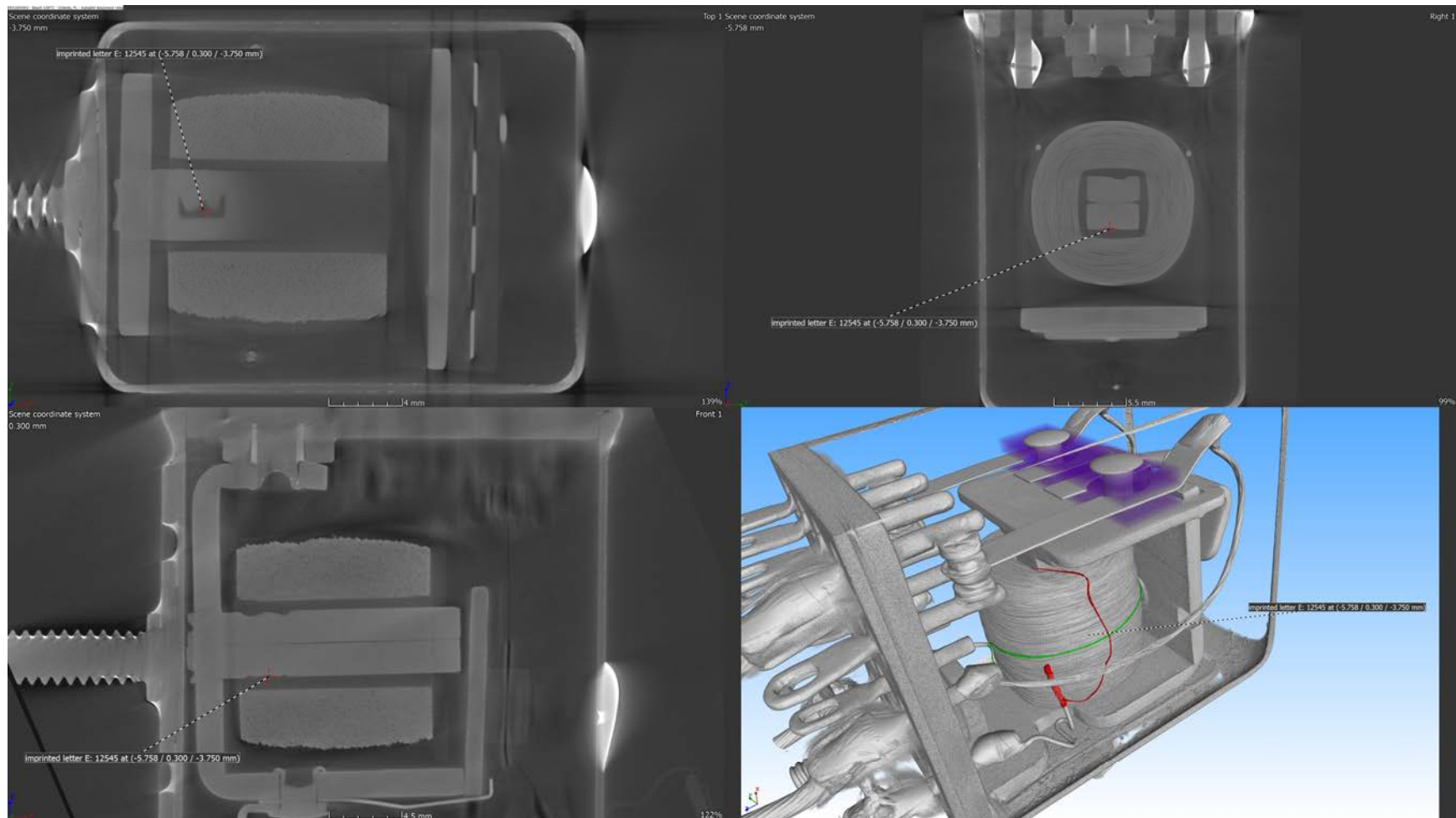


Figure 16
Autopilot disconnect relay – Imprinted letter E

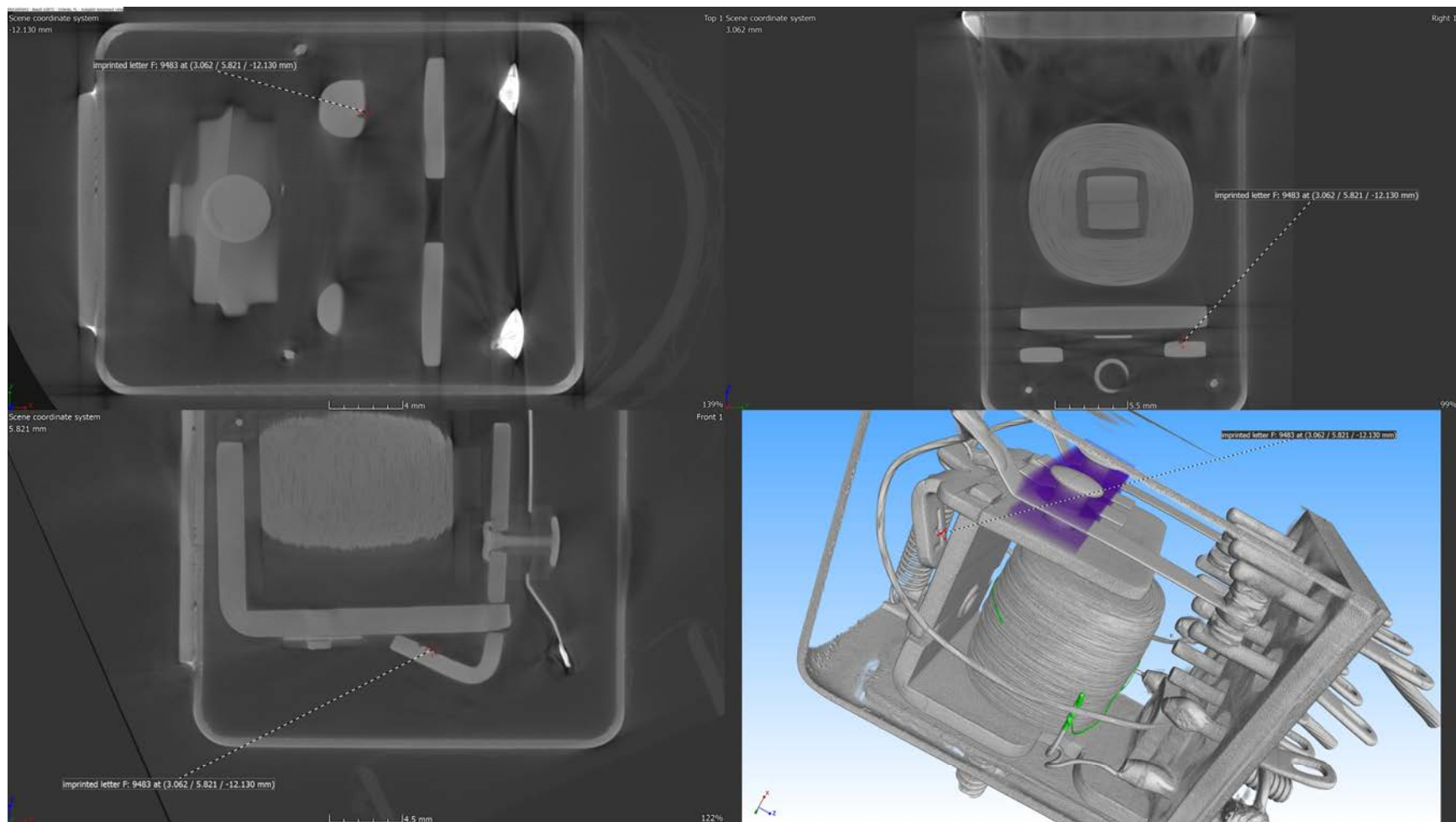


Figure 17
Autopilot disconnect relay – Imprinted letter F

2.2 Autopilot disconnect/trim interrupt switch

The computed tomography (CT) results for the autopilot disconnect/trim interrupt switch are shown in figures 18 through 39. Review of the images indicated that there were cracks in the switch insulator; there was an indentation in one of the contacts; there were no indications of welded contacts within the component; there were grooves in the moving contact body consistent with wear patterns from the springs; and there was one terminal lug with a solder fill pattern that appeared to be different from the other lugs.

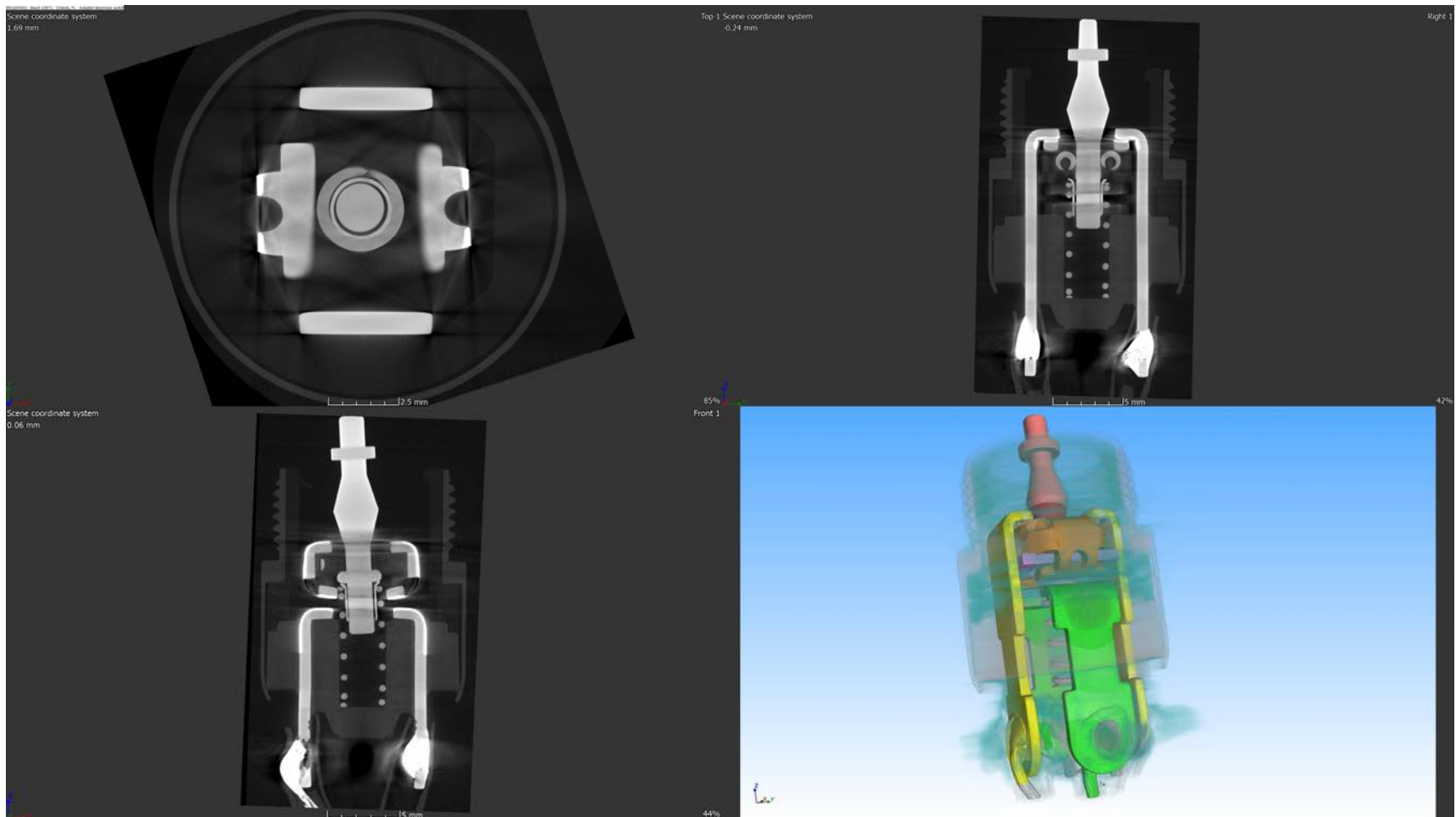


Figure 18
Autopilot disconnect/trim interrupt switch – Overall view

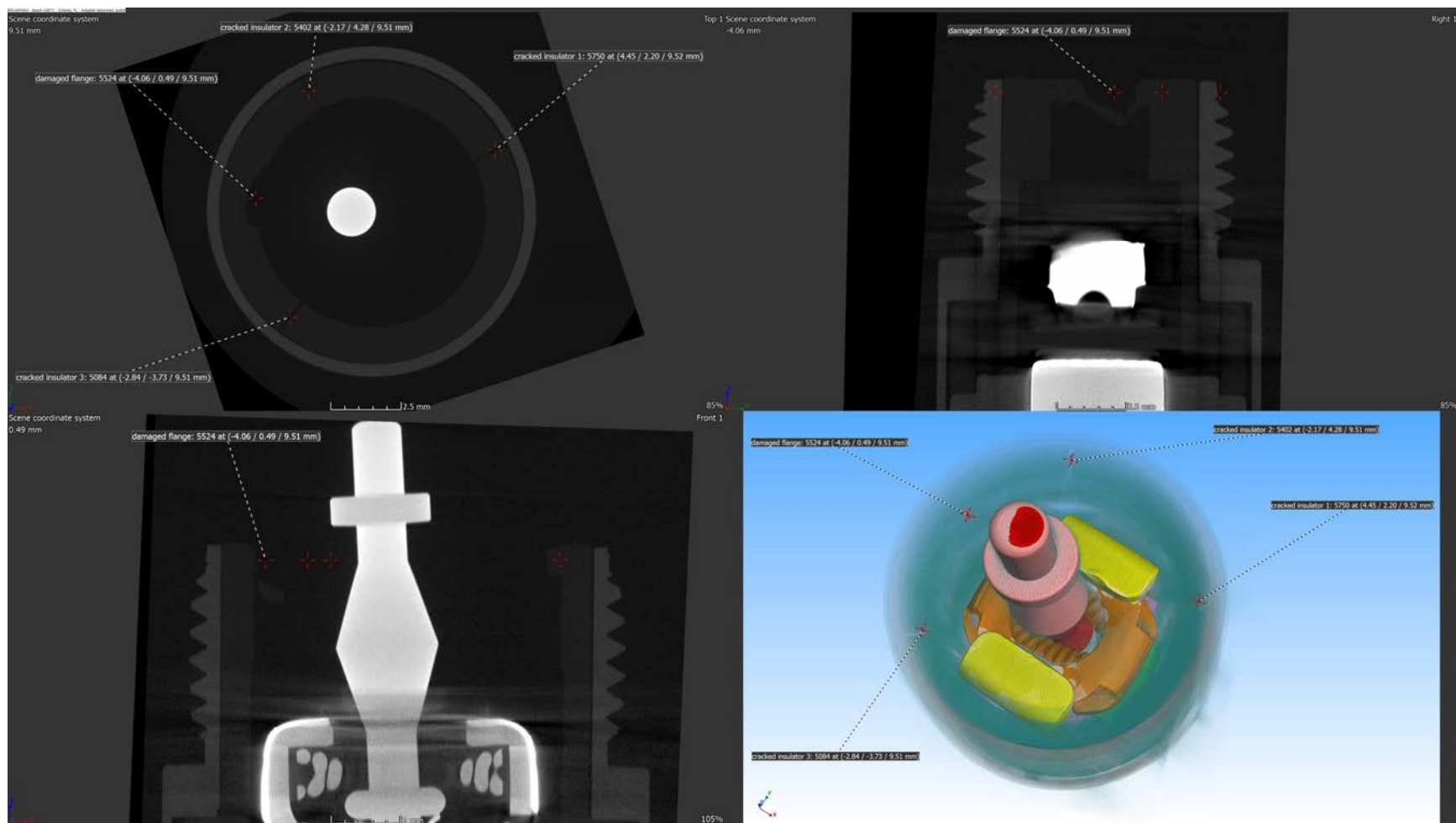


Figure 19
Autopilot disconnect/trim interrupt switch – Damaged flange

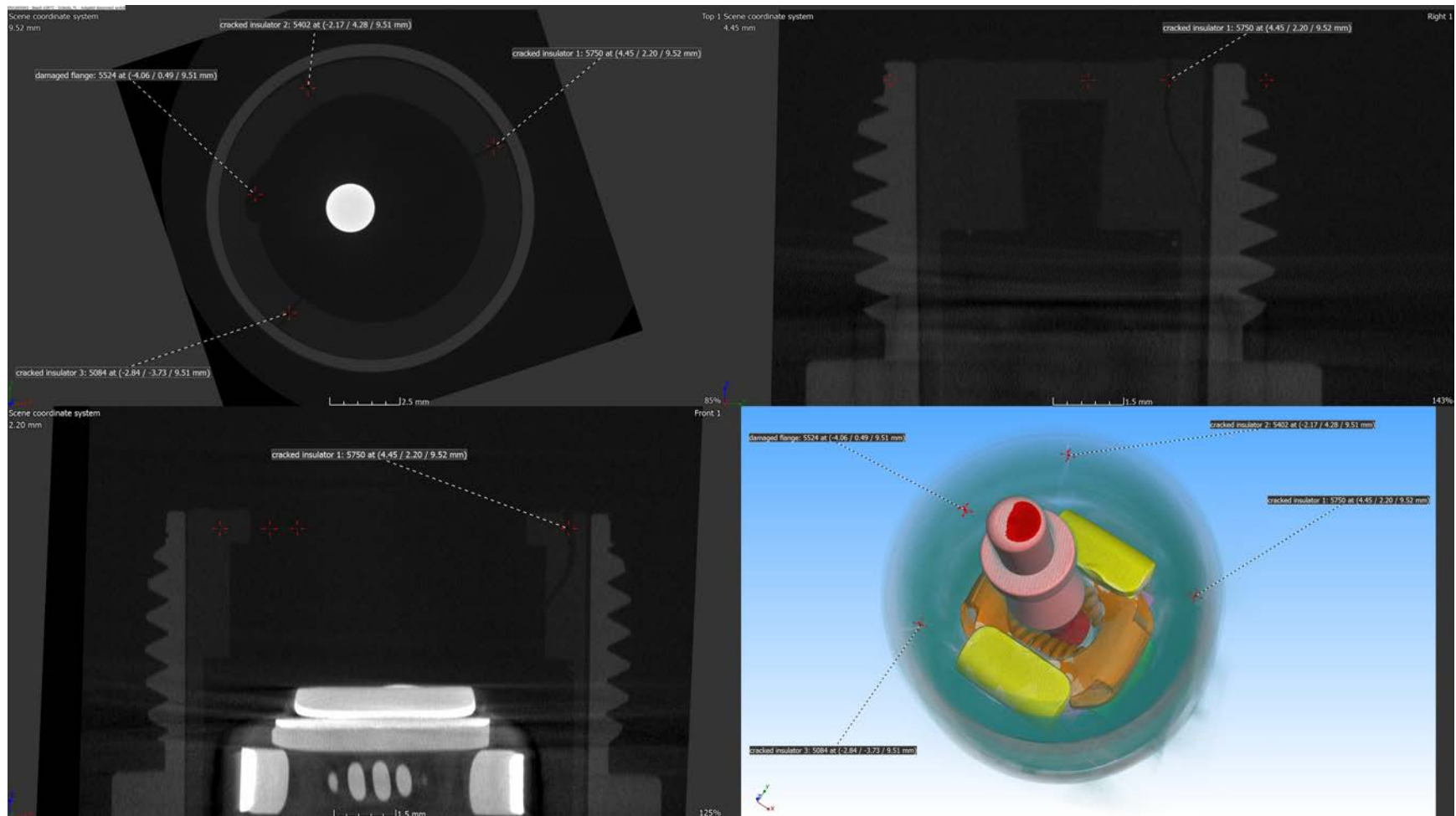


Figure 20
Autopilot disconnect/trim interrupt switch – Cracked insulator 1

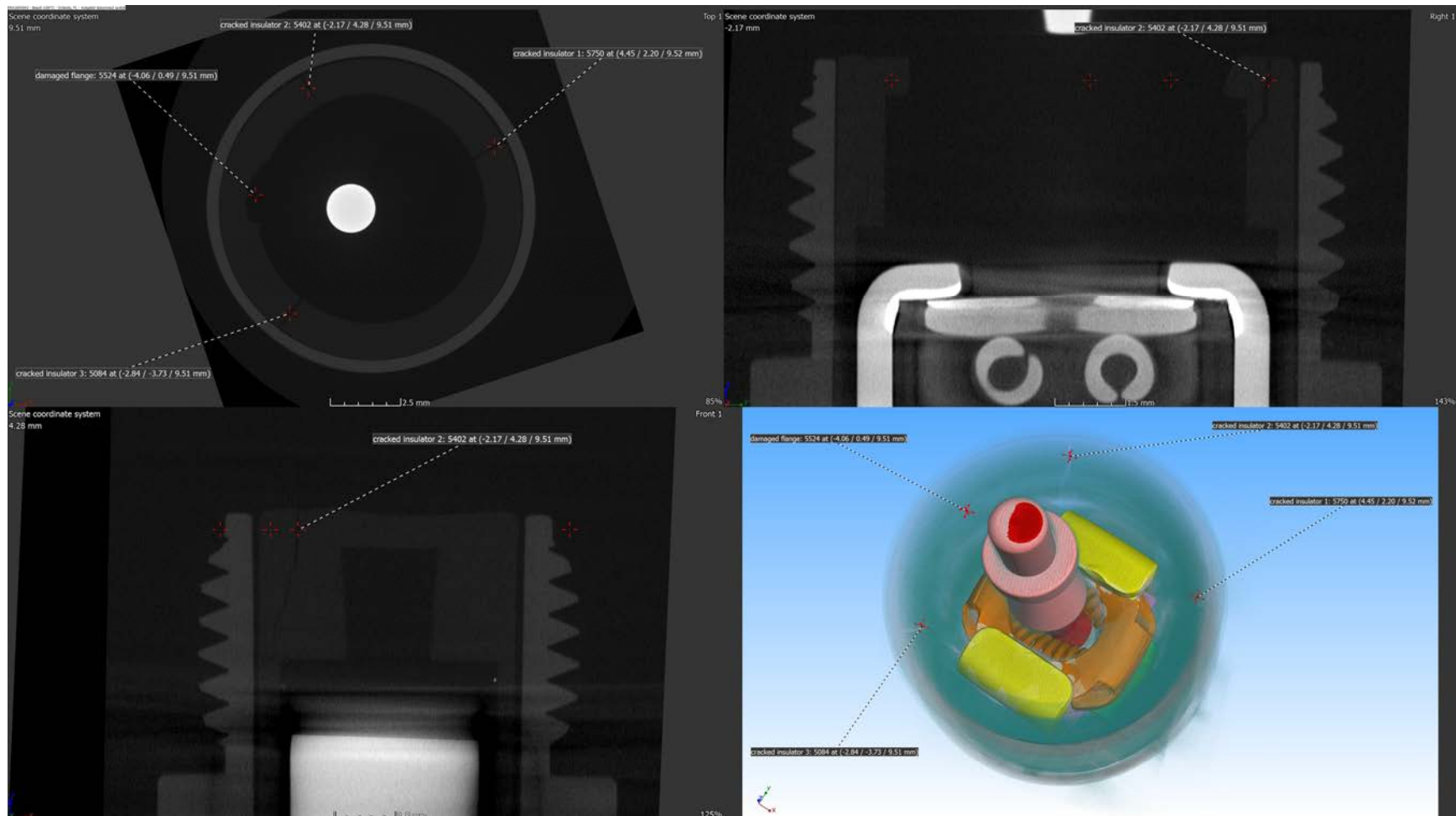


Figure 21
Autopilot disconnect/trim interrupt switch – Cracked insulator 2

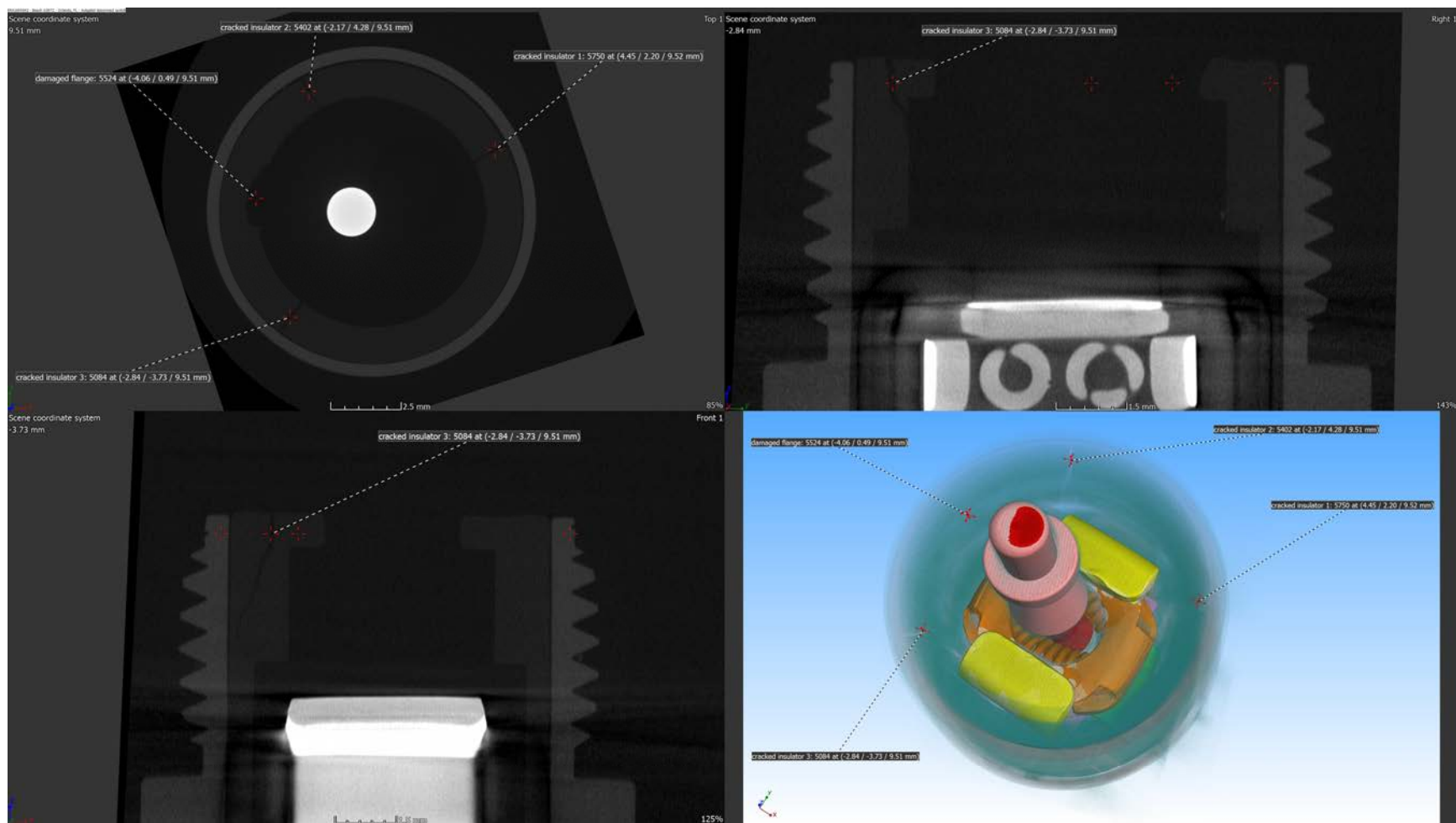


Figure 22
Autopilot disconnect/trim interrupt switch – Cracked insulator 3

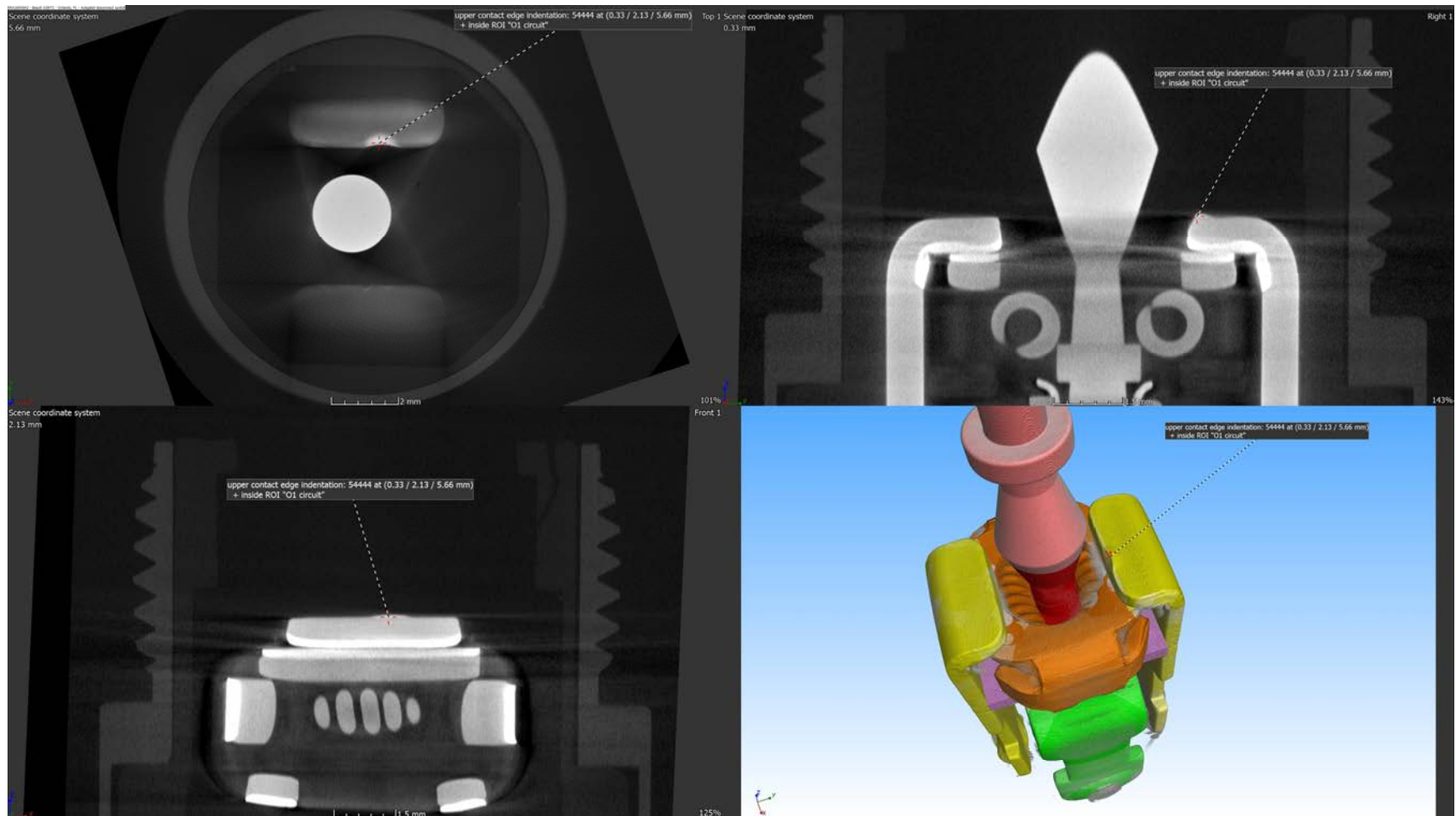


Figure 23
Autopilot disconnect/trim interrupt switch – Upper contact edge indentation

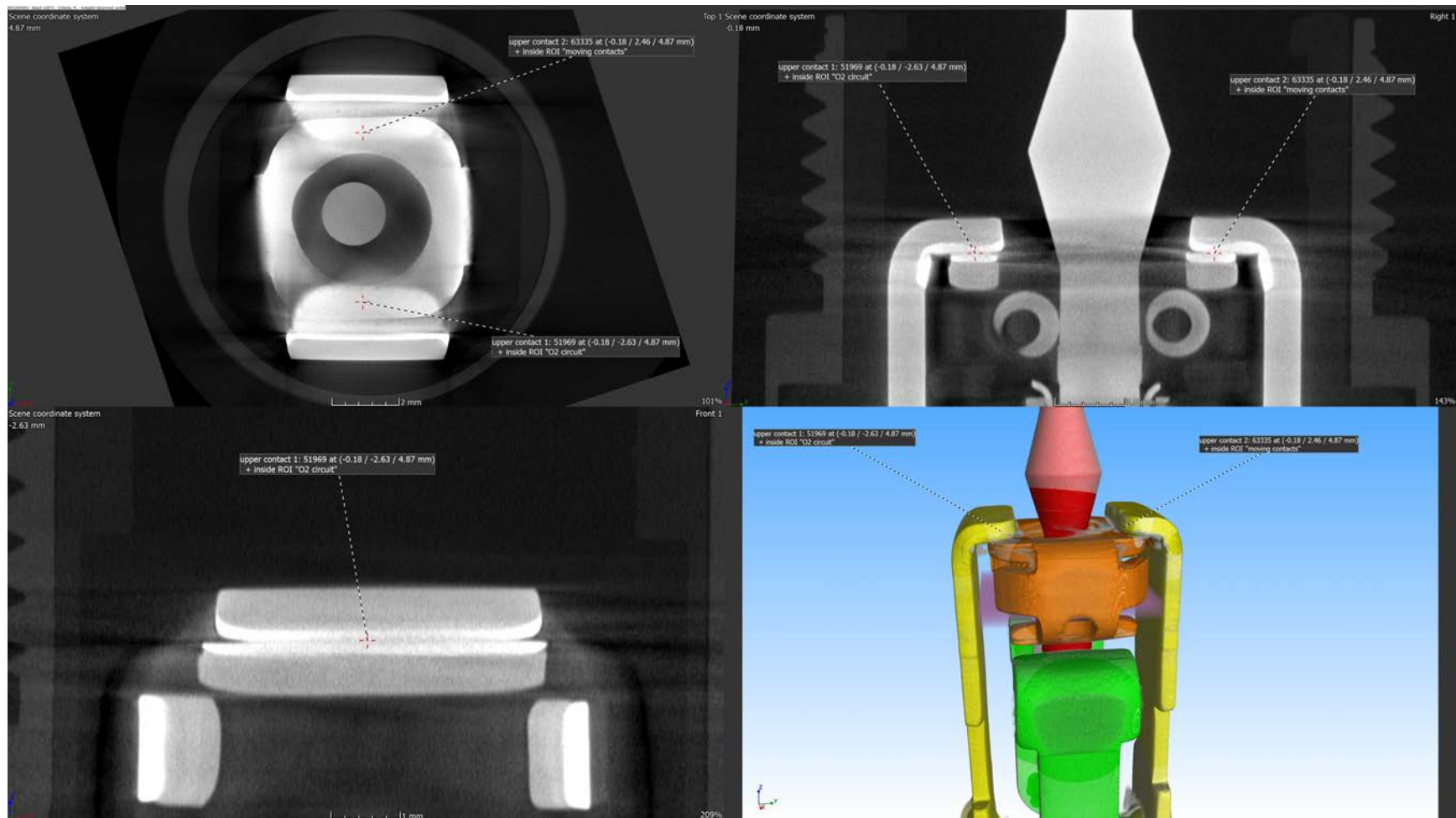


Figure 24
Autopilot disconnect/trim interrupt switch – Upper contact 1

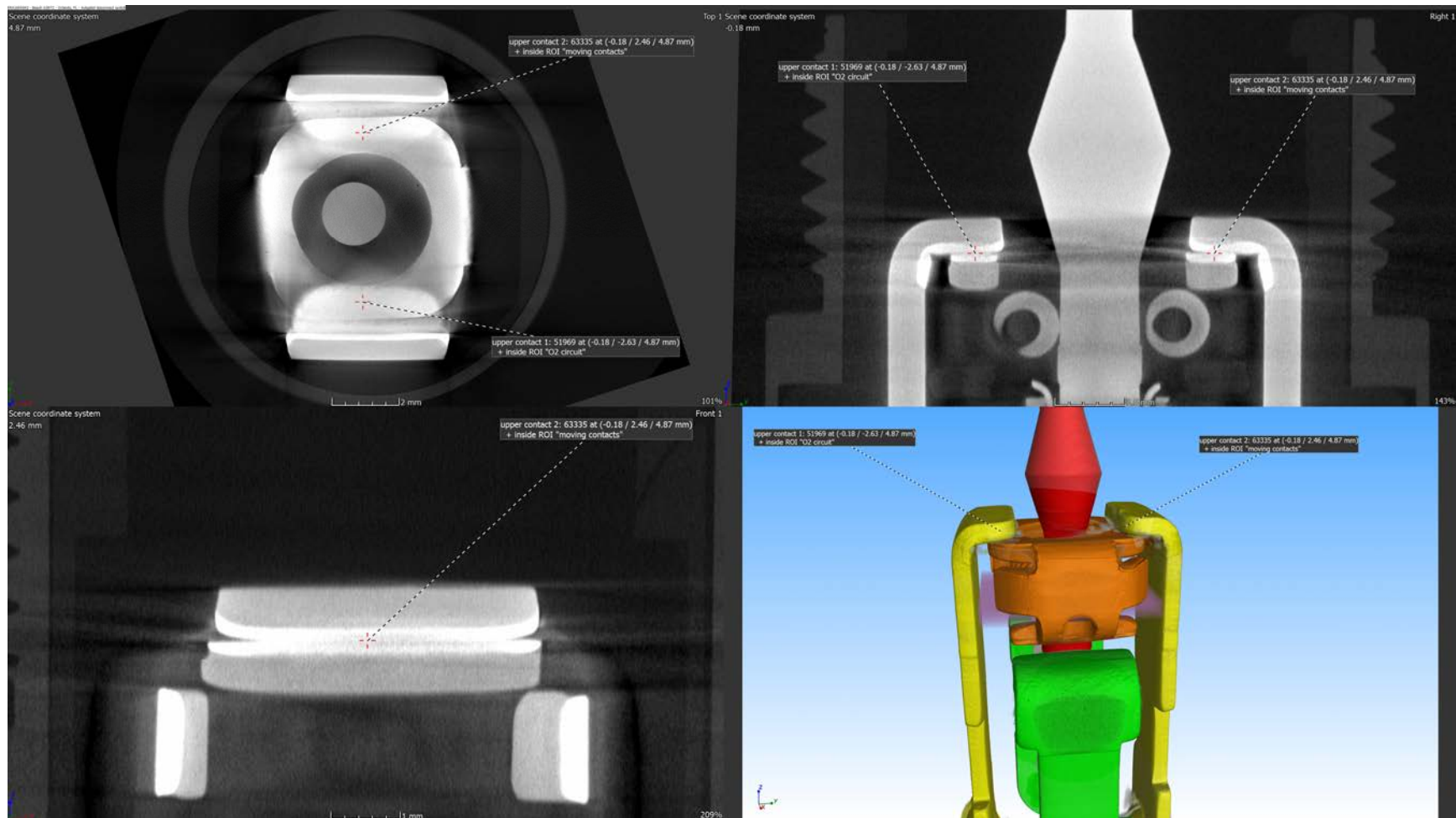


Figure 25
Autopilot disconnect/trim interrupt switch – Upper contact 2

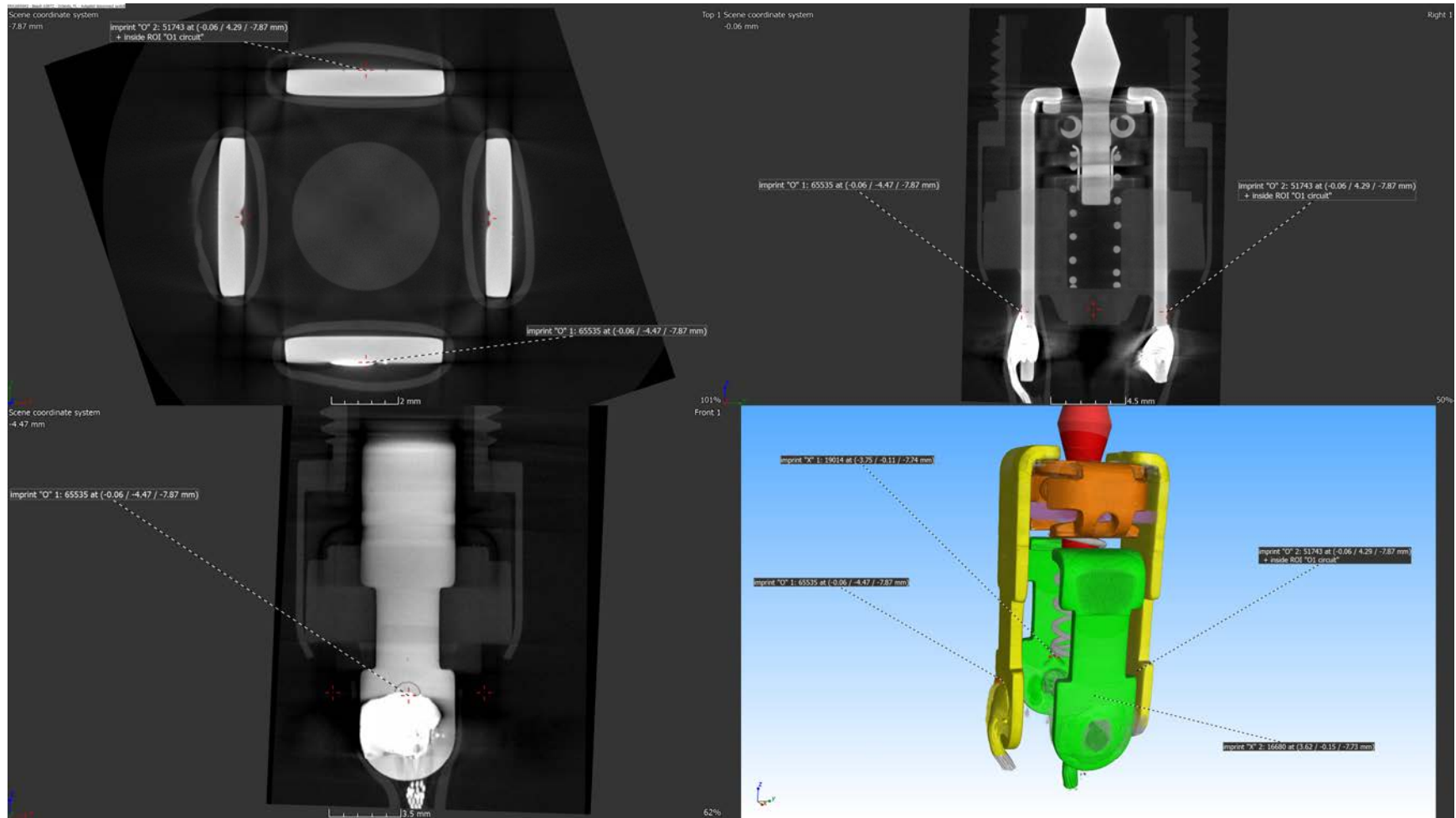


Figure 26
Autopilot disconnect/trim interrupt switch – Contact imprints - O

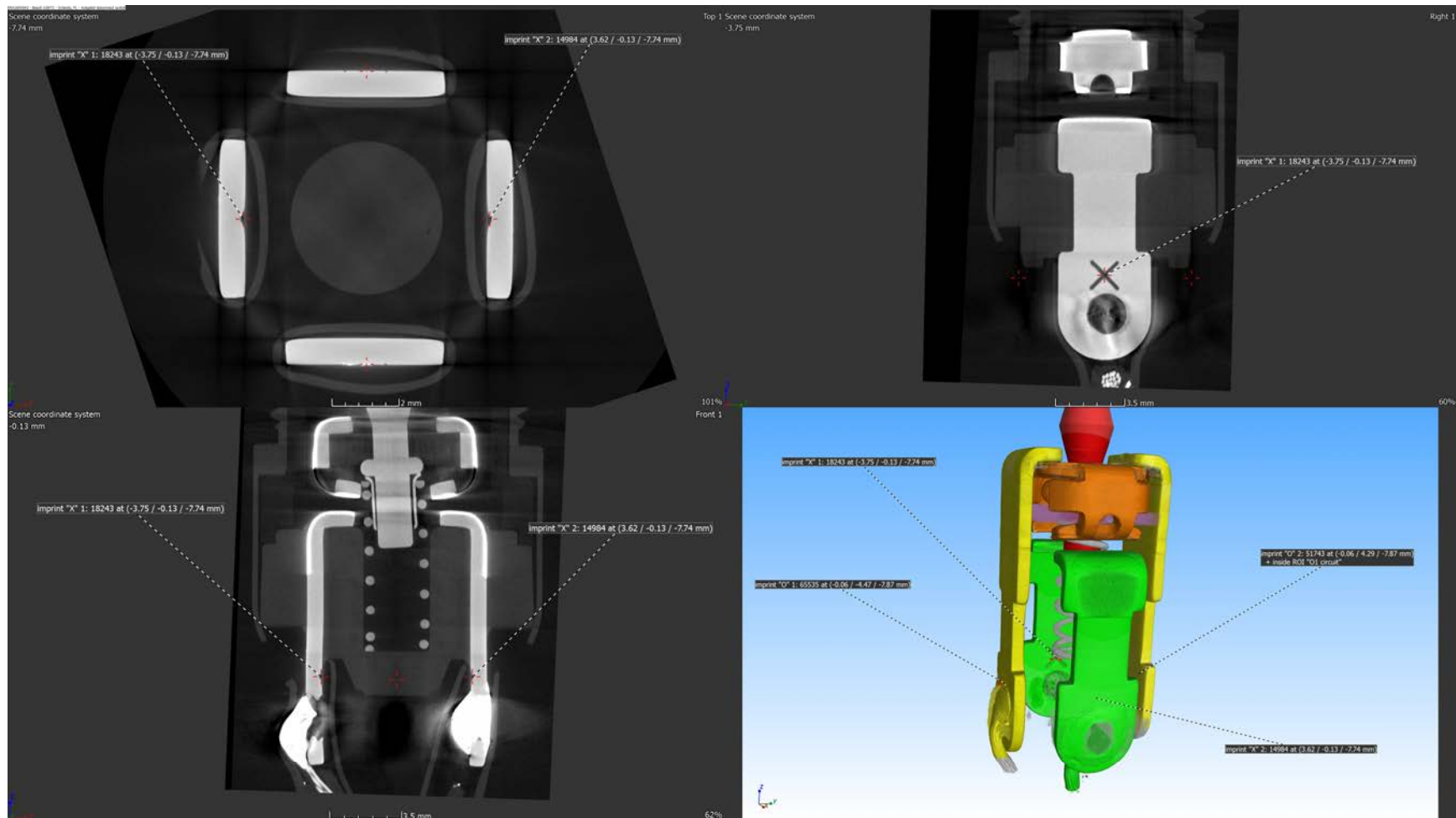


Figure 27
Autopilot disconnect/trim interrupt switch – Contact imprints - X

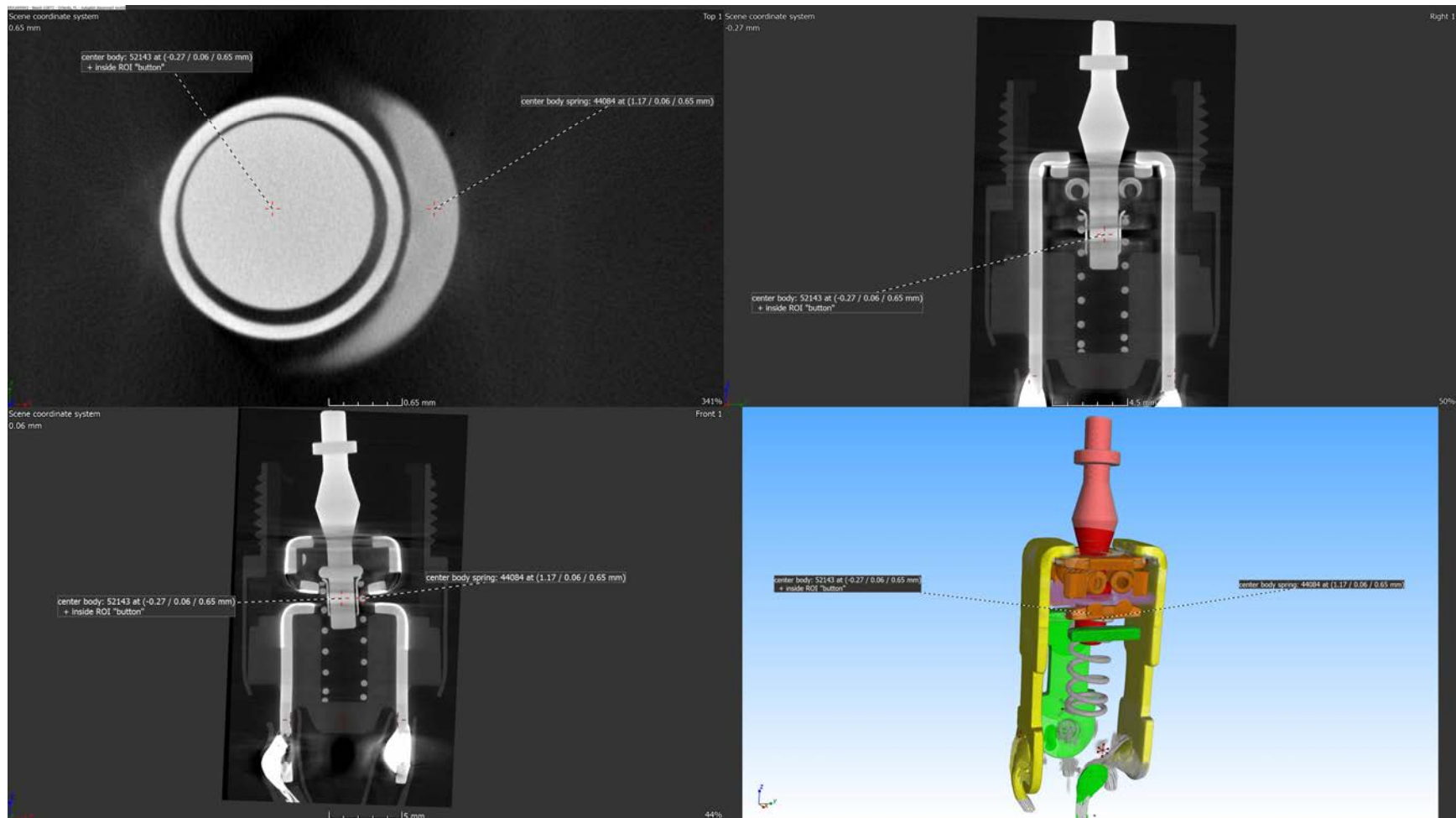


Figure 28
Autopilot disconnect/trim interrupt switch – Center body and center body spring

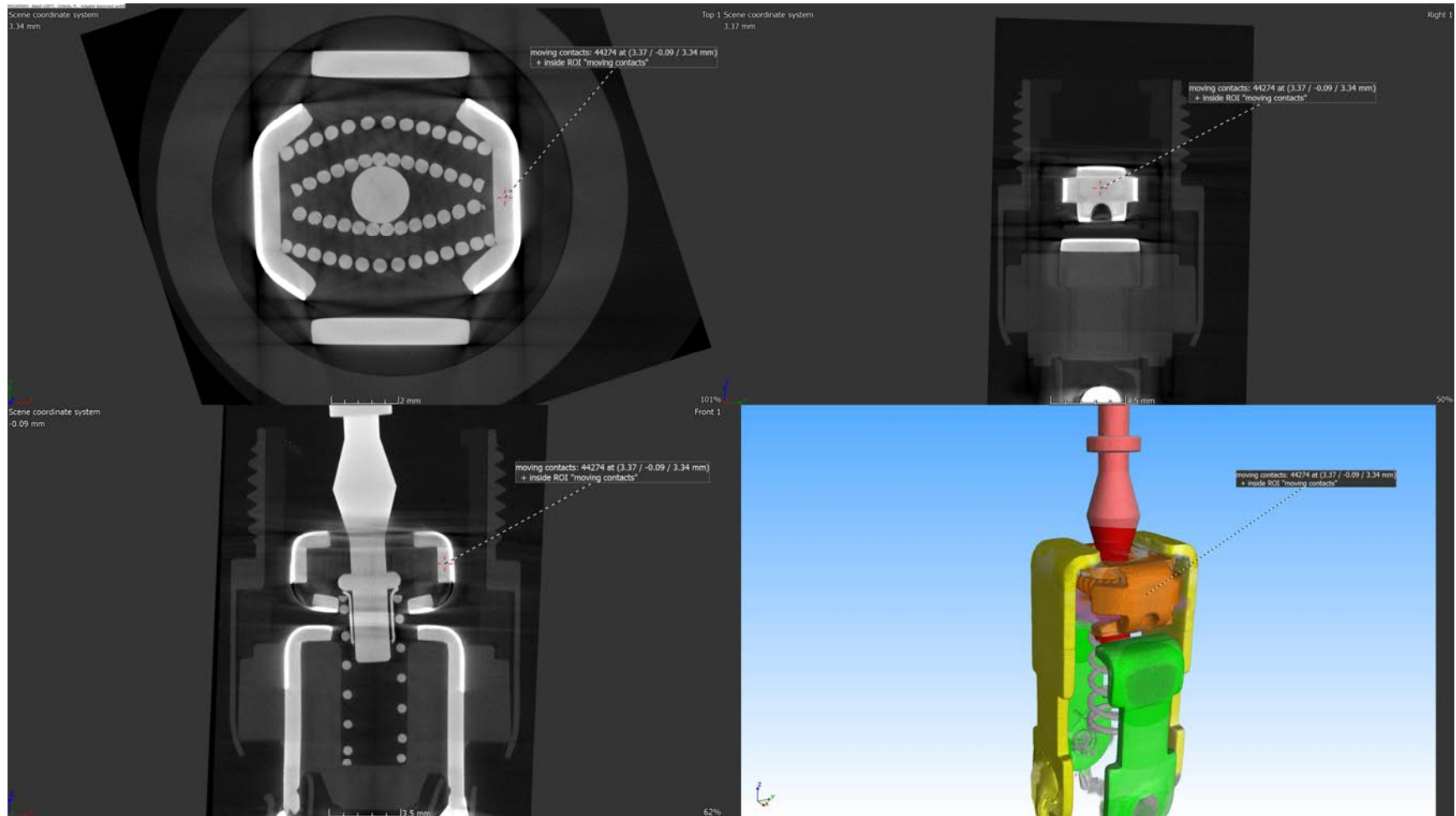


Figure 29
Autopilot disconnect/trim interrupt switch – Moving contacts

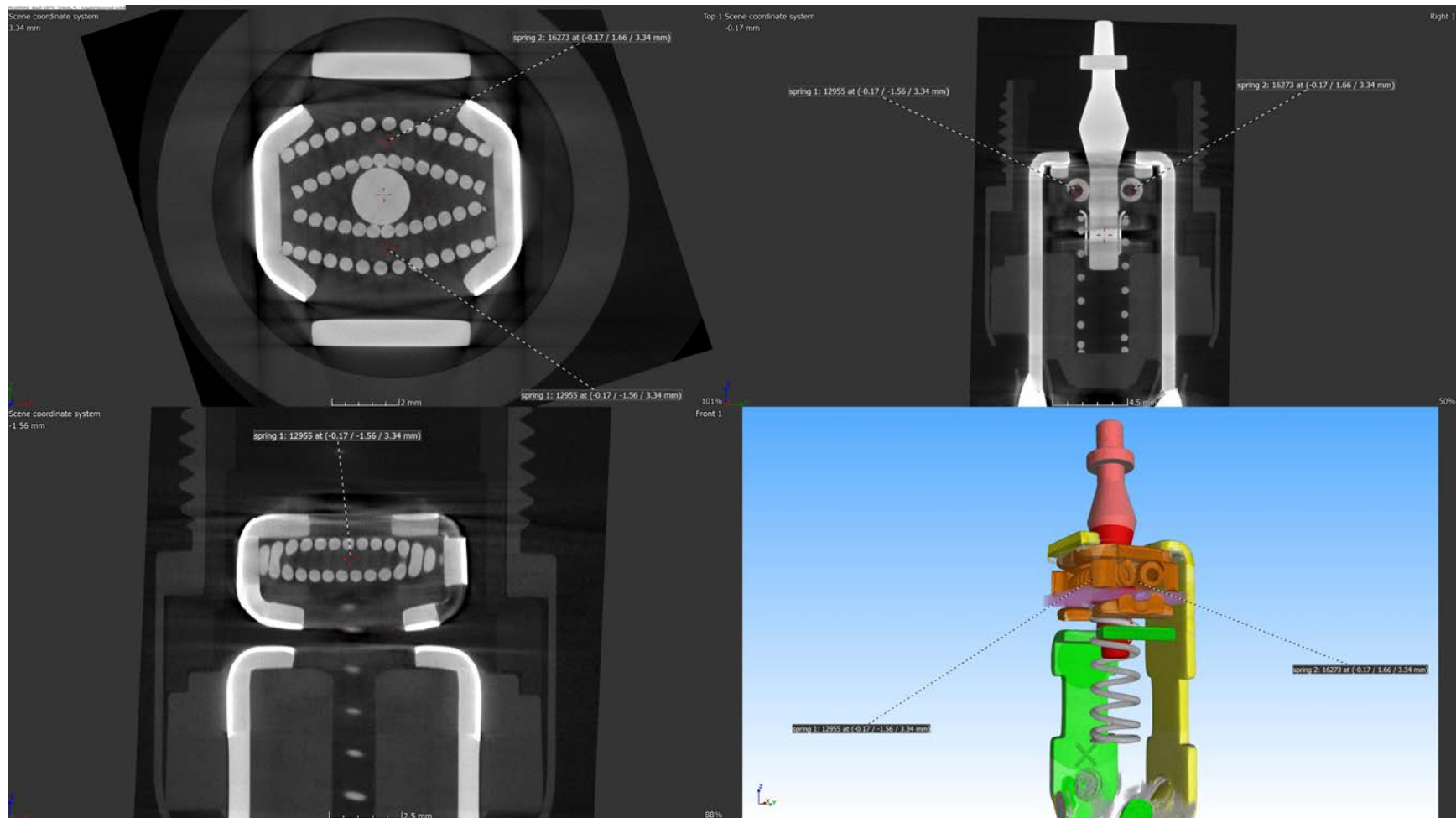


Figure 30
Autopilot disconnect/trim interrupt switch – Moving contacts springs 1 and 2

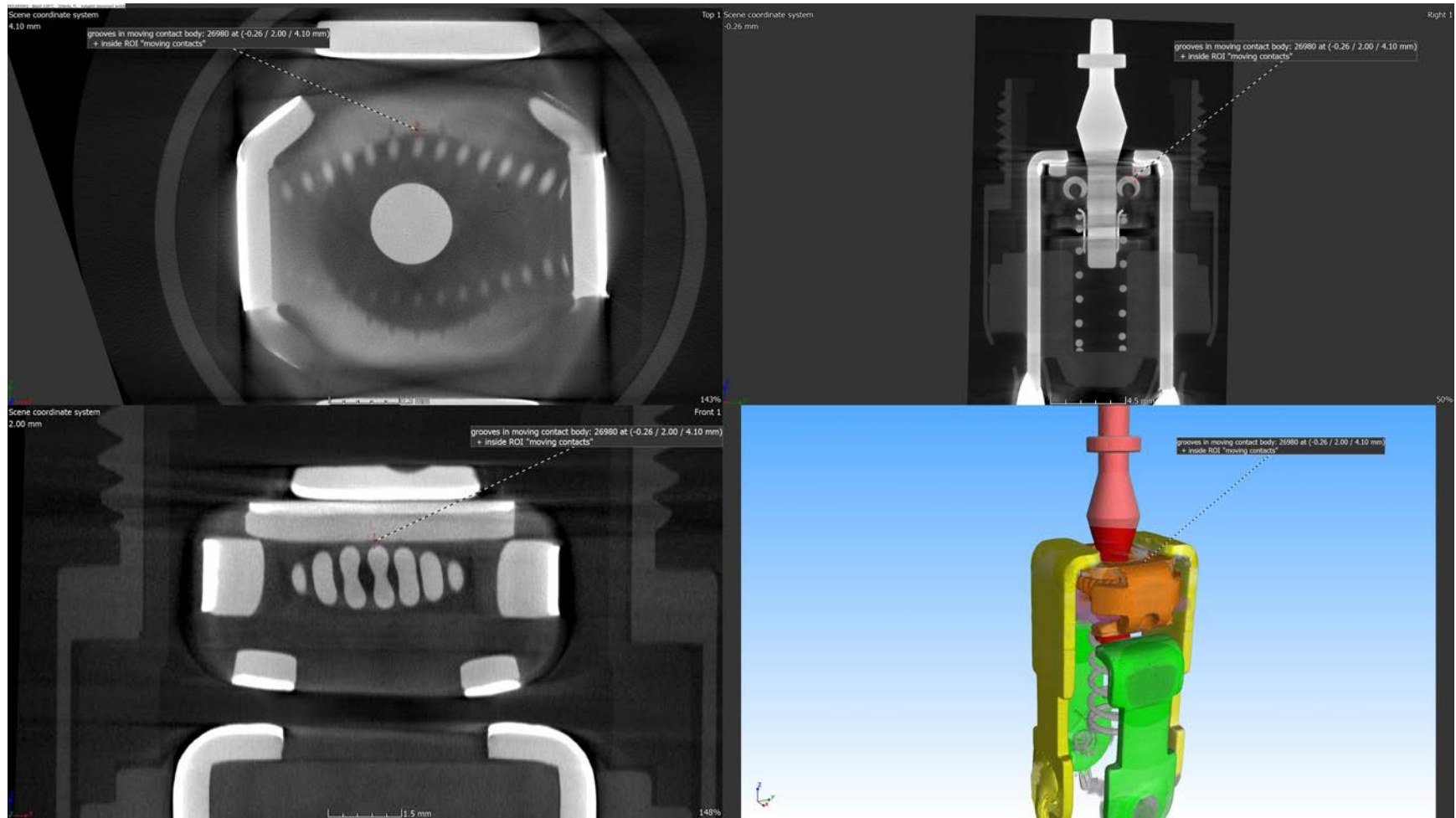


Figure 31
Autopilot disconnect/trim interrupt switch – Grooves in moving contact body

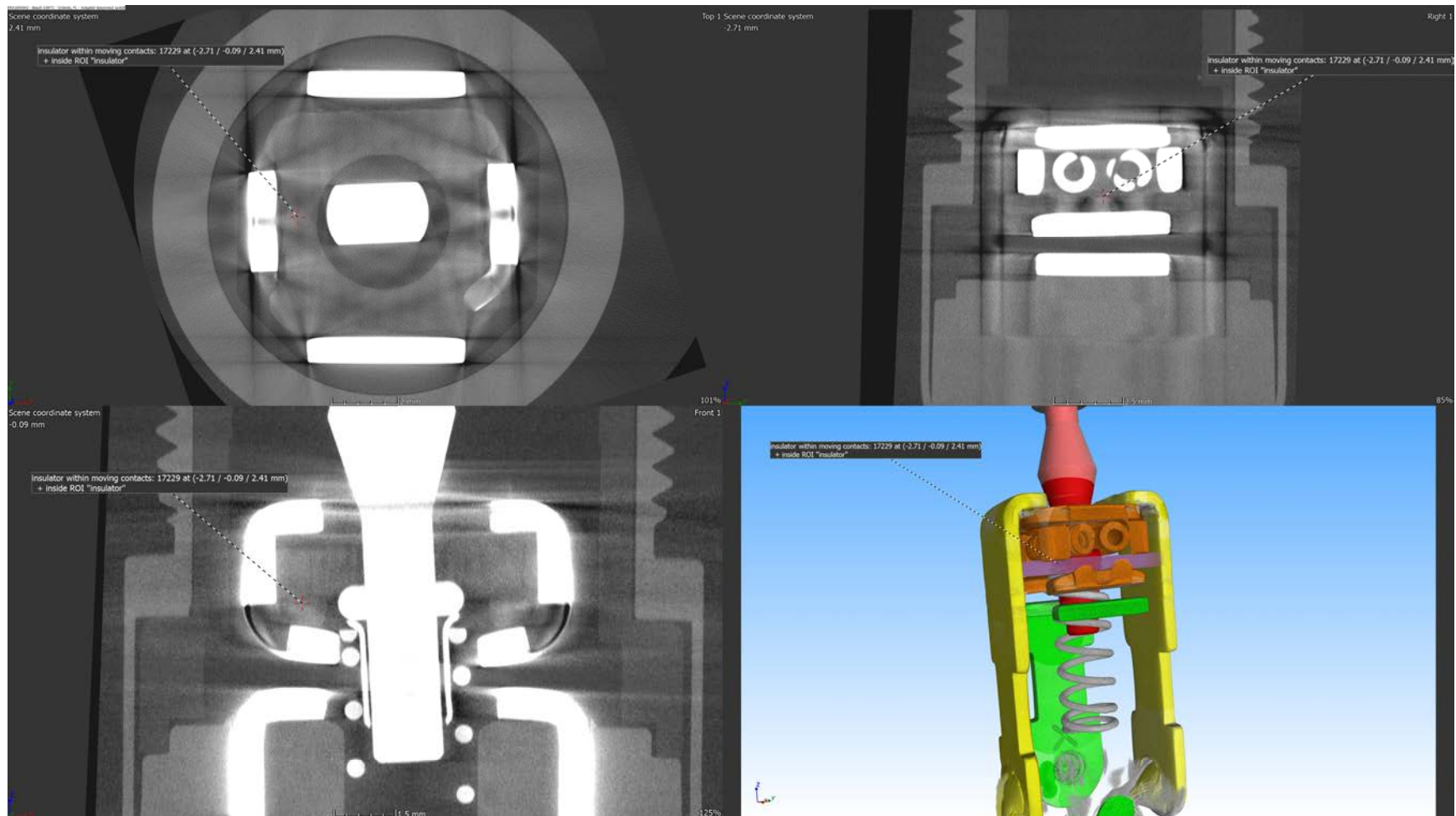


Figure 32
Autopilot disconnect/trim interrupt switch – Insulator within moving contacts

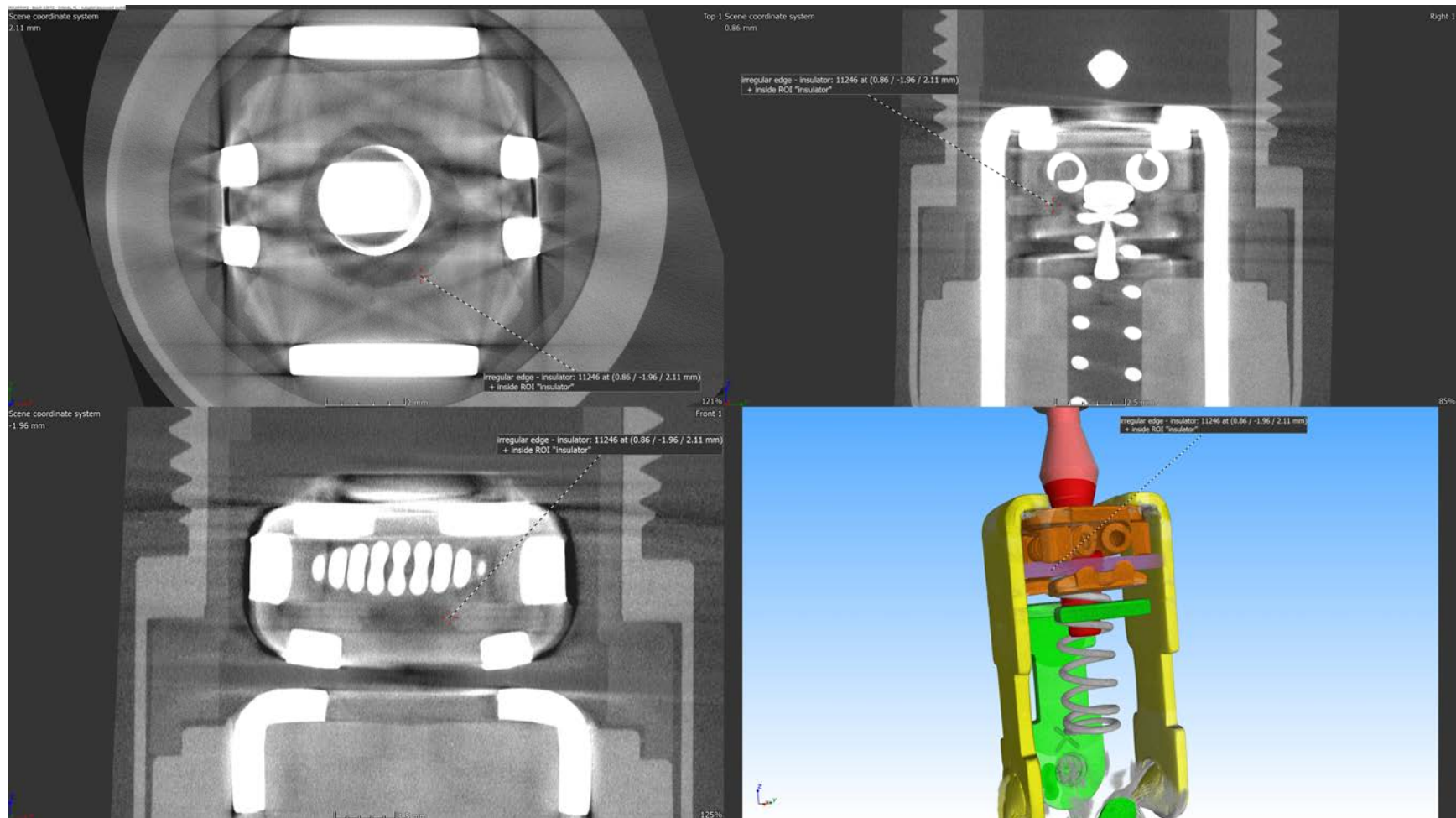


Figure 33
Autopilot disconnect/trim interrupt switch – Insulator irregular edge

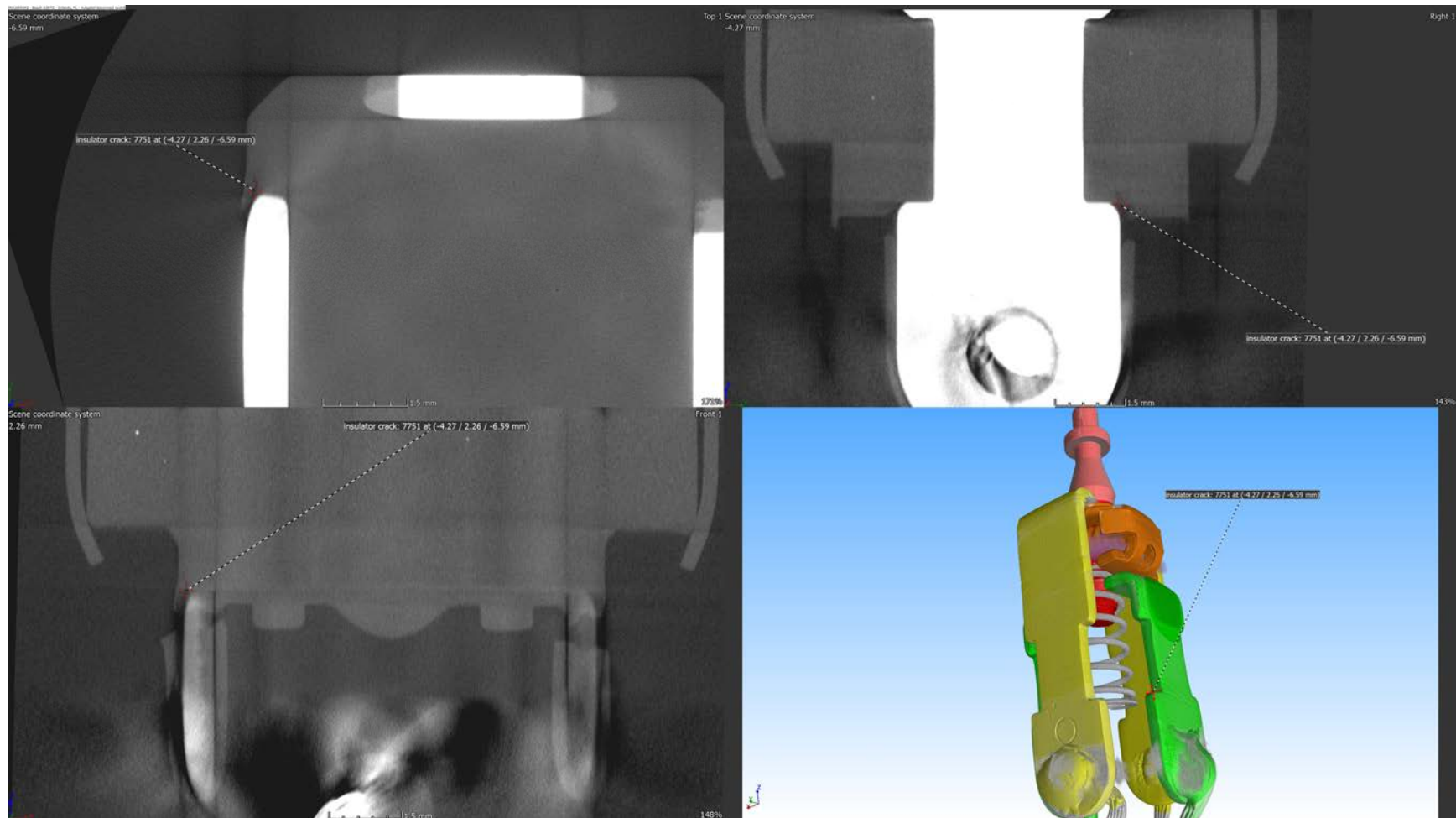


Figure 34
Autopilot disconnect/trim interrupt switch – Insulator crack

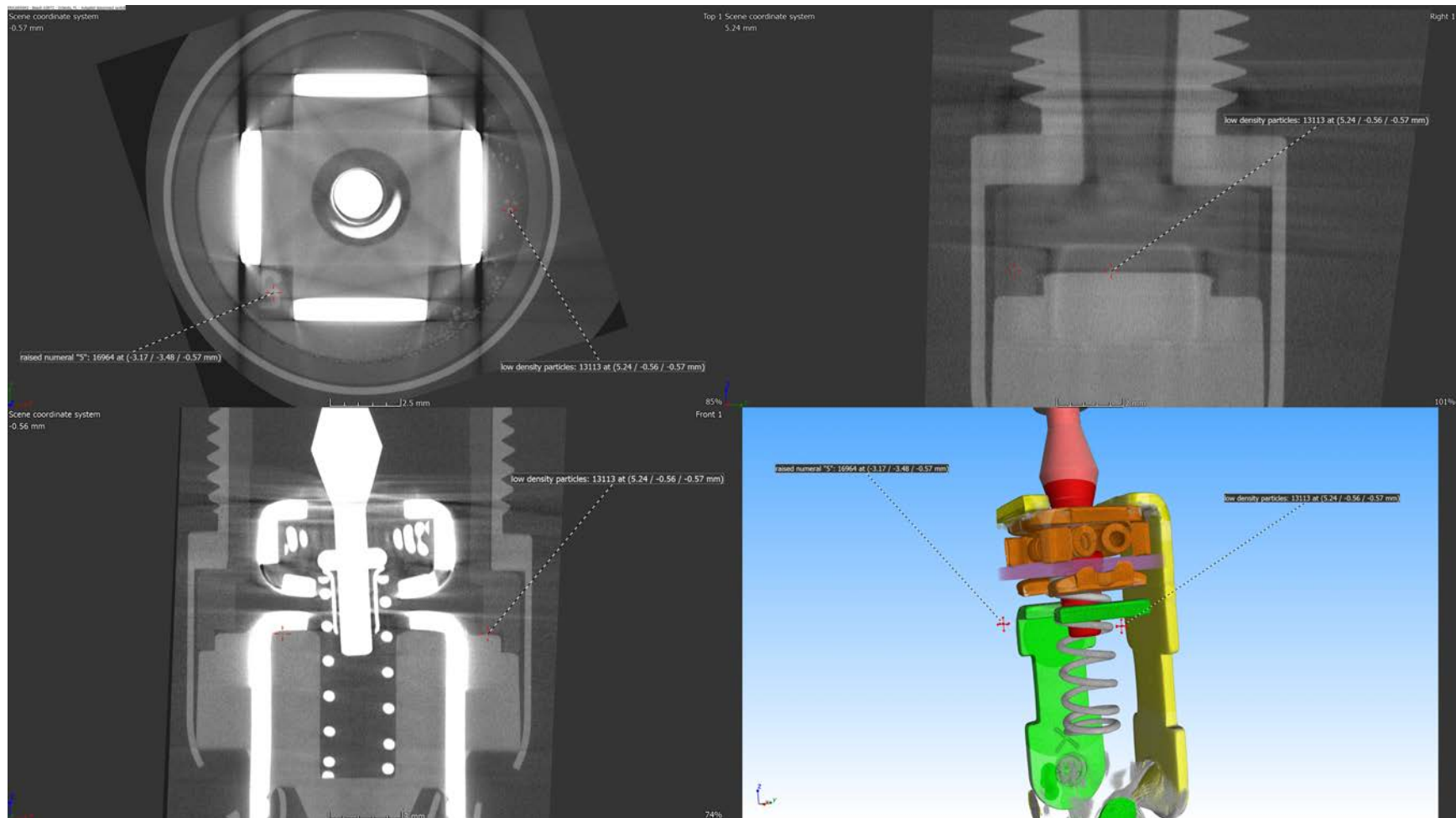


Figure 35
Autopilot disconnect/trim interrupt switch – Low density particles and raised numeral 5

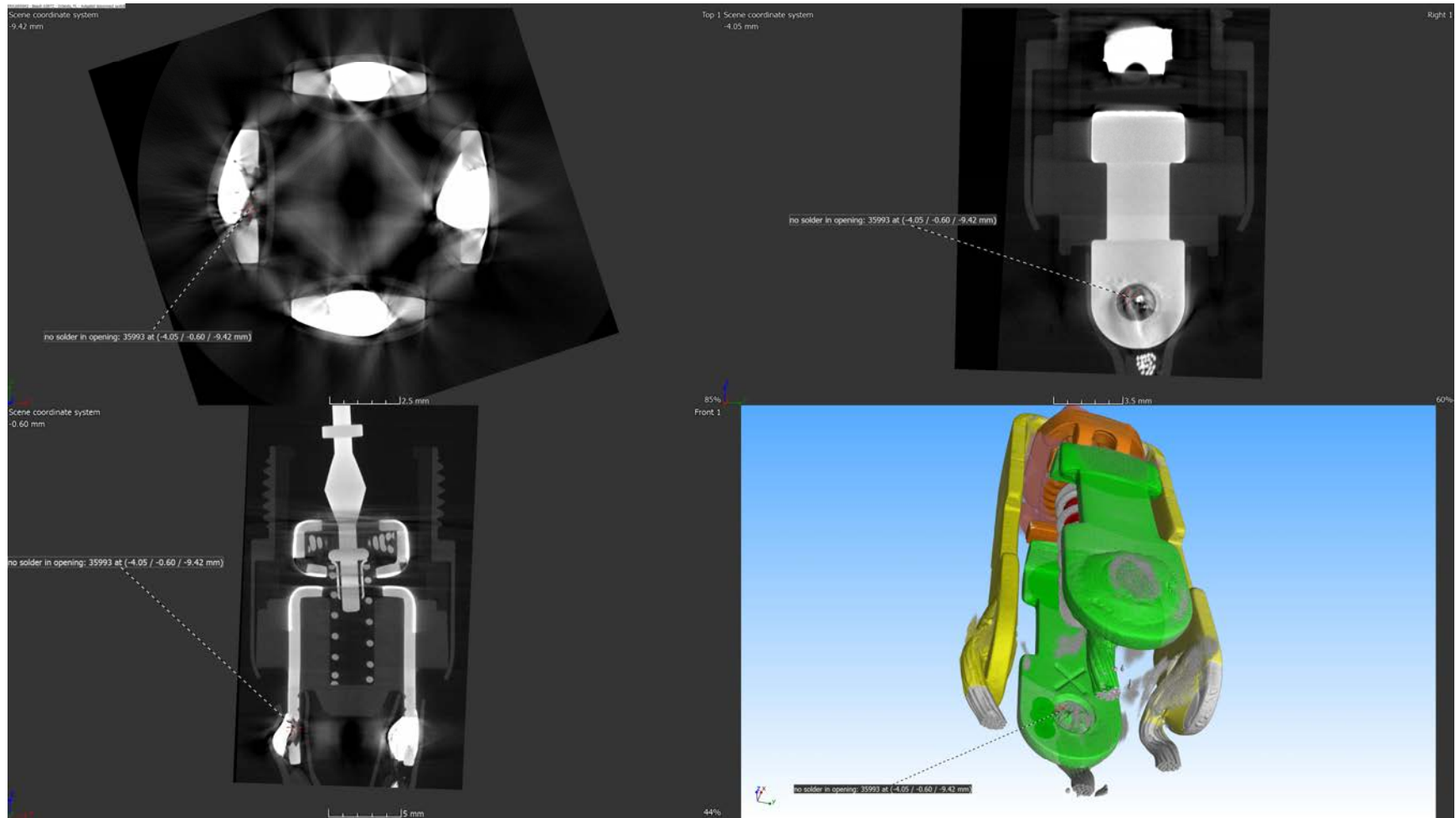


Figure 36
Autopilot disconnect/trim interrupt switch – No solder in terminal opening

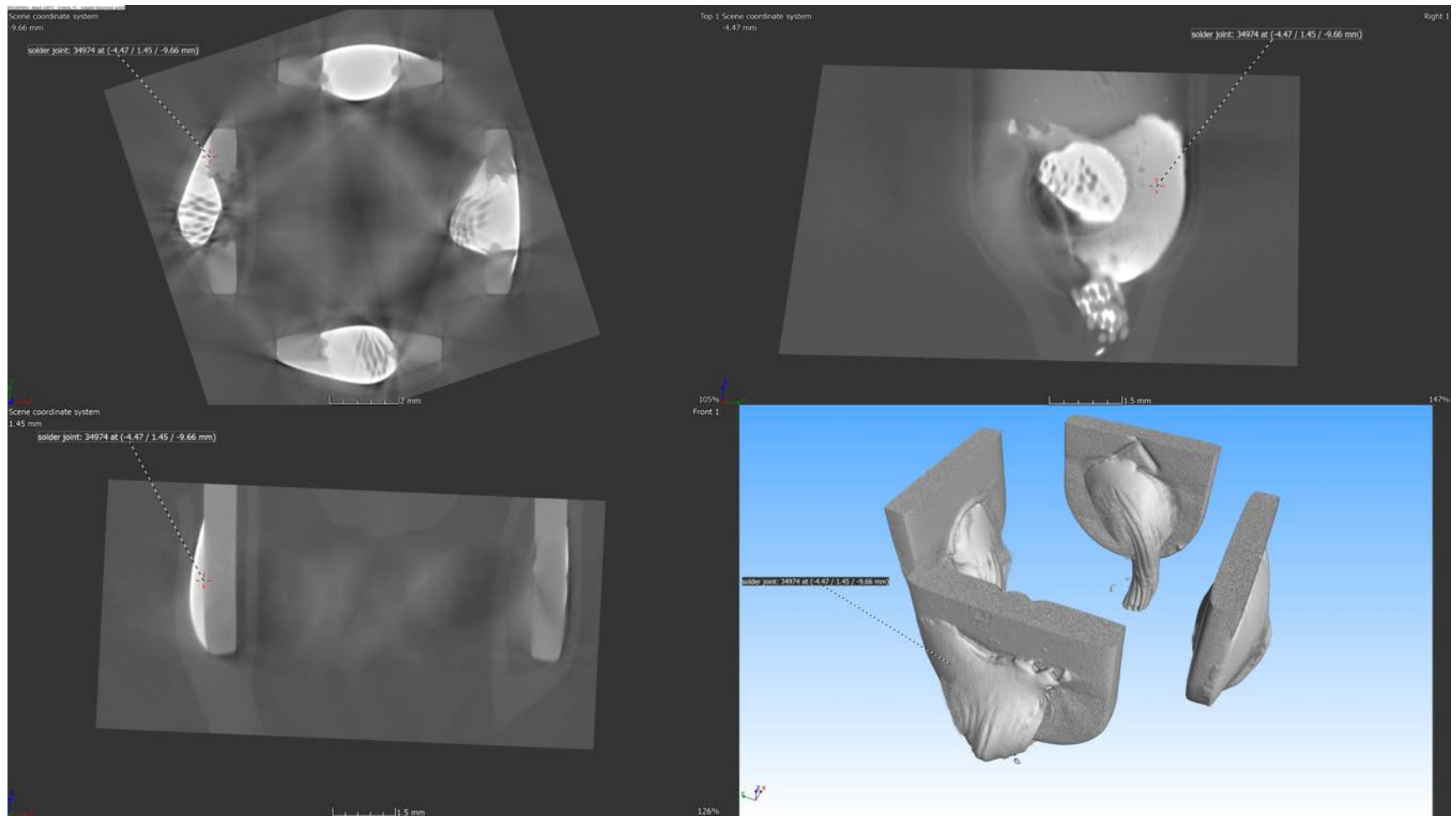


Figure 37
Autopilot disconnect/trim interrupt switch – Solder connections only – Exemplar solder joint

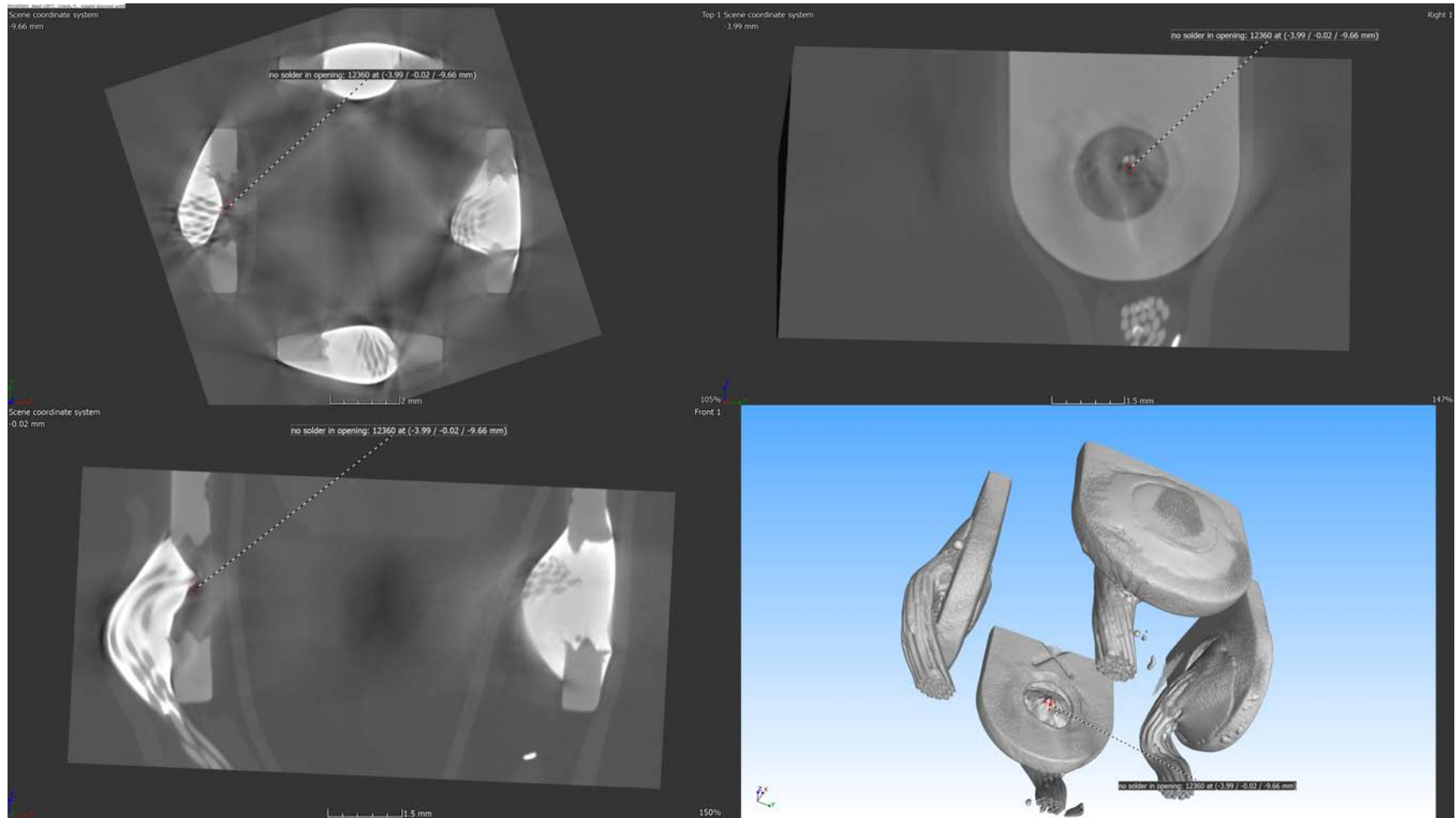


Figure 38
Autopilot disconnect/trim interrupt switch – Solder connections only – No solder in terminal opening – view 1

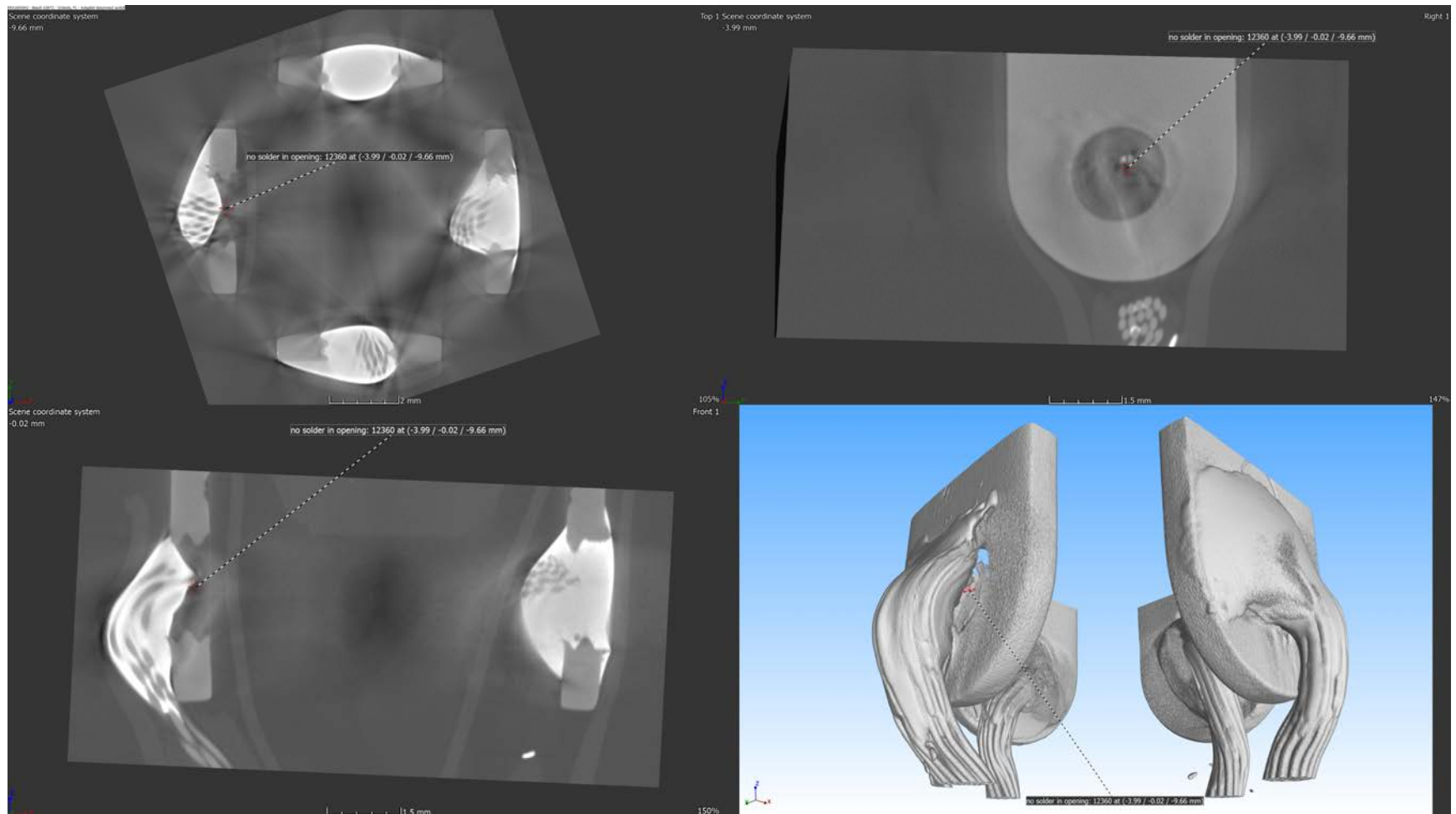


Figure 39
Autopilot disconnect/trim interrupt switch – Solder connections only – No solder in terminal opening – view 2

2.3 Autopilot trim switch assembly

The computed tomography (CT) results for the autopilot trim switch assembly are shown in figures 40 through 68. Review of the images indicated that there were cracks in the switch housing; rocker switch 01 was displaced from the vertical position; there were deformation indications on some corners of both switch rocker 01 and 03; the stop plates for both rocker switch 01 and 03 were deformed; there were no indications of broken components, welded contacts, or foreign materials within the microswitches; and the wire spring for rocker switch 01 appeared to be interfering with the movement of the switch 101 actuator.

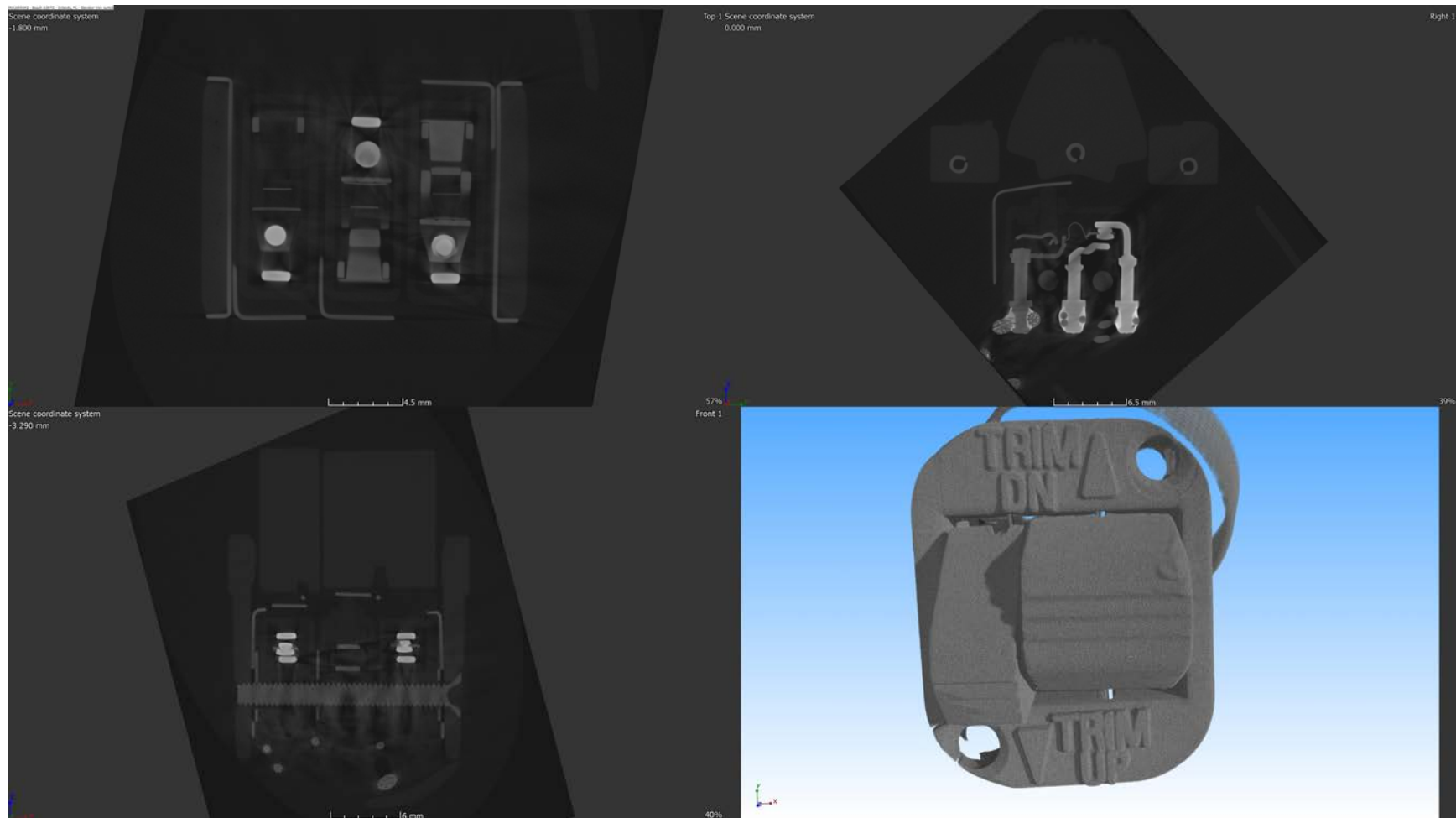


Figure 40
Autopilot trim switch assembly – Overall view

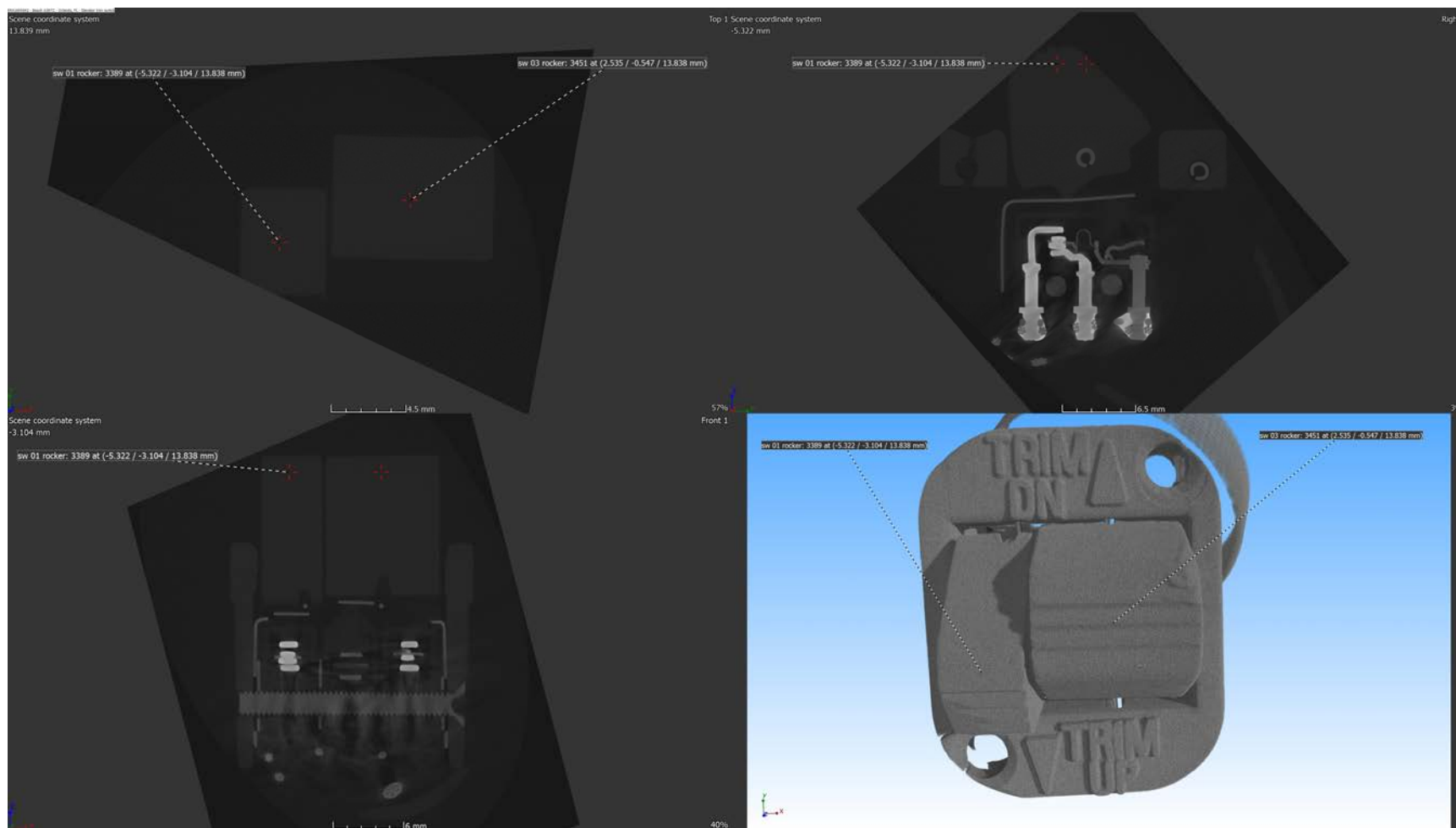


Figure 41
Autopilot trim switch assembly – Rocker switch identification

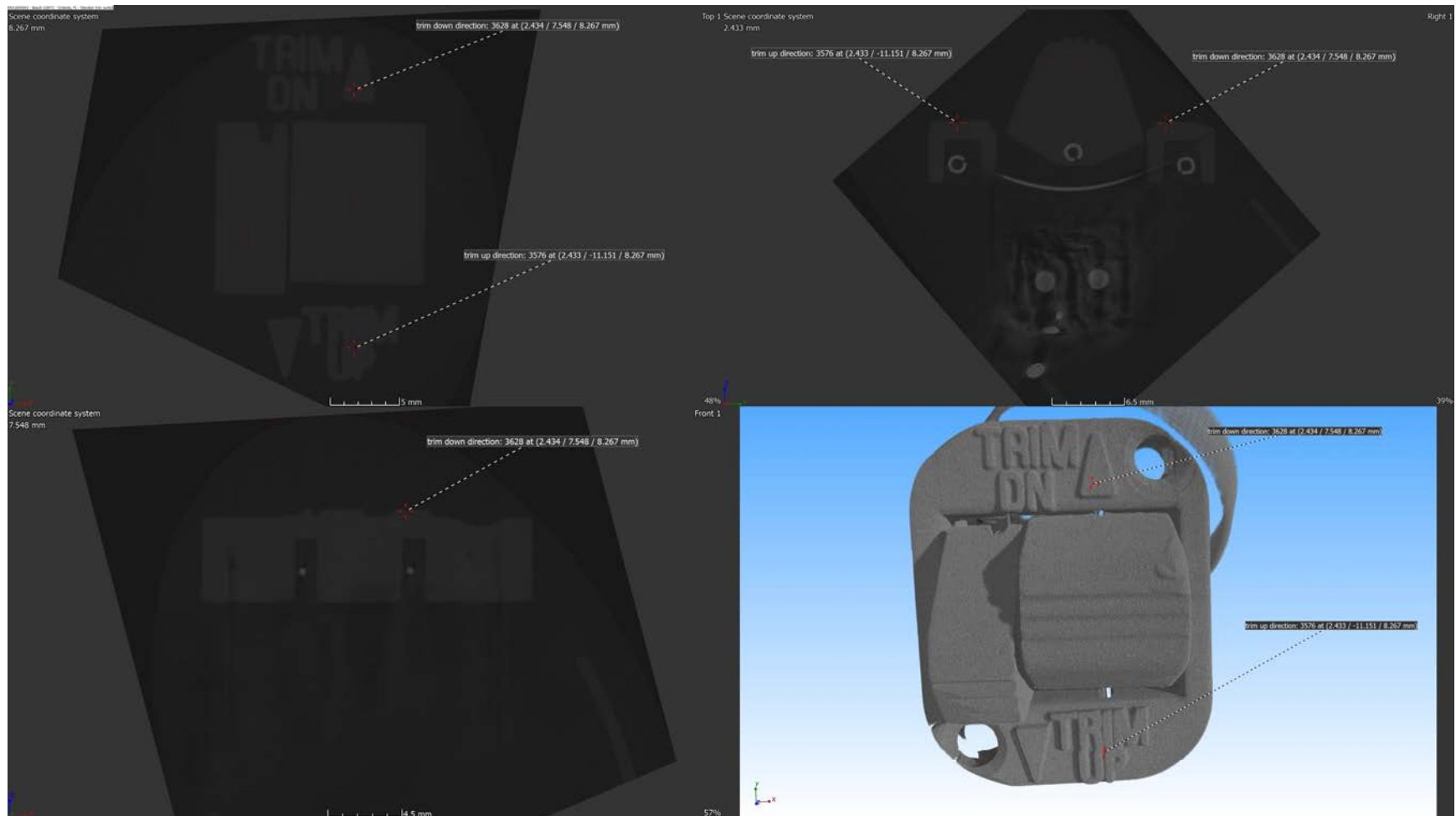


Figure 42
Autopilot trim switch assembly – Trim direction identification

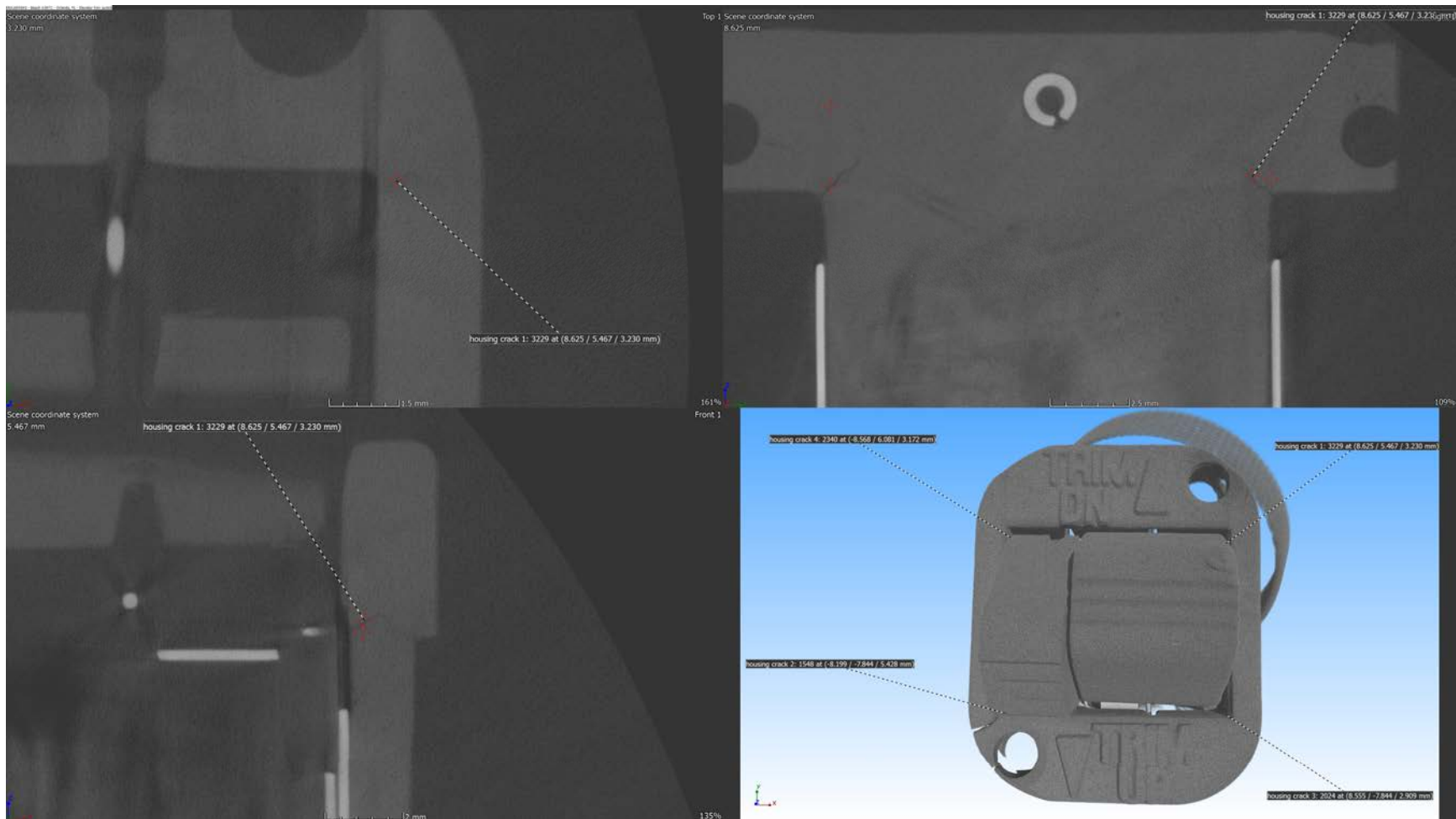


Figure 43
Autopilot trim switch assembly – Housing crack 1

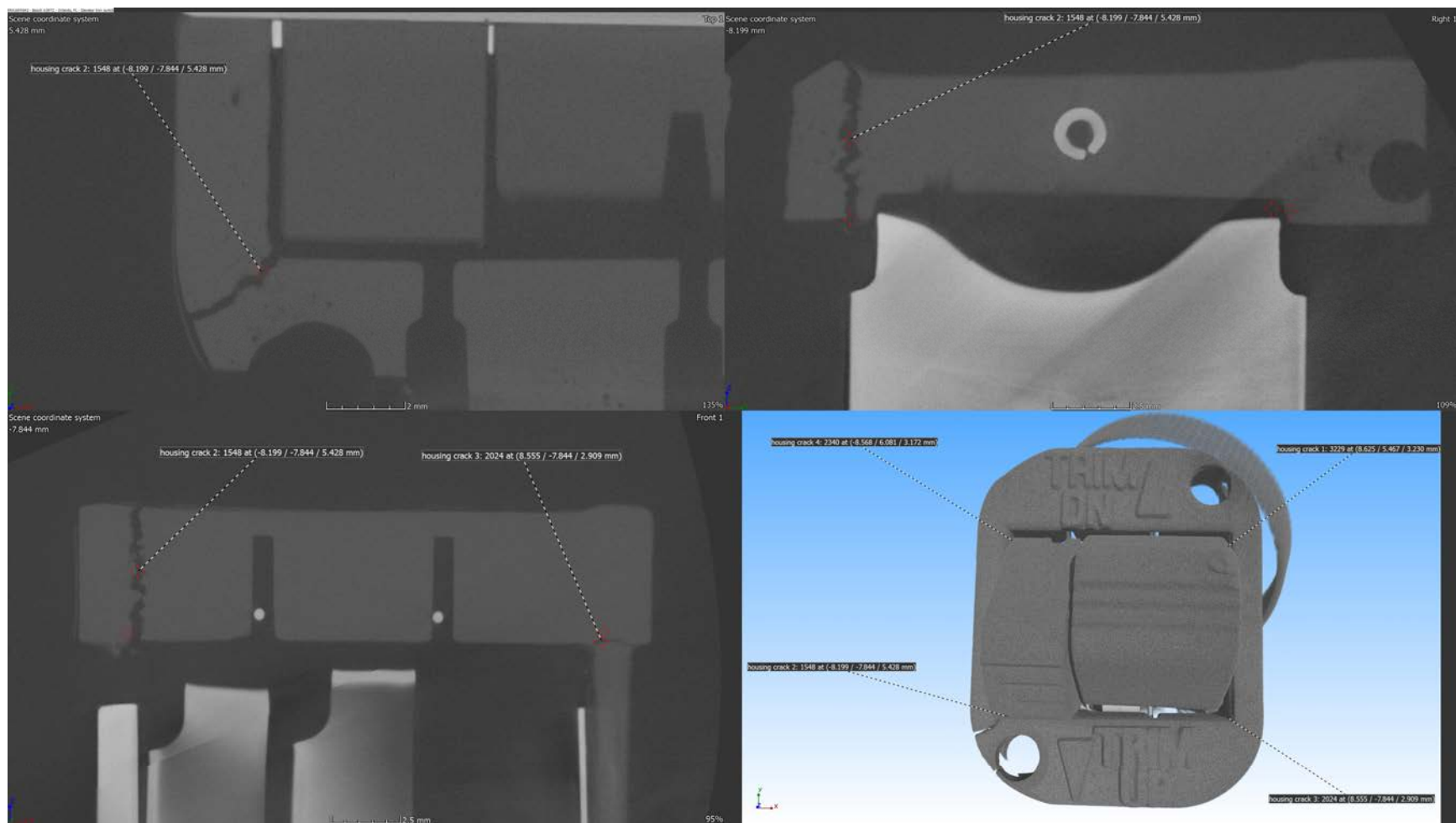


Figure 44
Autopilot trim switch assembly – Housing crack 2

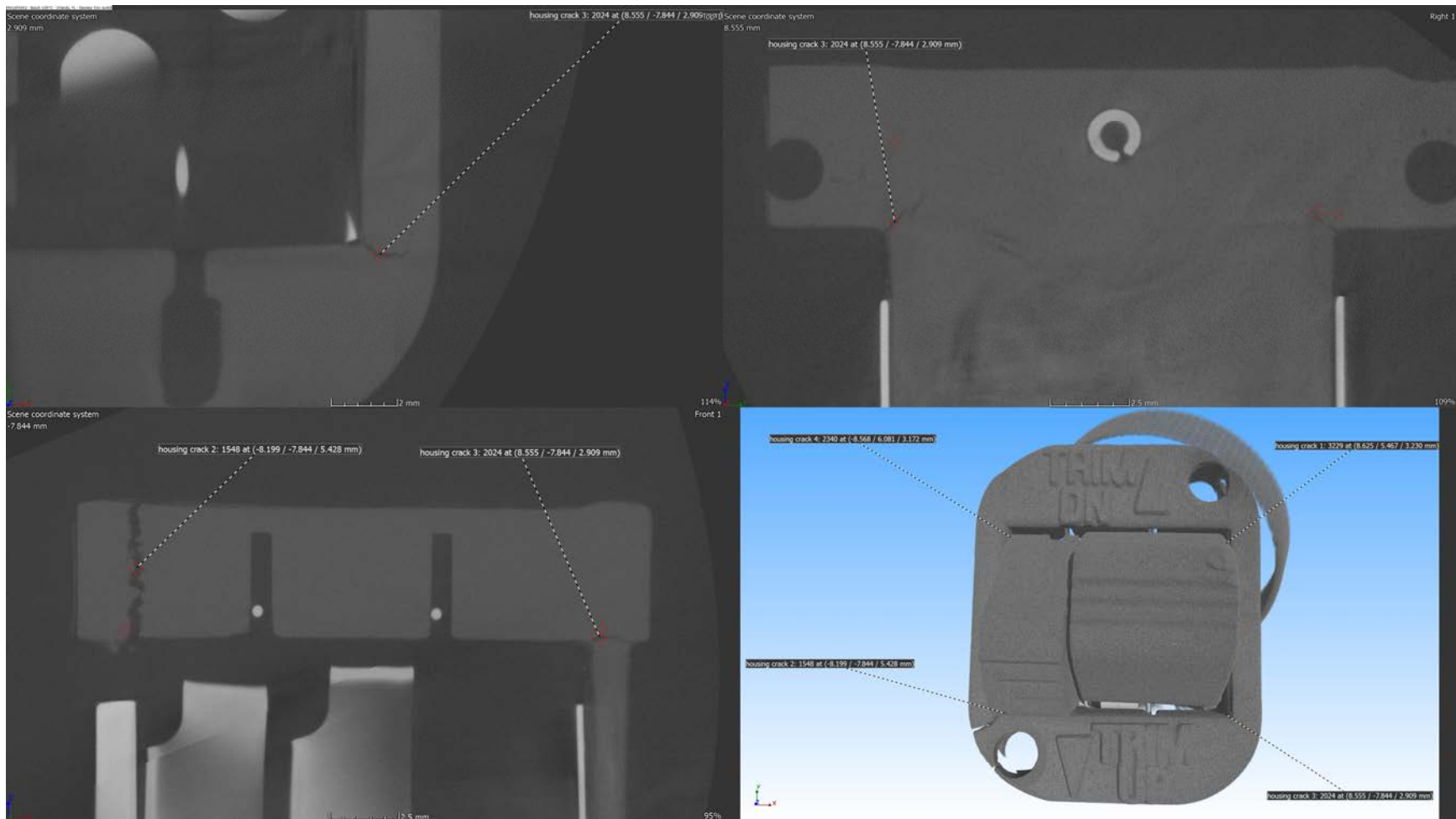


Figure 45
Autopilot trim switch assembly – Housing crack 3

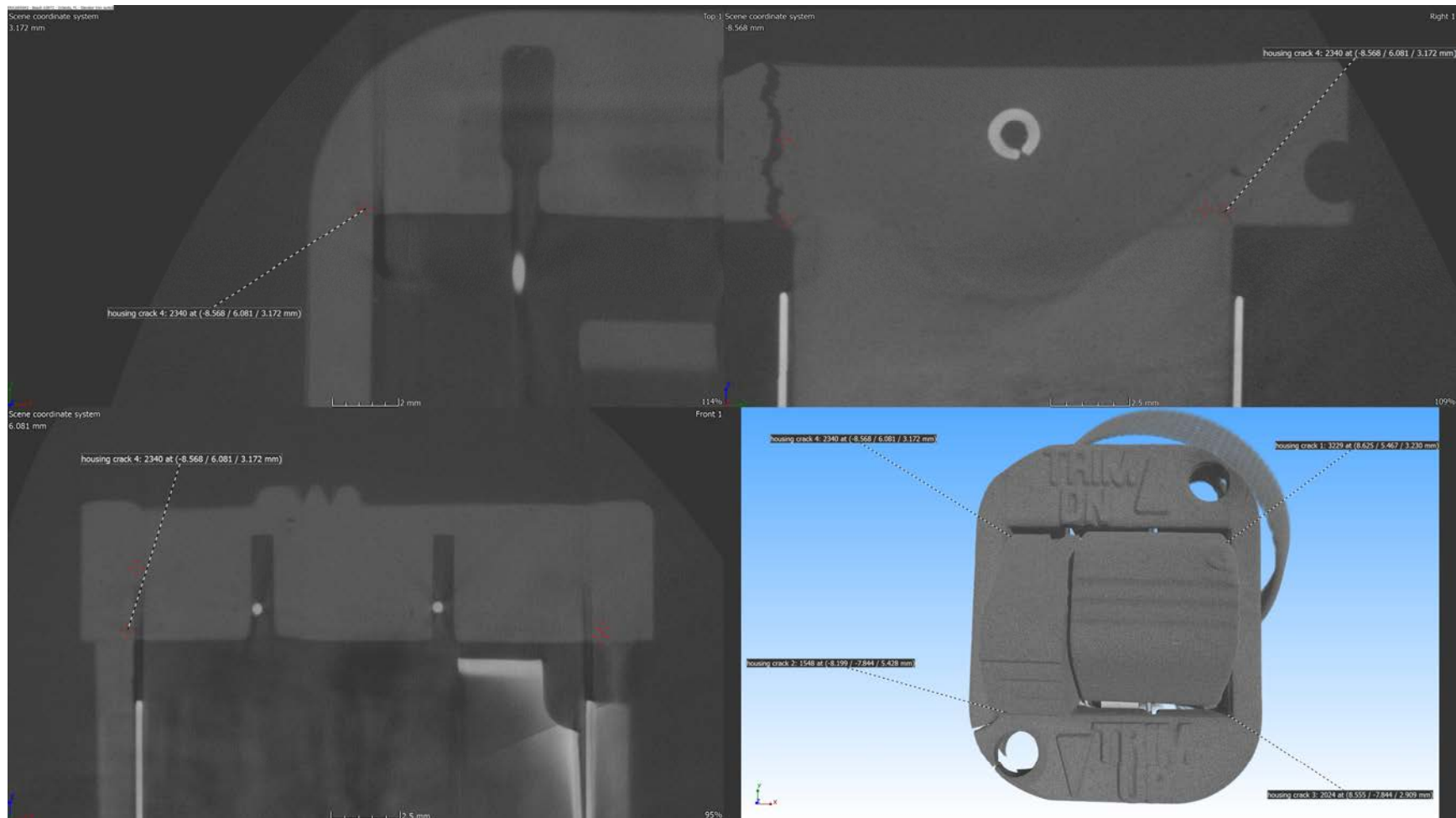


Figure 46
Autopilot trim switch assembly – Housing crack 4

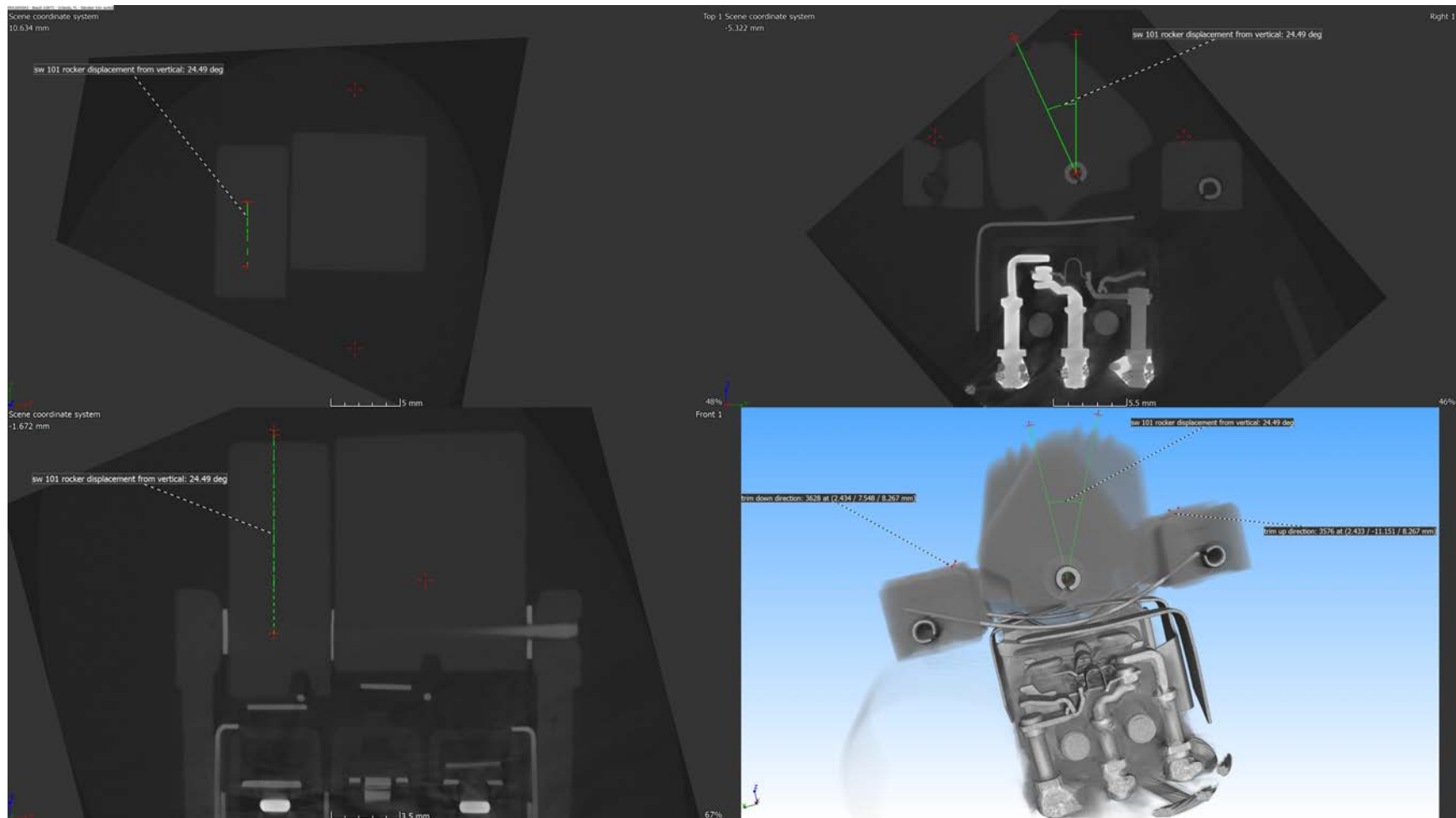


Figure 47
Autopilot trim switch assembly – Switch 01 (sw 01) rocker displacement from vertical

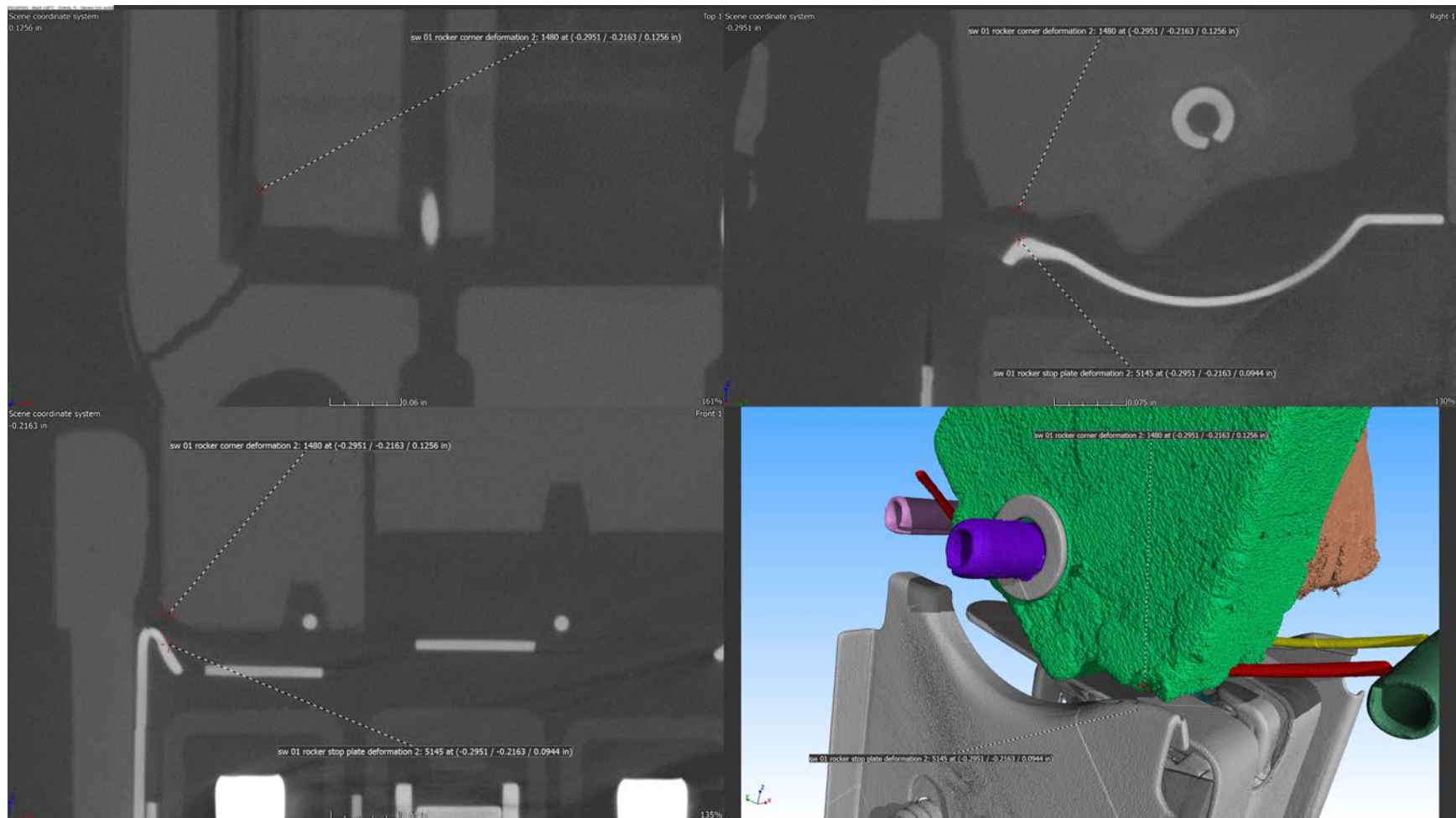


Figure 49
Autopilot trim switch assembly – Switch 01 rocker corner deformation area 2

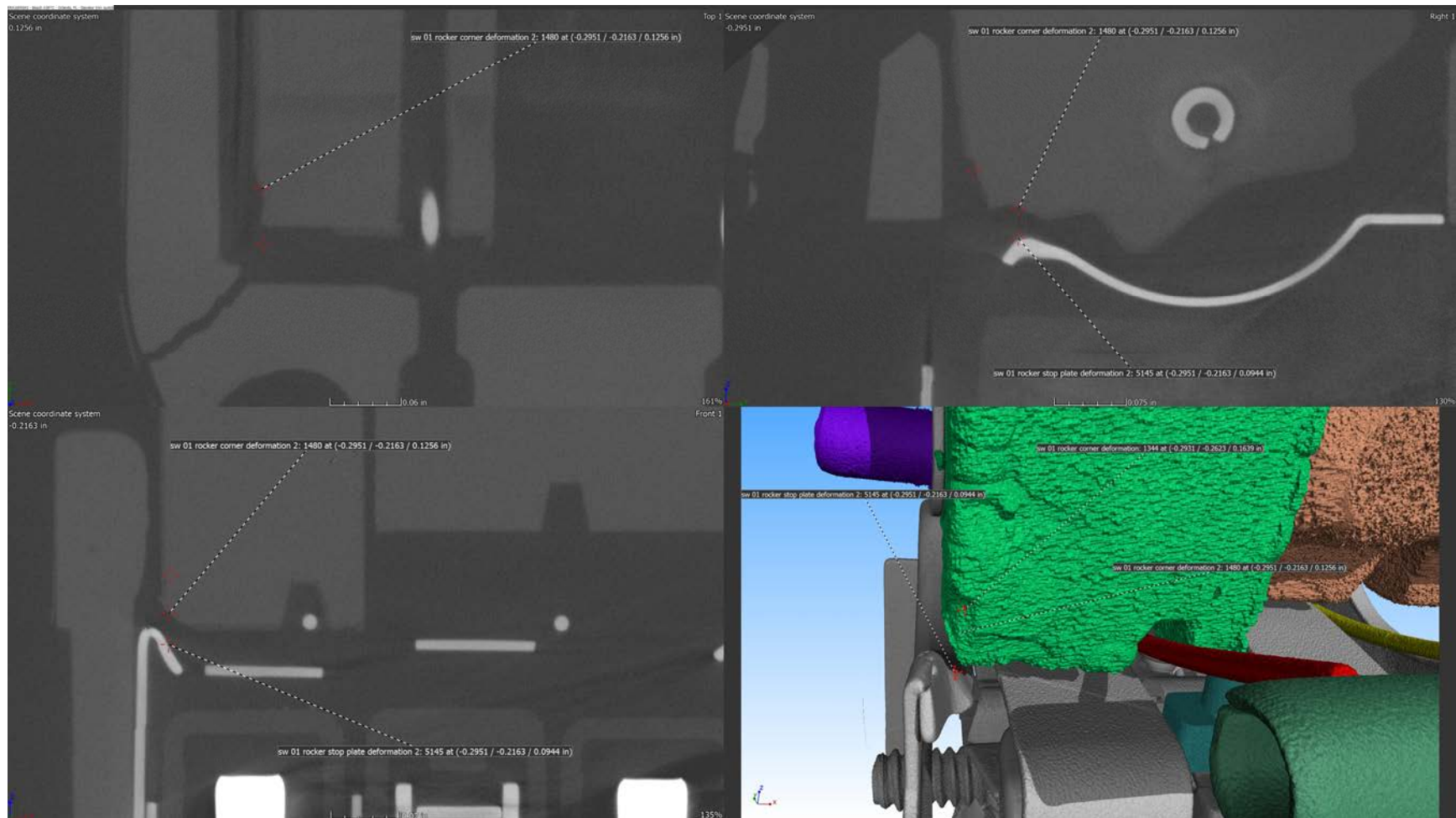


Figure 50
Autopilot trim switch assembly – Switch 01 rocker stop plate deformation area 2



Figure 51
Autopilot trim switch assembly – Switch 03 (sw 03) rocker corner and stop plate deformation

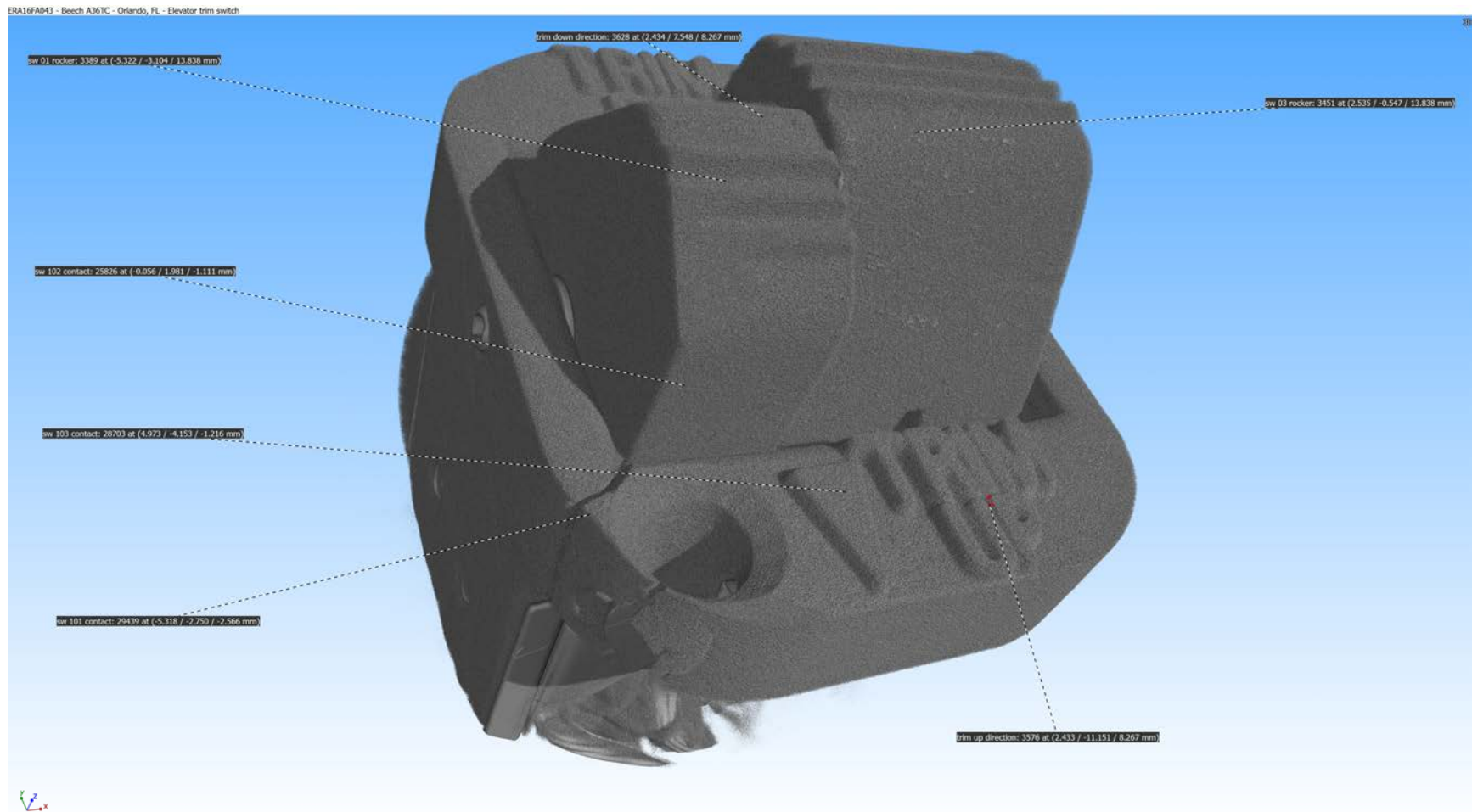


Figure 52
Autopilot trim switch assembly – 3D – Overall view with low density items visible

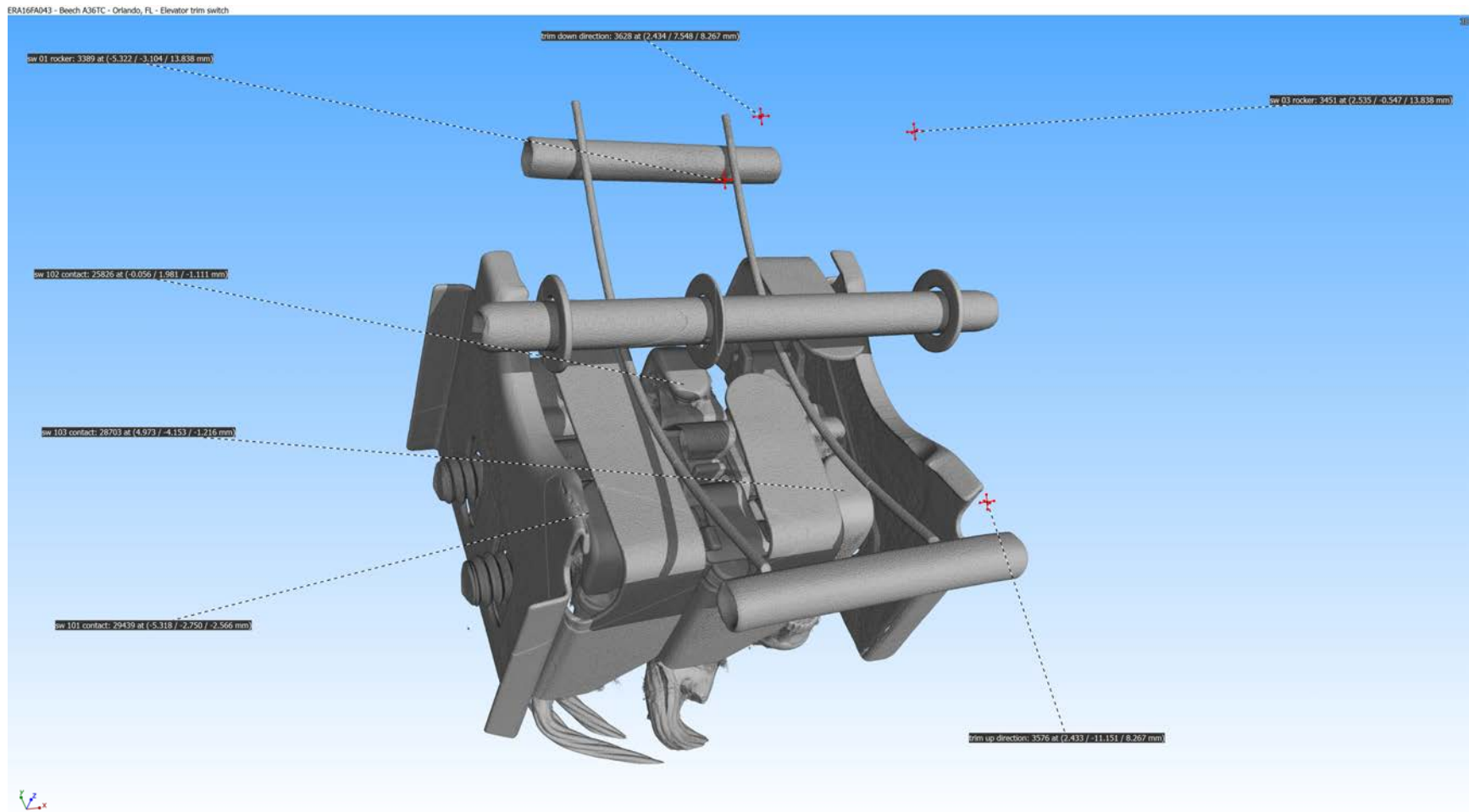


Figure 53
Autopilot trim switch assembly – 3D – Overall view with low density items removed

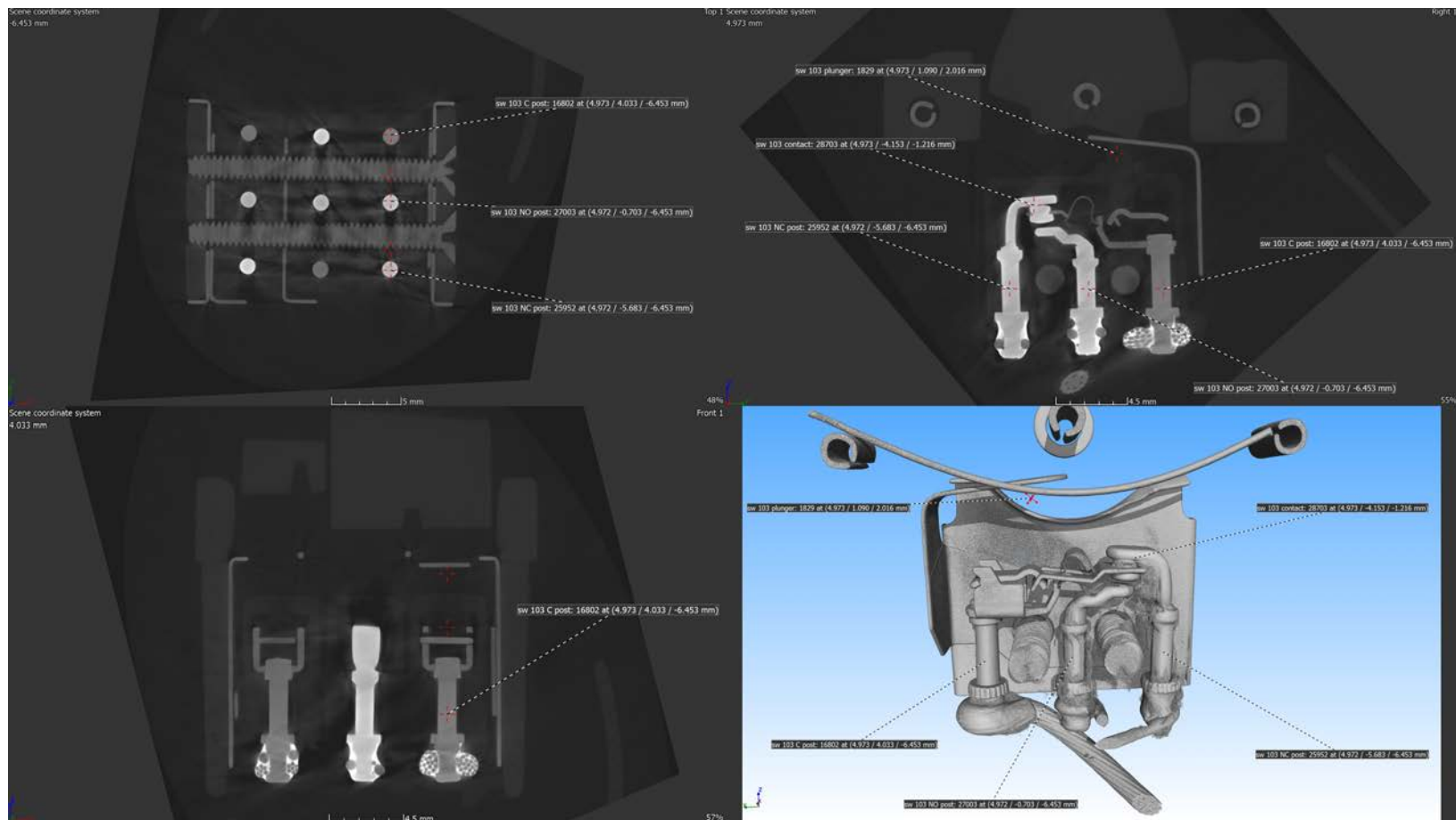


Figure 54
Autopilot trim switch assembly – Switch 103 component identification²

² Note: C Post: Common post
NC Post: Normally closed post
NO Post: Normally open post

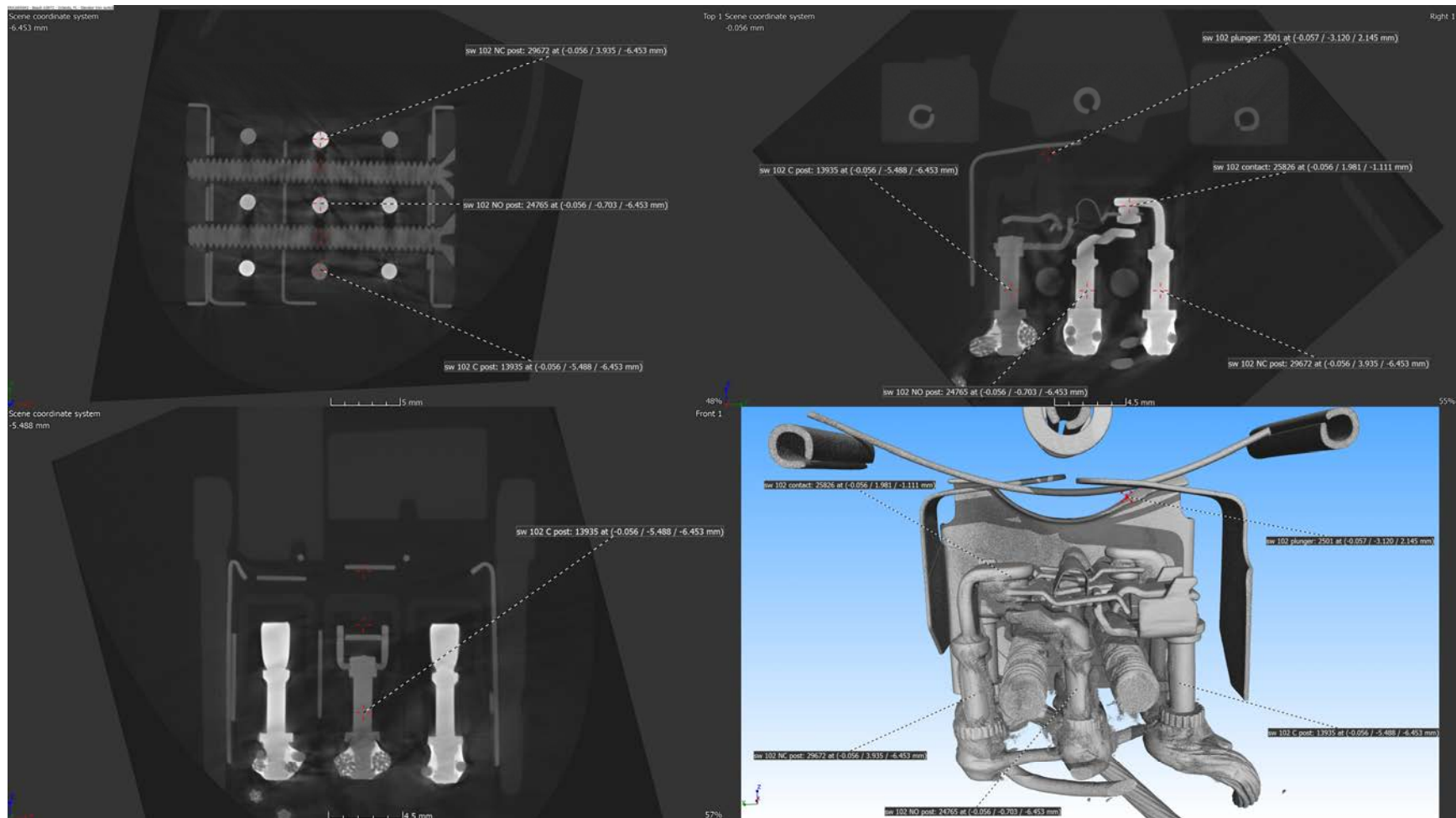


Figure 55
Autopilot trim switch assembly – Switch 102 component identification

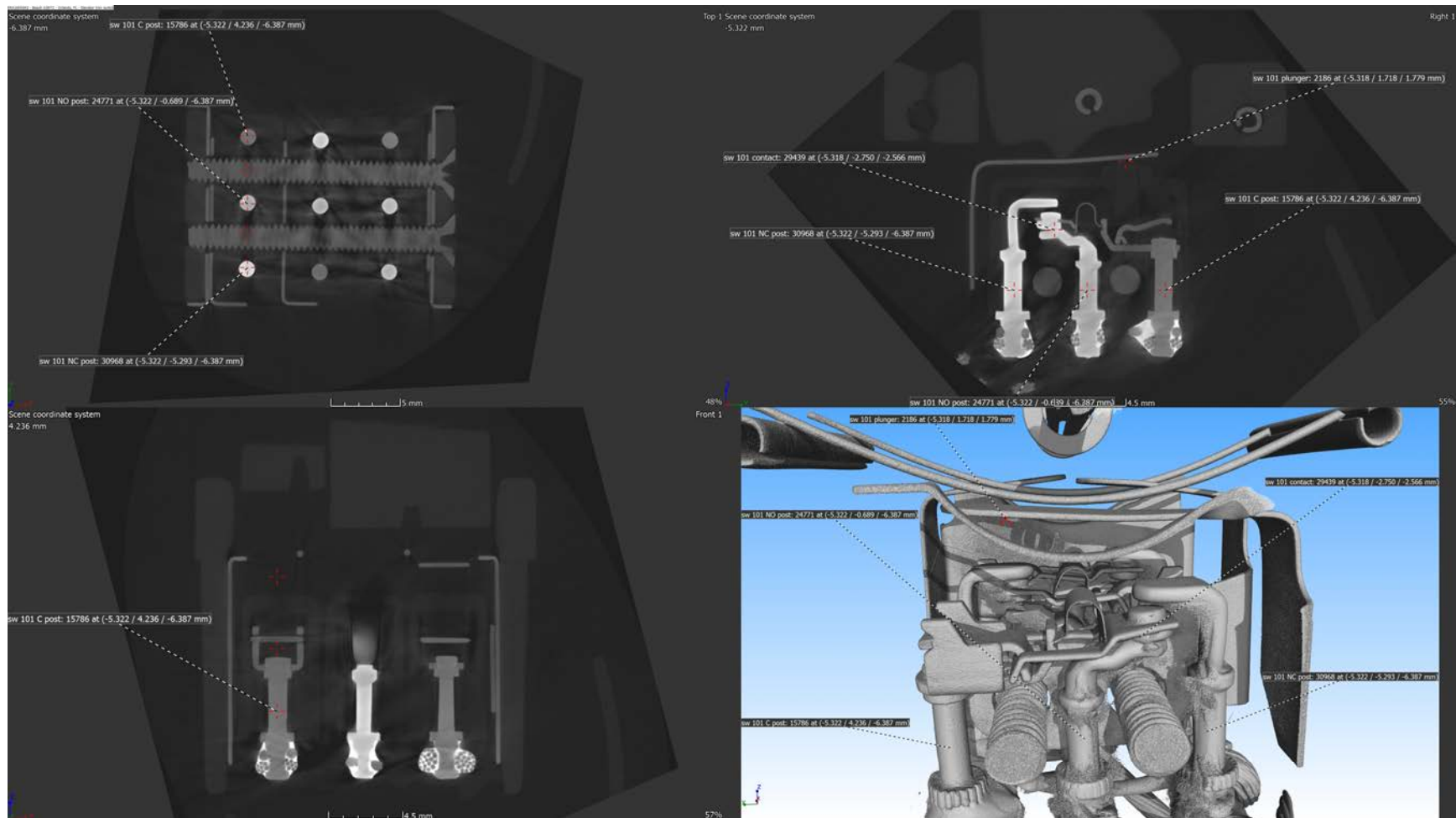


Figure 56
Autopilot trim switch assembly – Switch 101 component identification

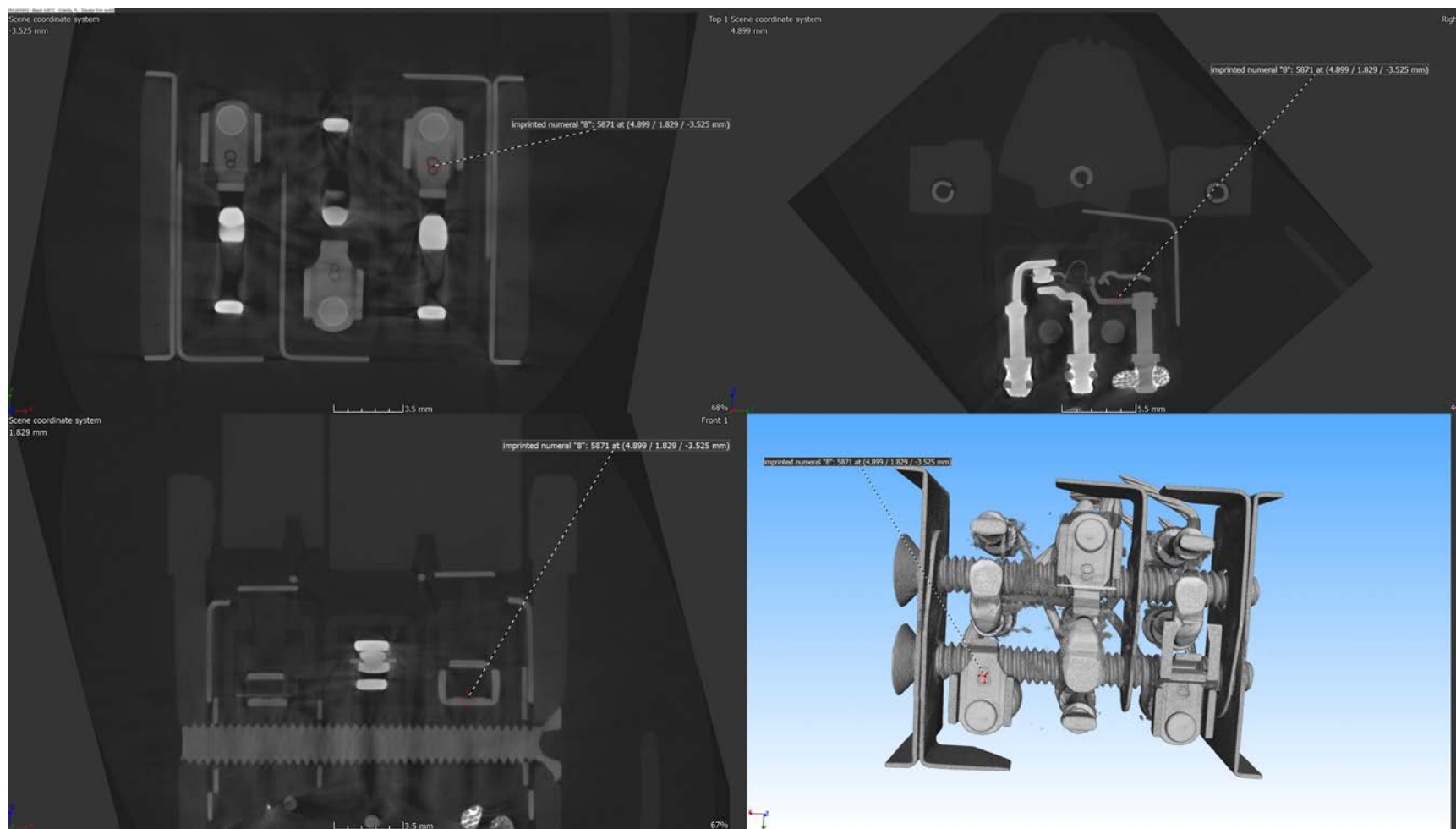


Figure 57
Autopilot trim switch assembly – Imprinted numeral 8

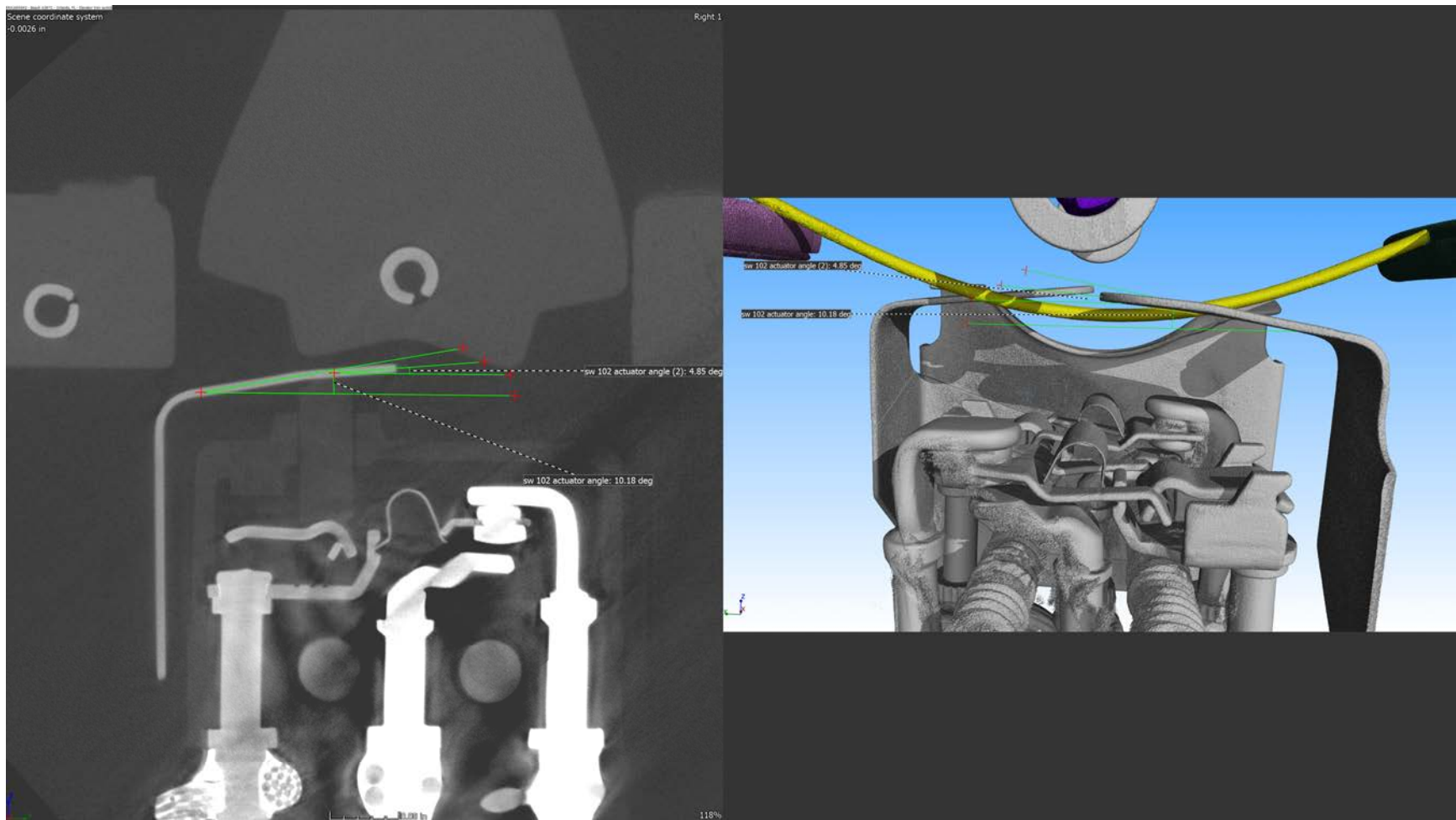


Figure 58
Autopilot trim switch assembly – Switch 102 actuator bend angle

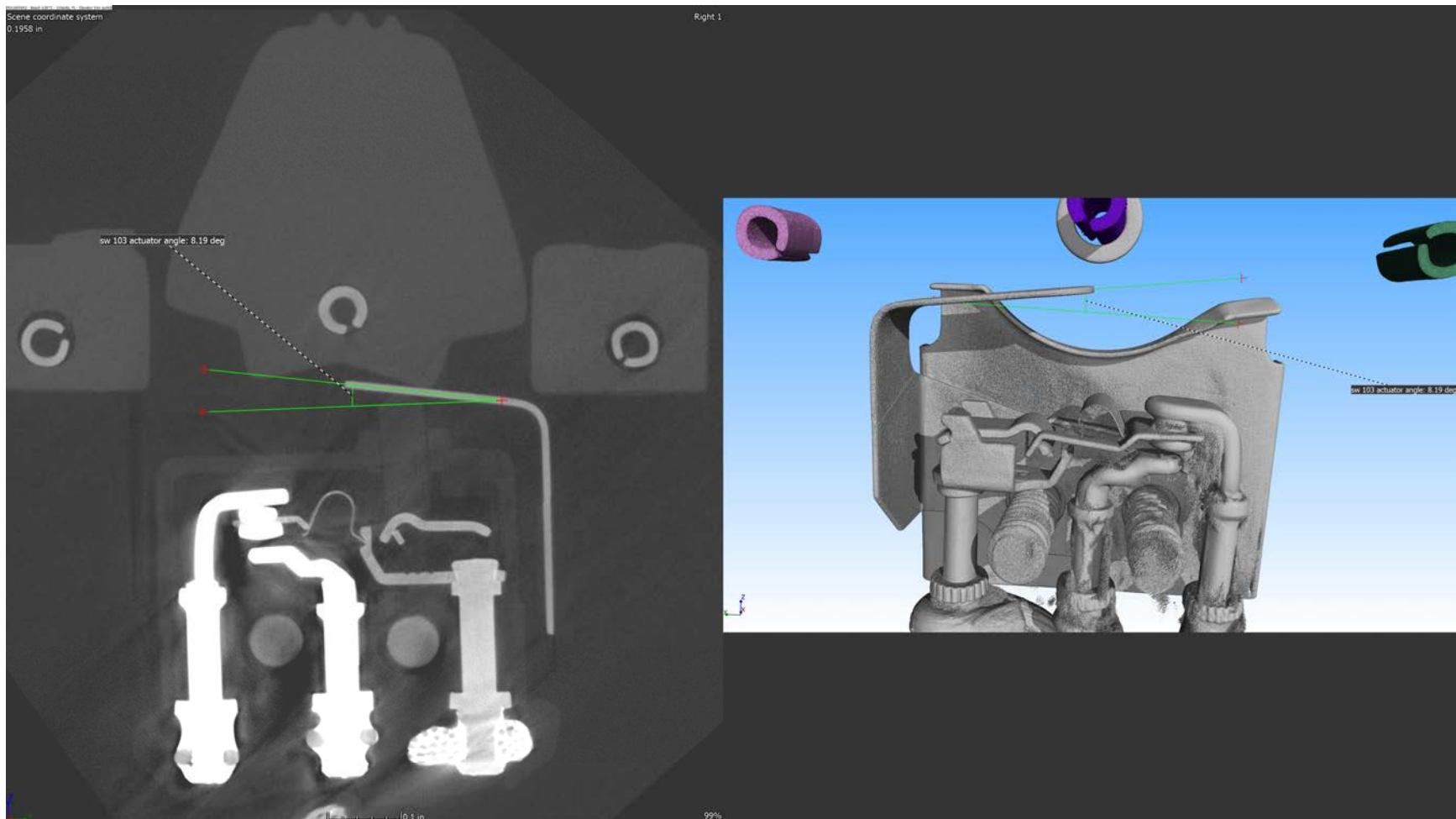


Figure 59
Autopilot trim switch assembly – Switch 103 actuator bend angle

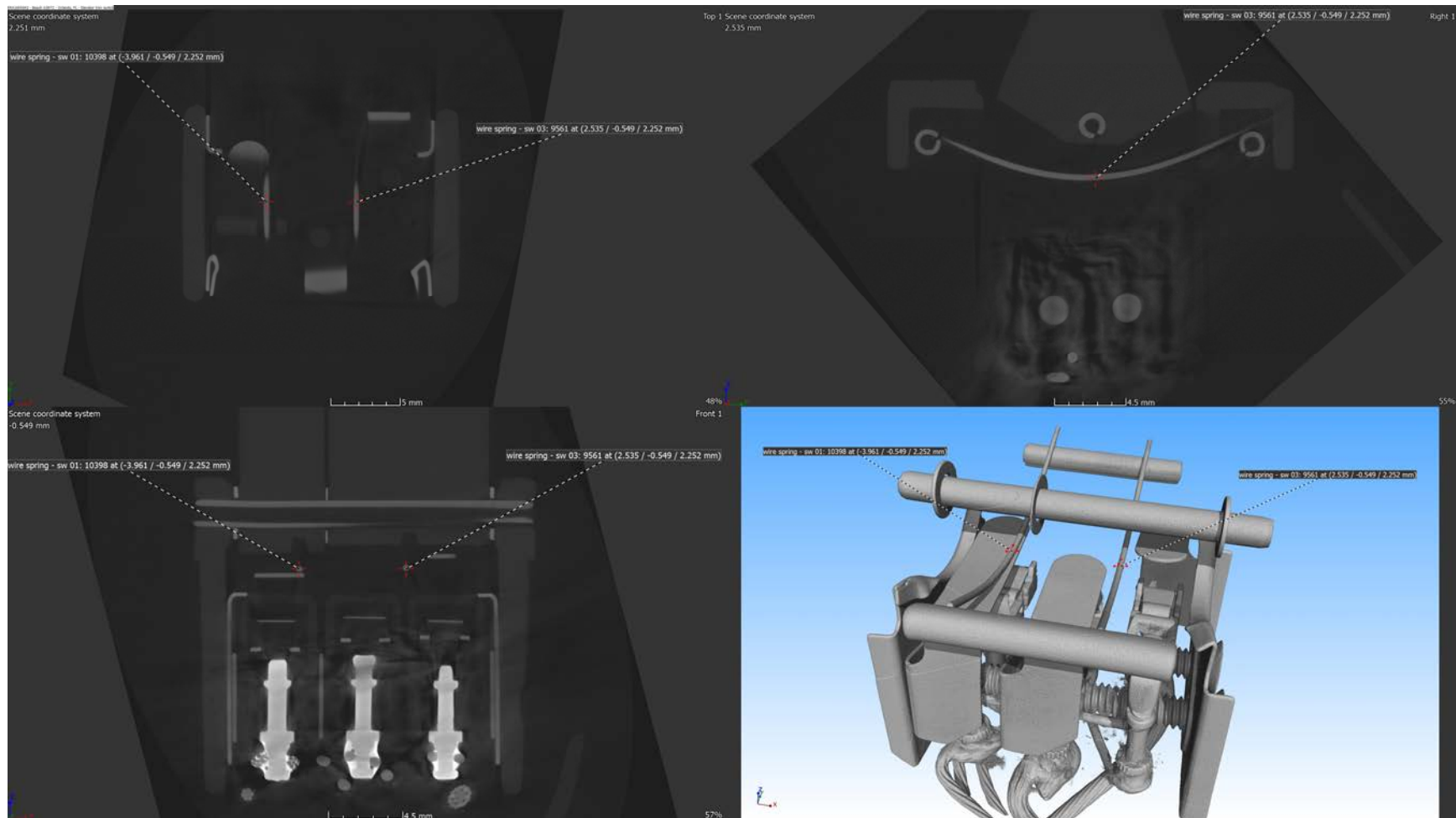


Figure 60
Autopilot trim switch assembly – Wire spring for switch rocker 03

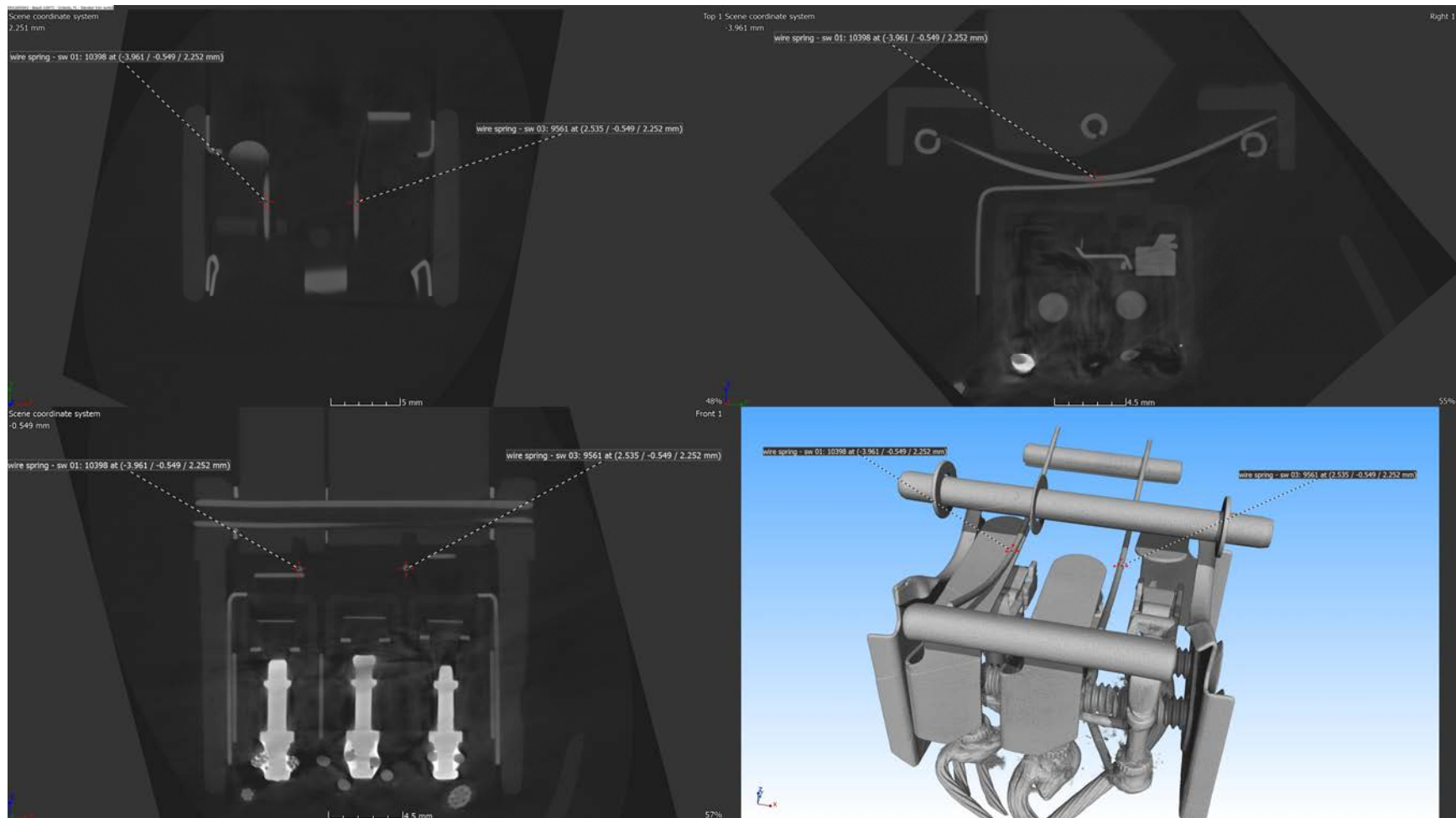


Figure 61
Autopilot trim switch assembly – Wire spring for switch rocker 01

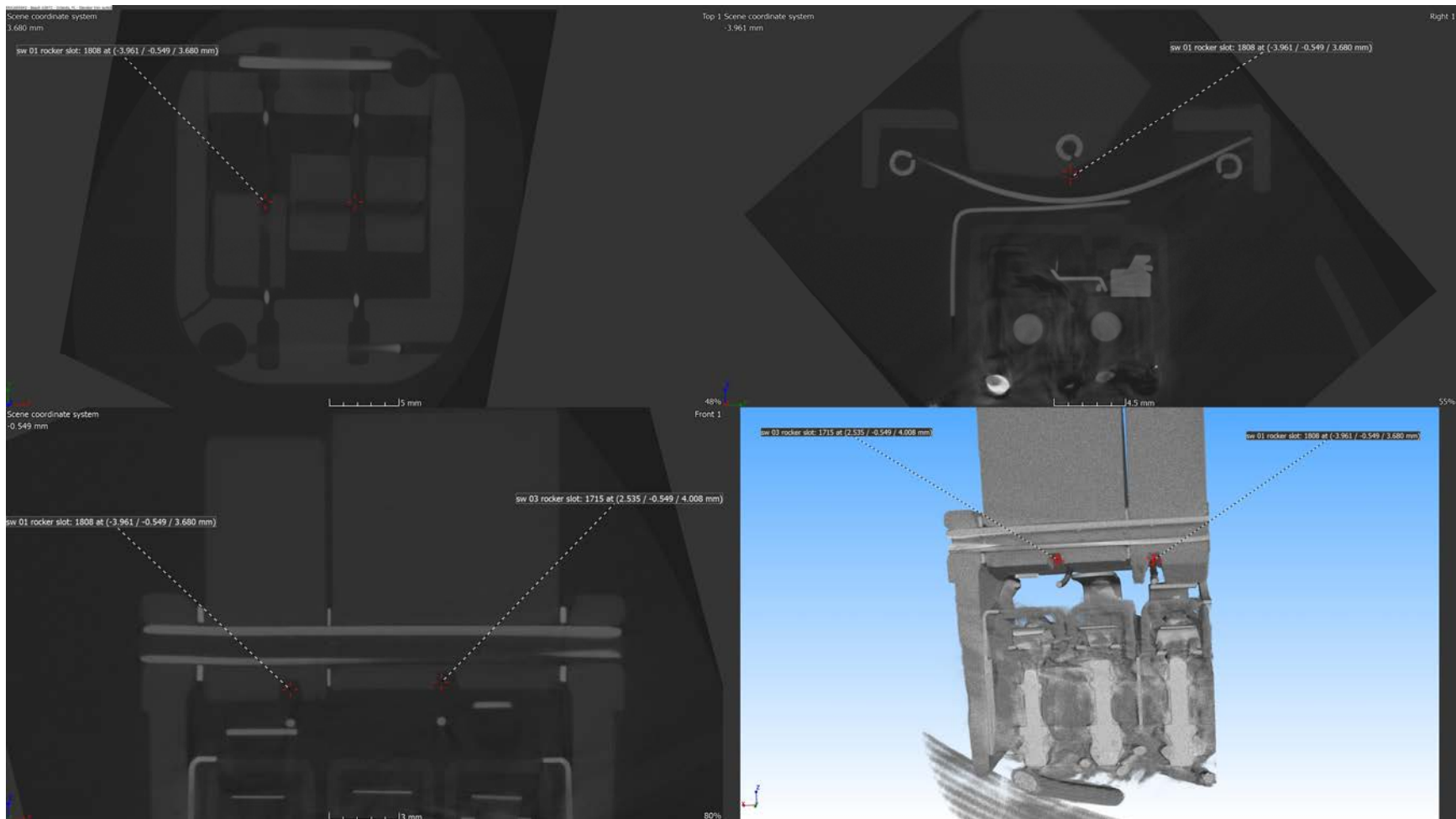


Figure 62
Autopilot trim switch assembly – Wire springs within rocker slots

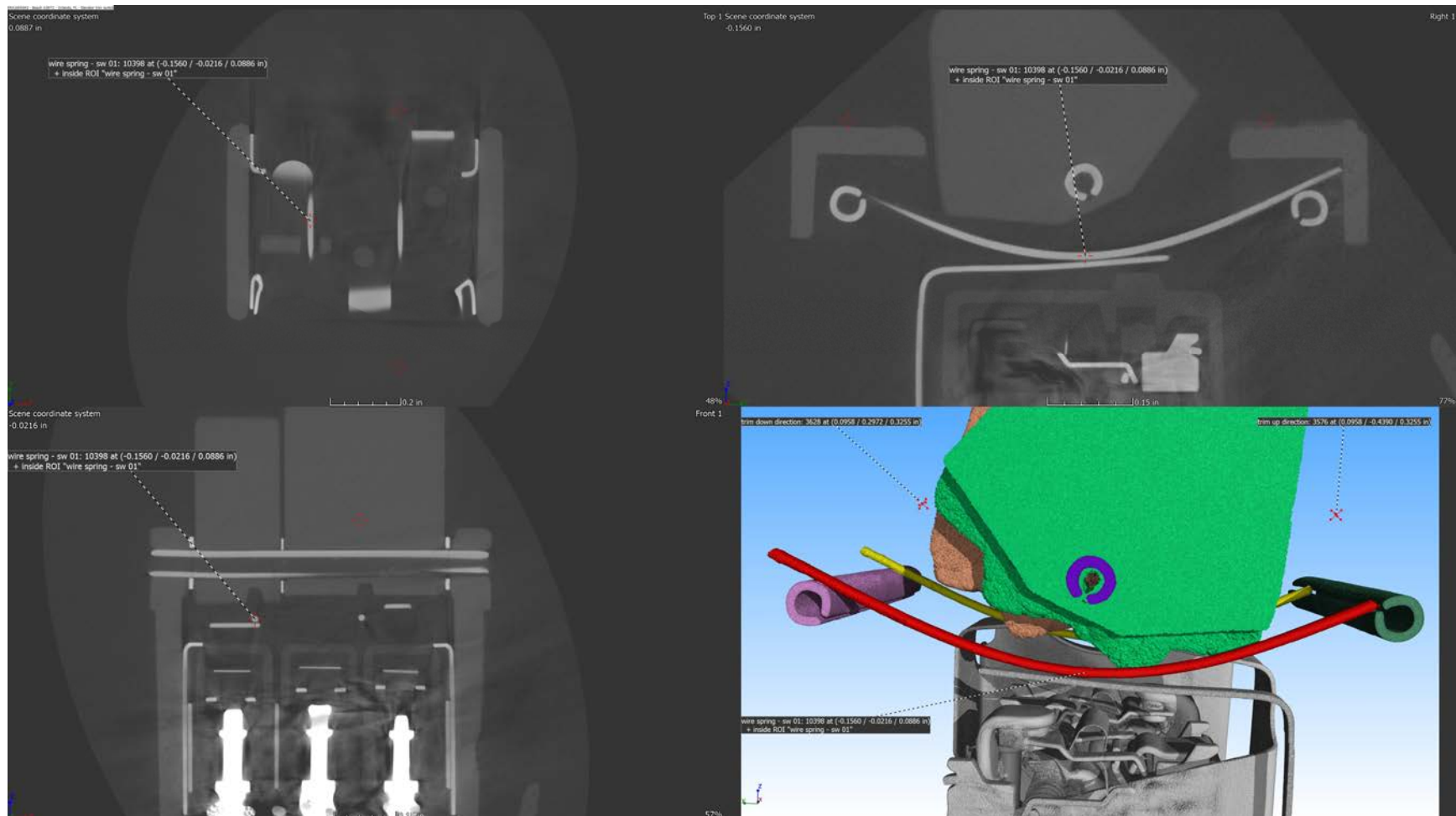


Figure 63
Autopilot trim switch assembly – Switch 01 rocker groove and wire spring

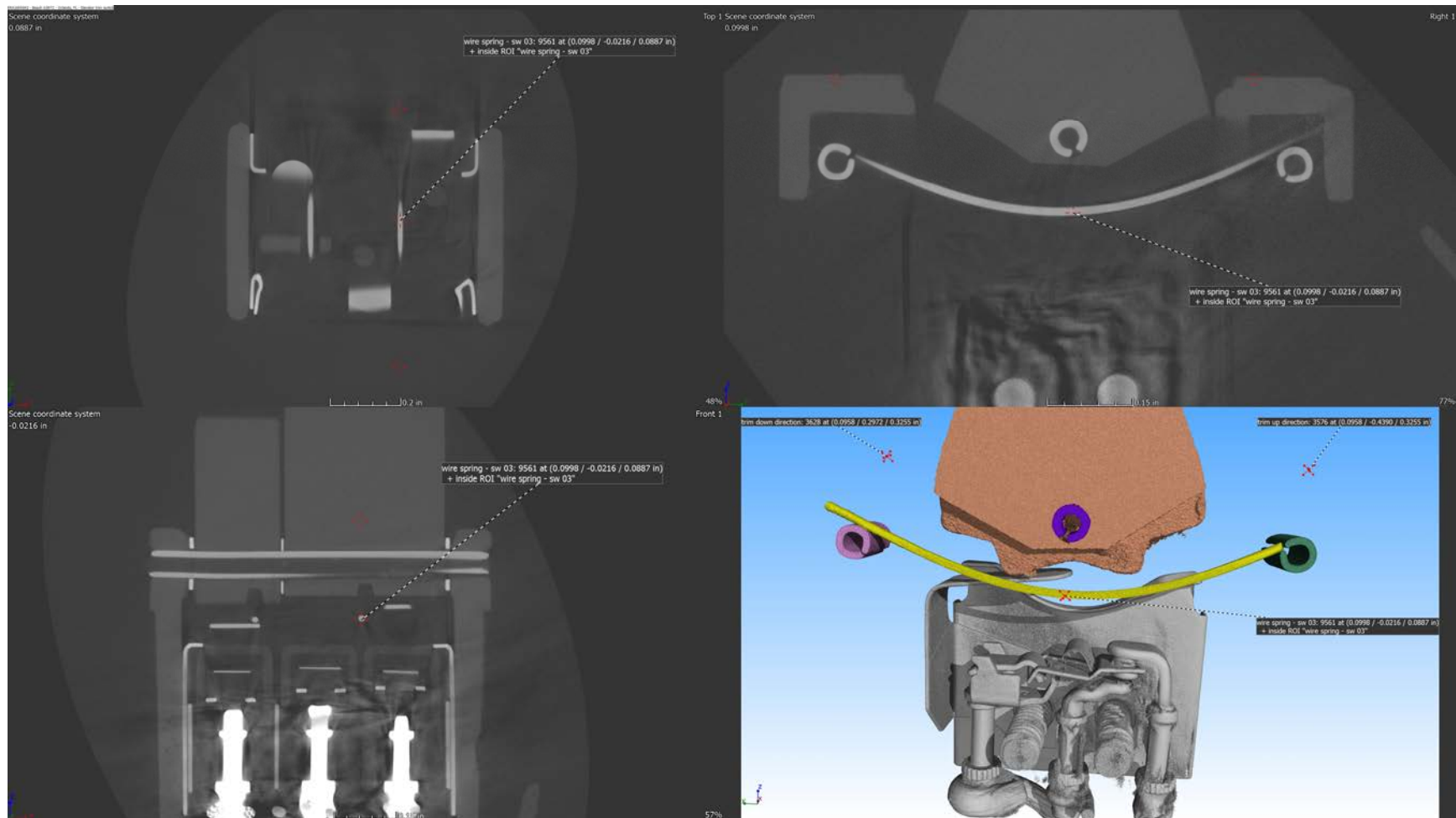


Figure 64
Autopilot trim switch assembly – Switch 03 rocker groove and wire spring

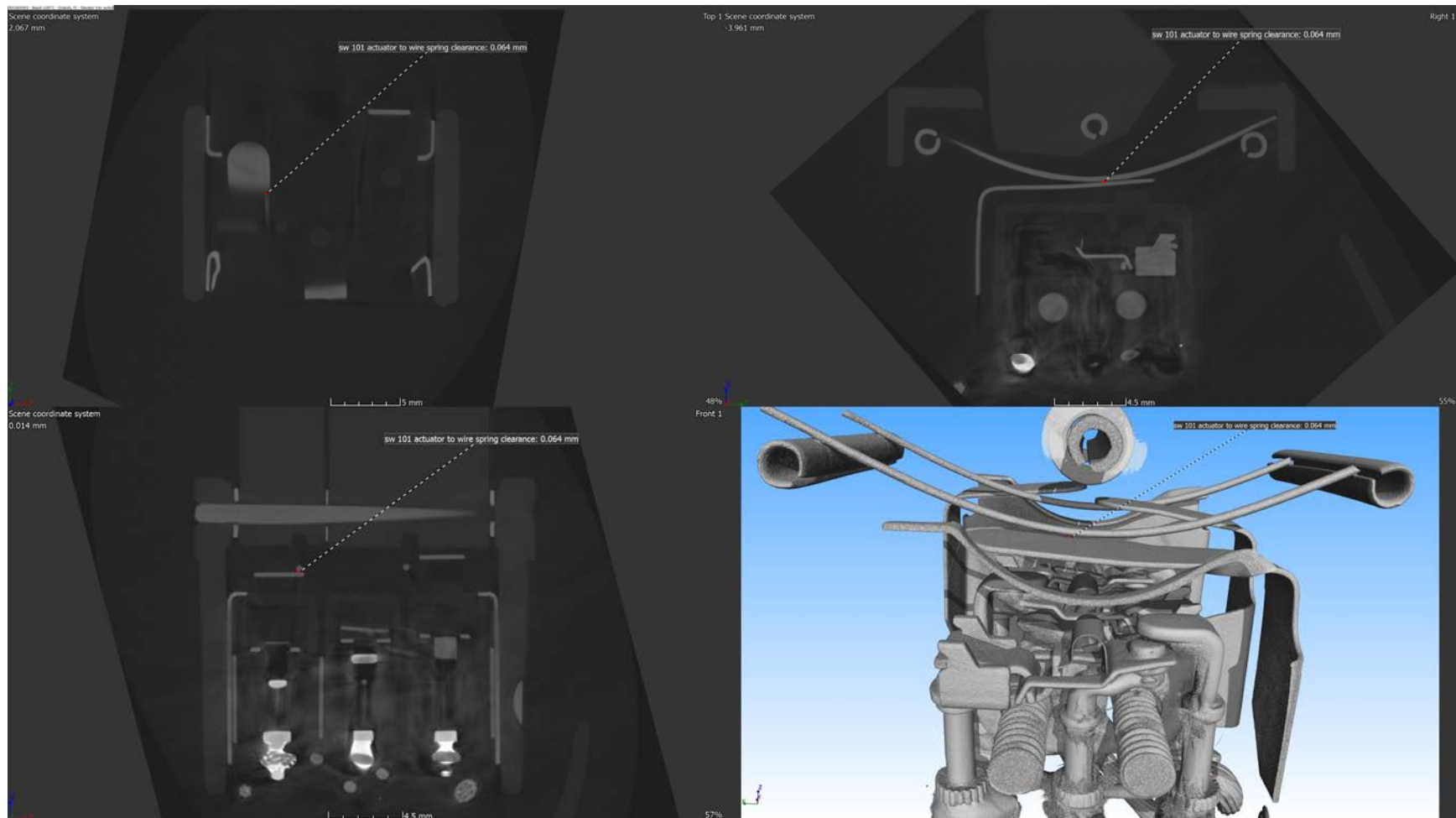


Figure 65
Autopilot trim switch assembly – Switch 101 actuator to wire spring clearance

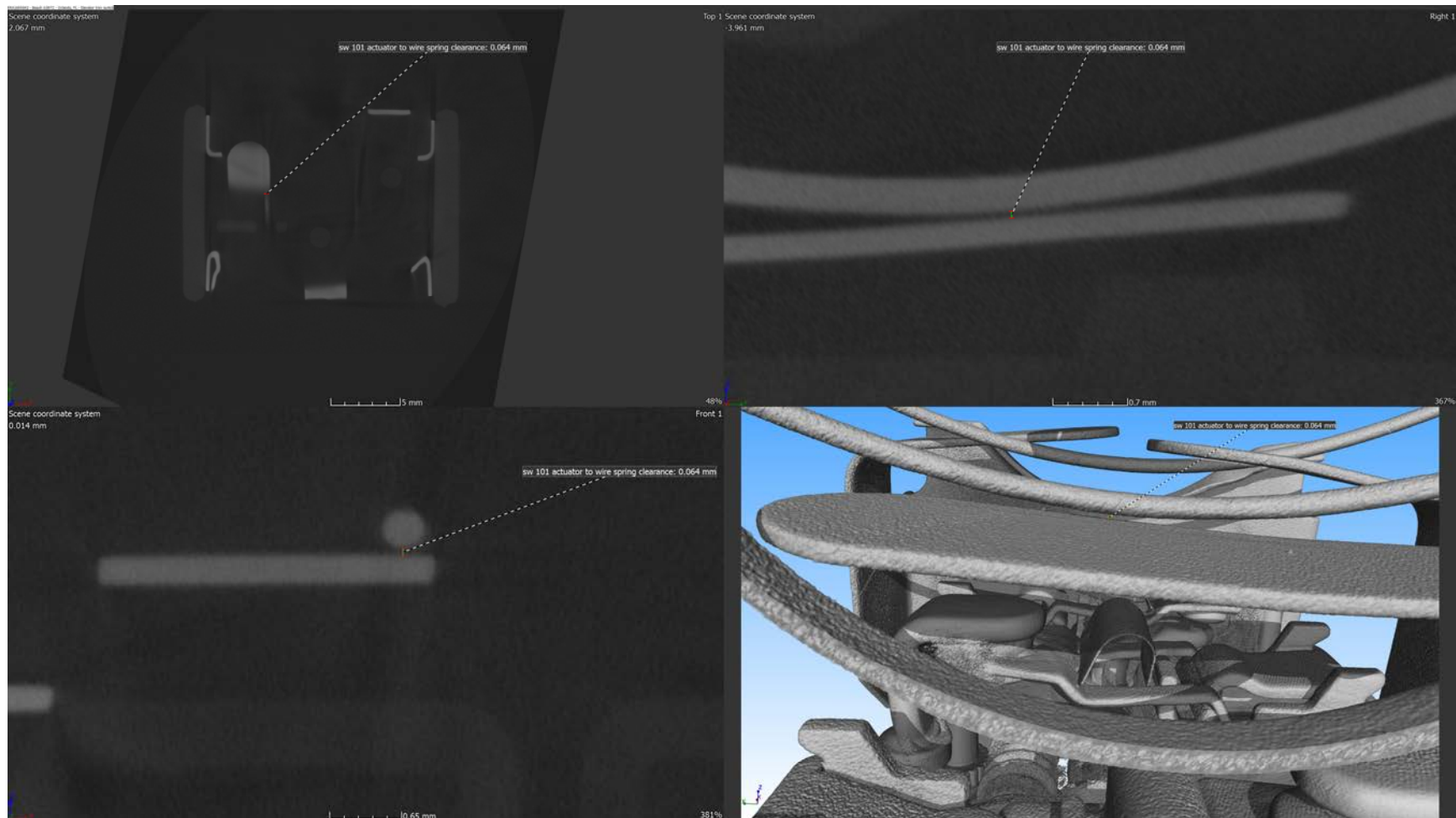


Figure 66
Autopilot trim switch assembly – Switch 101 actuator to wire spring clearance – close up view

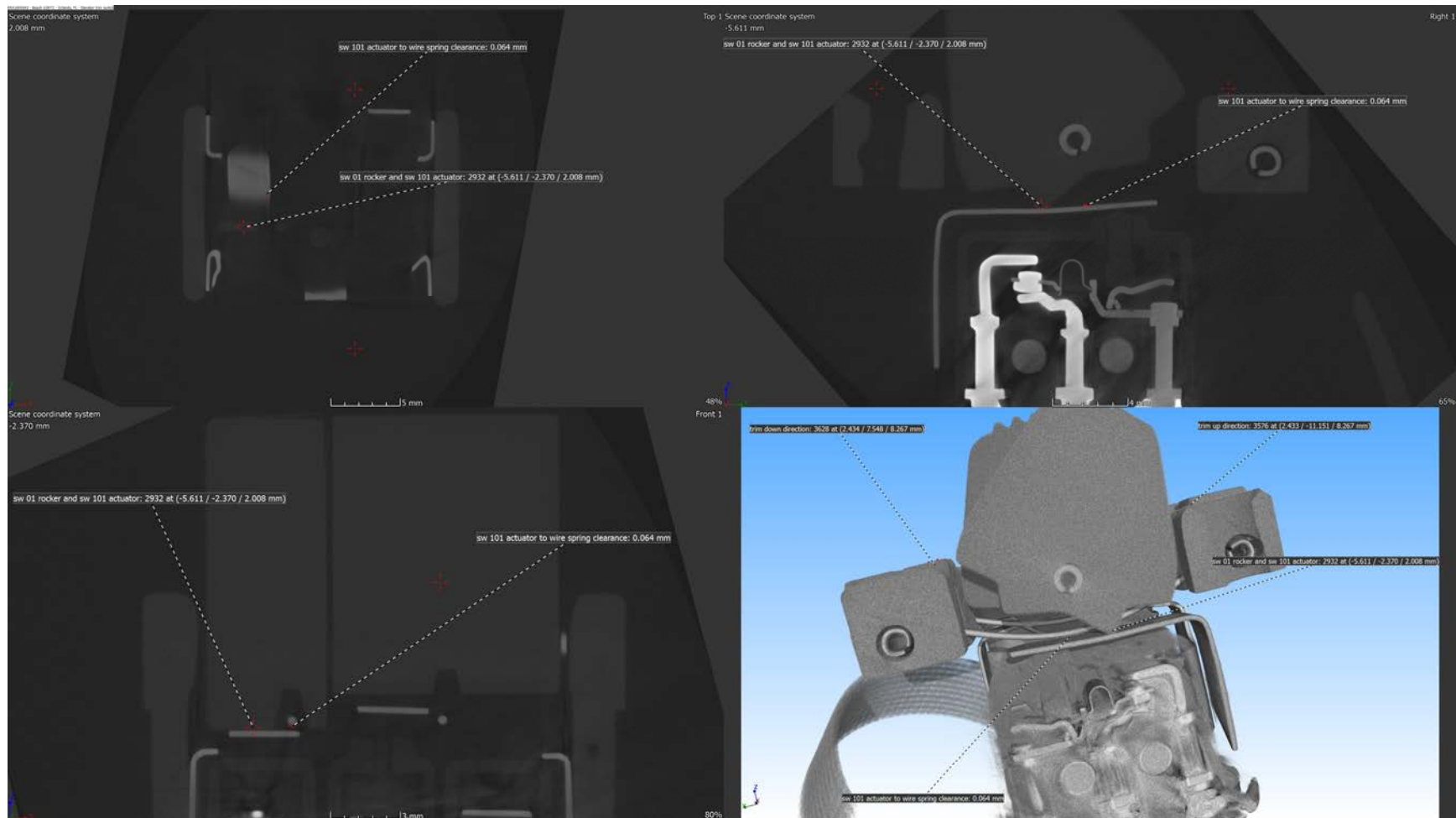


Figure 67
Autopilot trim switch assembly – Switch 01 rocker and switch 101 actuator

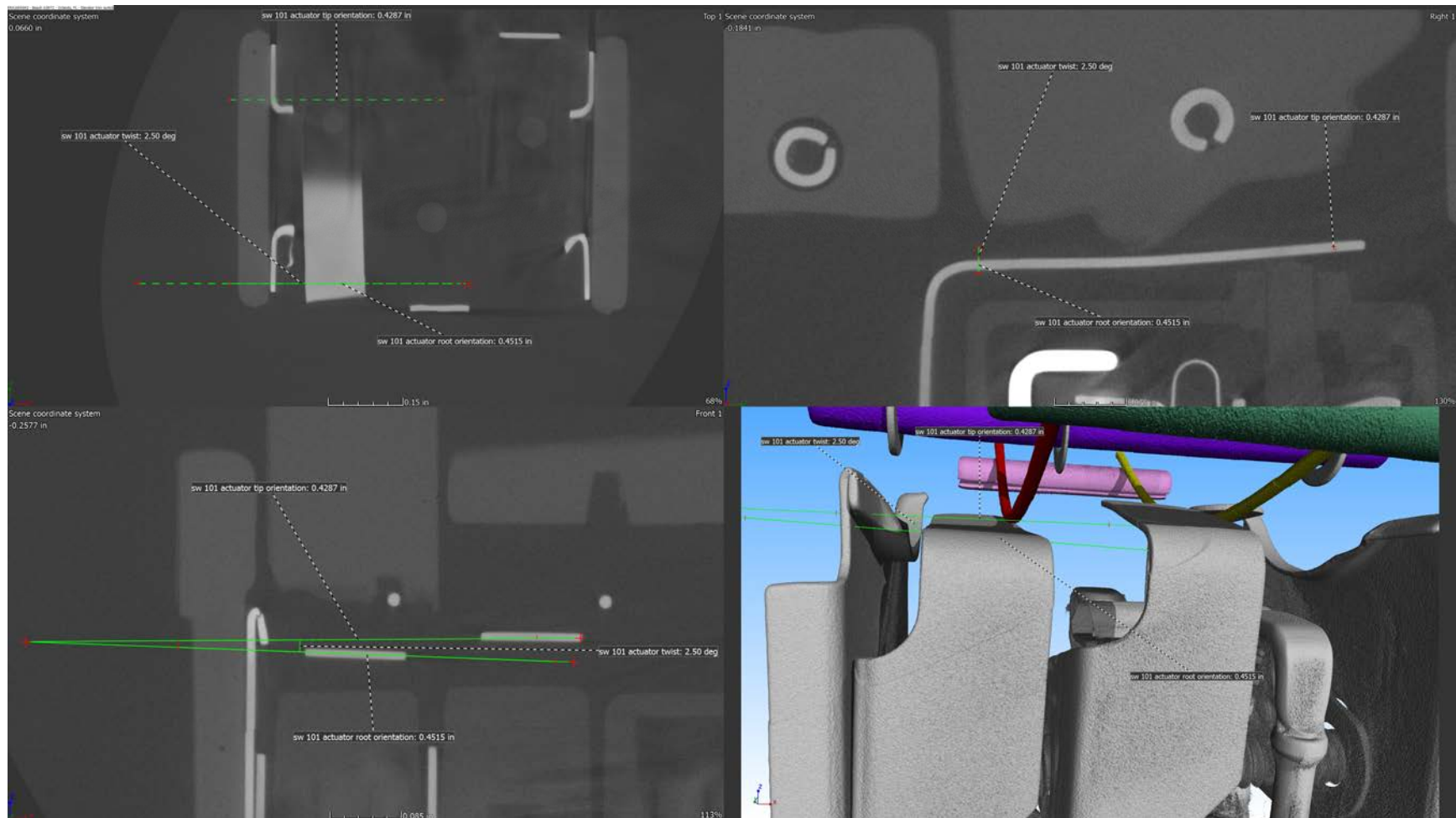


Figure 68
Autopilot trim switch assembly – Switch 101 actuator twist orientation

Scott Warren
Lead Aerospace Engineer
(Computed Tomography Specialist)