

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

September 7, 2017

Computed Tomography Specialist's Factual Report

WPR-17-FA-021

A. ACCIDENT

Location: about 1-mile north of Pukoo, Hawaii
Date: November 15, 2016
Time: 1841 Hawaii standard time
Airplane: Hughes 369D (500D) helicopter, N81GG

B. GROUP

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

C. SUMMARY

On November 15, 2016, about 1841 Hawaii standard time, a turbine-powered Hughes 369D (500D) helicopter, N81GG, was destroyed after impacting mountainous tree-covered terrain about 1-mile north of Pukoo, Hawaii. The certificated airline transport pilot and the sole passenger were fatally injured. The helicopter was registered to the pilot and operated as a visual flight rules (VFR) personal flight conducted under Title 14 Code of Federal Regulations Part 91. No flight plan was filed. At the time of the accident, dark night, visual meteorological conditions prevailed with localized reports of low visibility with heavy rain showers. The flight departed the Honolulu International Airport, Hawaii, at 1756, destined for a private residence near Pukoo, located on the Island of Molokai.

The internal configuration of the cyclic grip from the accident helicopter was documented using radiographic images that were collected from June 6-23, 2017 in Chicago, Illinois. A total of 6,336 computed tomography (CT) slice images were examined, processed, and analyzed by the NTSB to evaluate the components.

Review of the images indicated that, when it was scanned, there were cracks in multiple locations within the cyclic grip; the trigger switch interior mechanisms were displaced from their normal locations; there was one location noted where the core strands within a wire were splayed out; there was a location, below the trim switch, where the nose down trim wire appeared to be closer to the trim switch ground contact solder than the thickness of the wire insulation; the solder composing the junction of the nose down trim wire and its corresponding trim switch contact appeared to be distorted. The splayed core wire strands, the wire-solder proximity, and the distorted nose down trim wire-contact solder joint appeared to be consistent with a tension load applied to the wires during the impact sequence.

D. DETAILS OF THE INVESTIGATION

1.0 General

The cyclic grip was subjected to x-ray radiograph and computed tomography (CT) scanning to document its internal conditions. The scanning was conducted from June 6-23, 2017. The scans were performed by Varex, Inc under the direction of the NTSB using the Varex Actis 500/225 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 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 6,336 slices, and the total size of the combined data sets was approximately 49.6 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 components. Target CT techniques, where the scanned field of view was narrowed to allow better resolution, were used for some of the scans to gather more detailed information on a given area of interest.

Table 1
Scan Protocols

Component	Cyclic grip – overall scan	Cyclic grip – target CT scan
Number of slices	4001	2335
Voxel Size - X Direction (mm)	0.042	0.014
Voxel Size - Y Direction (mm)	0.042	0.014
Voxel Size - Z Direction (mm)	0.049	0.015
Image Projections per Revolution	1800	3240
Exposure time (ms)	285.58	285.58
Frames to Avg (frames per projection)	2	2
X-ray Source Voltage (kV)	222	222
X-ray Source Current (mA)	0.590	0.590
Source Filter Thickness (mm)	1.0	2.5
Source Filter Material	Brass	Brass
Image Matrix Size	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. Some areas within the component (such as wires or other internal components) were digitally grouped together into “regions of interest” and denoted with different colors to assist with the image review.

The images of the component 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 Digital Radiograph and Computed Tomography Results

The digital radiograph and computed tomography (CT) results for the cyclic grip are shown in figures 1 through 34. Review of the images indicated that, when it was scanned, there were cracks in multiple locations within the cyclic grip; the trigger switch interior mechanisms were displaced from their normal locations; there was one location noted where the core strands within a wire were splayed out; there was a location, below the trim switch, where the nose down trim wire appeared to be closer to the trim switch ground contact solder than the thickness of the wire insulation; the solder composing the junction of the nose down trim wire and its corresponding trim switch contact appeared to be distorted. The splayed core wire strands, the wire-solder proximity, and the distorted nose down trim wire-contact solder joint appeared to be consistent with a tension load applied to the wires during the impact sequence.

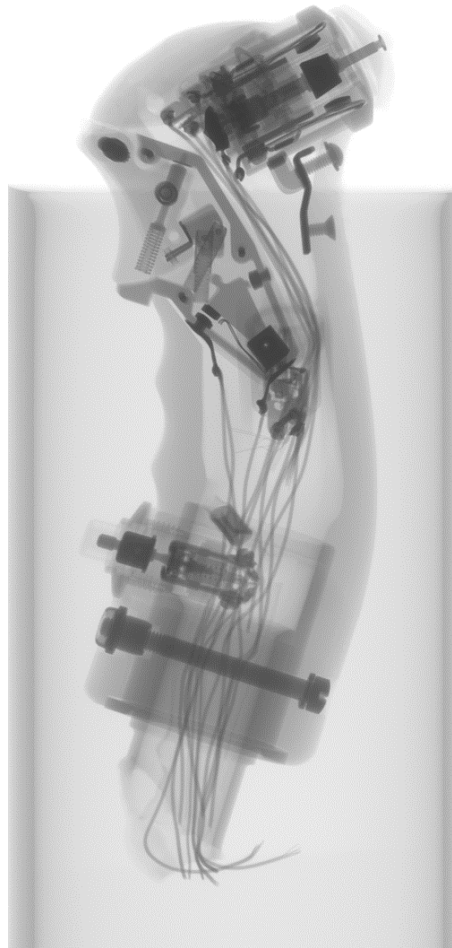


Figure 1
Cyclic grip – digital radiograph - overview

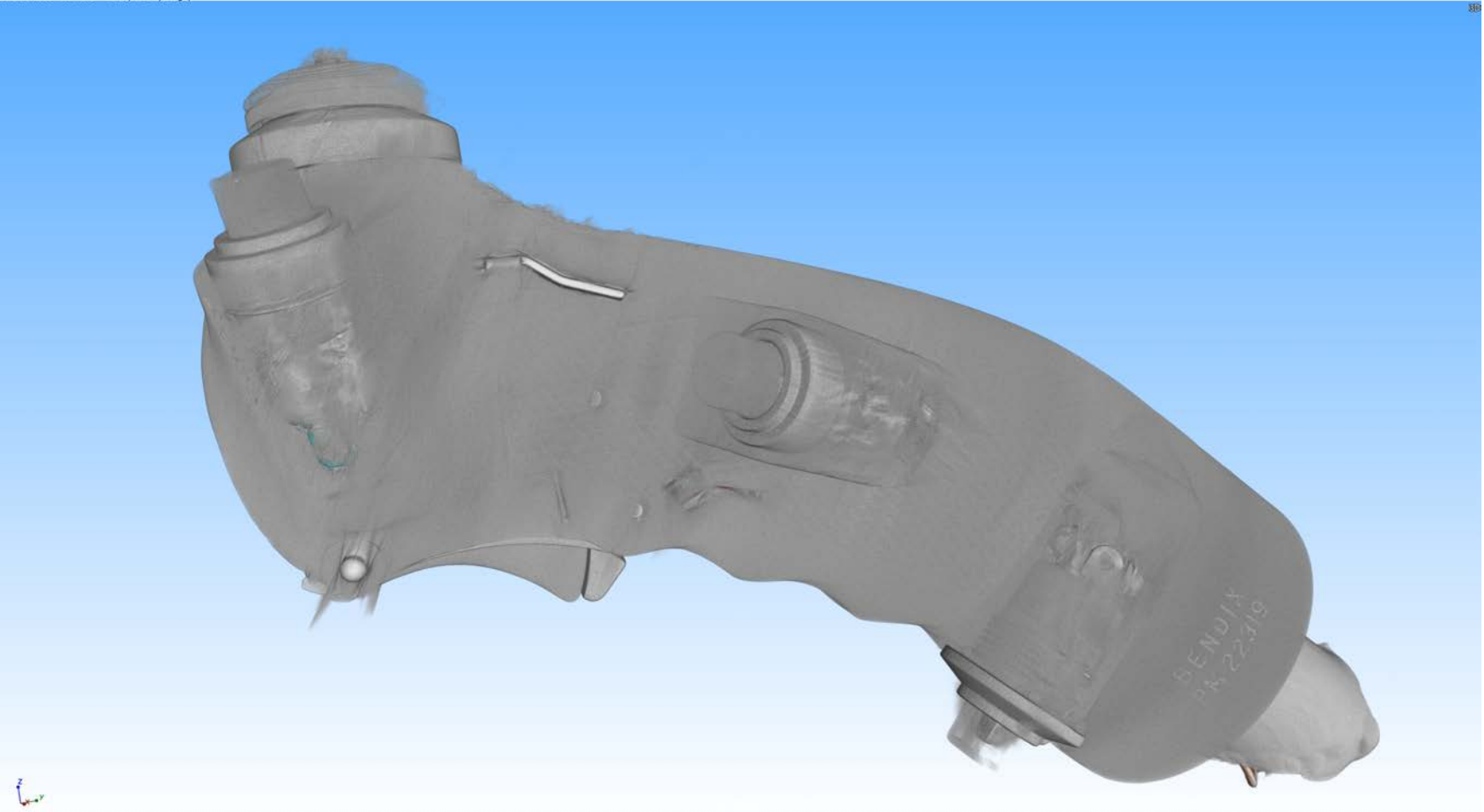


Figure 2
Cyclic grip – overview – left side - exterior

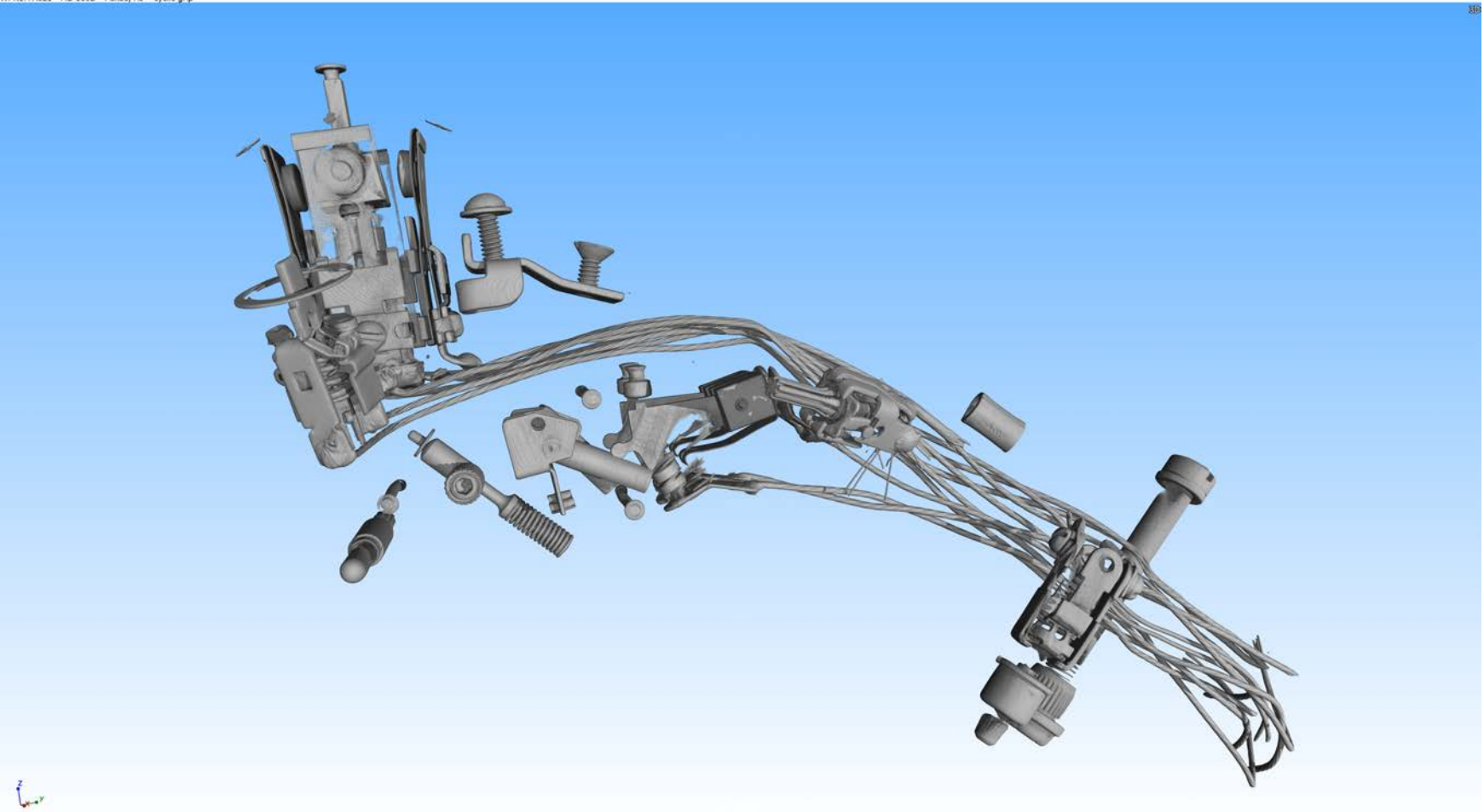


Figure 3
Cyclic grip – overview – left side – no exterior

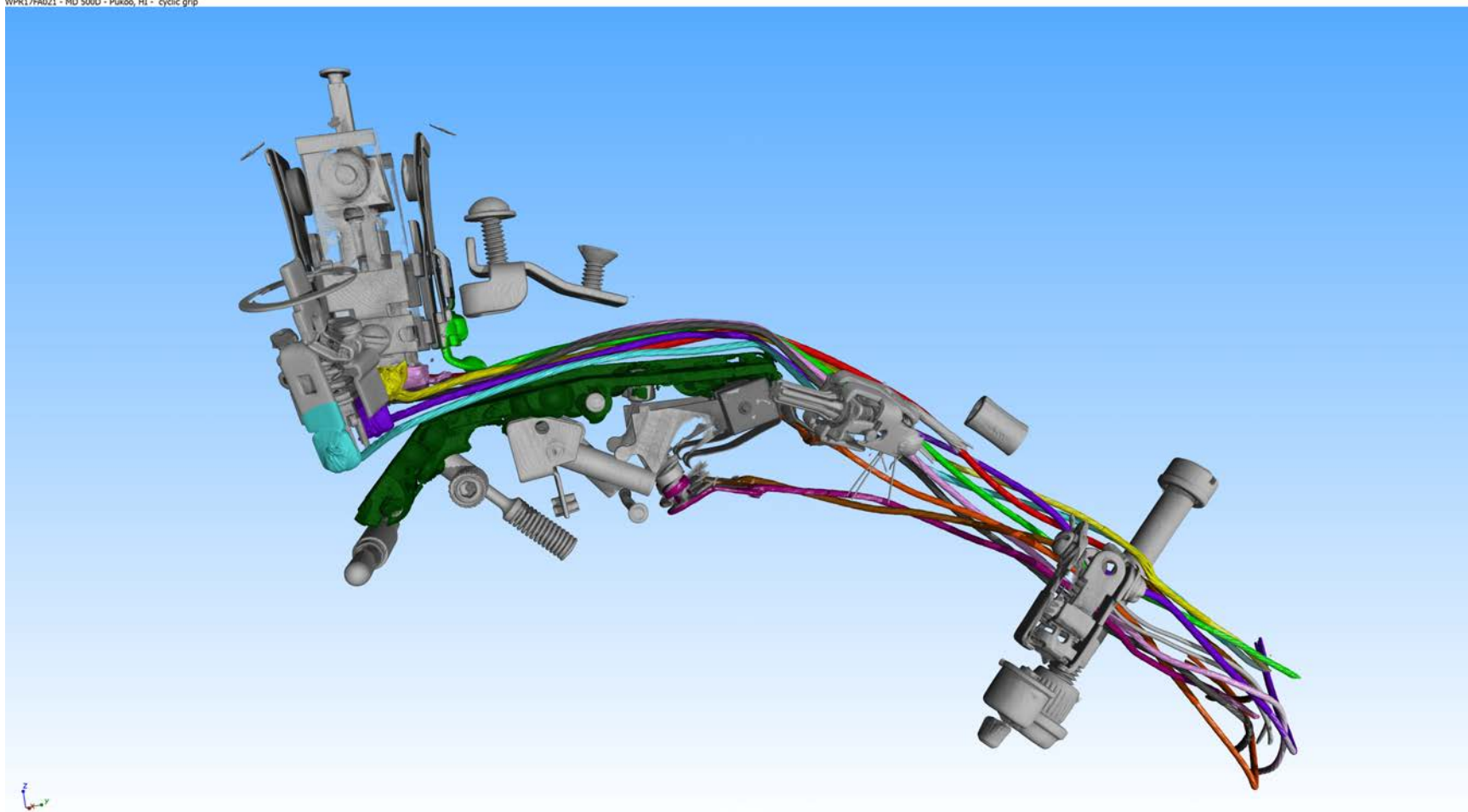


Figure 4
Cyclic grip – overview – left side – no exterior – regions of interest identified

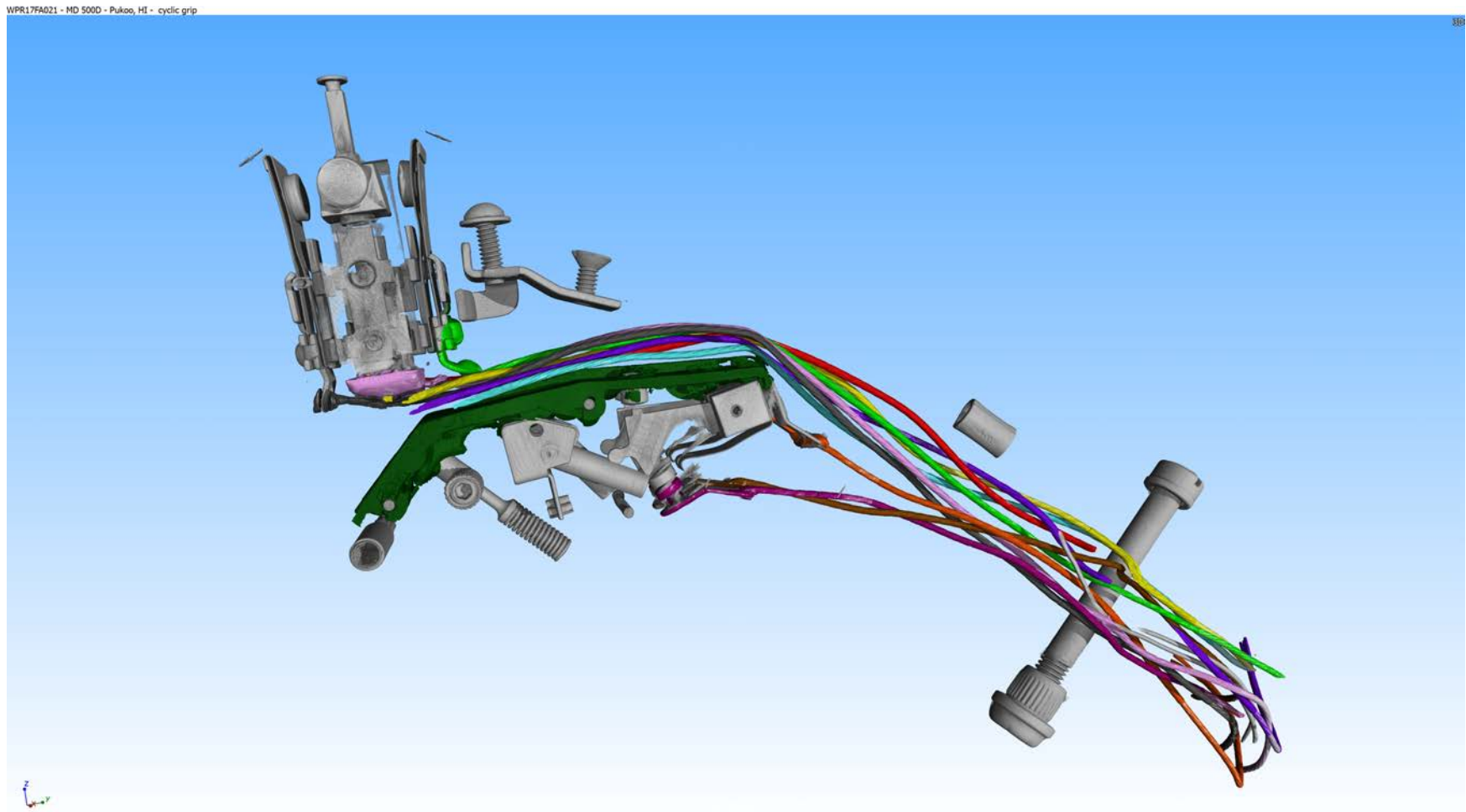


Figure 5
Cyclic grip – overview – left side – no exterior – regions of interest identified with foreground objects digitally removed

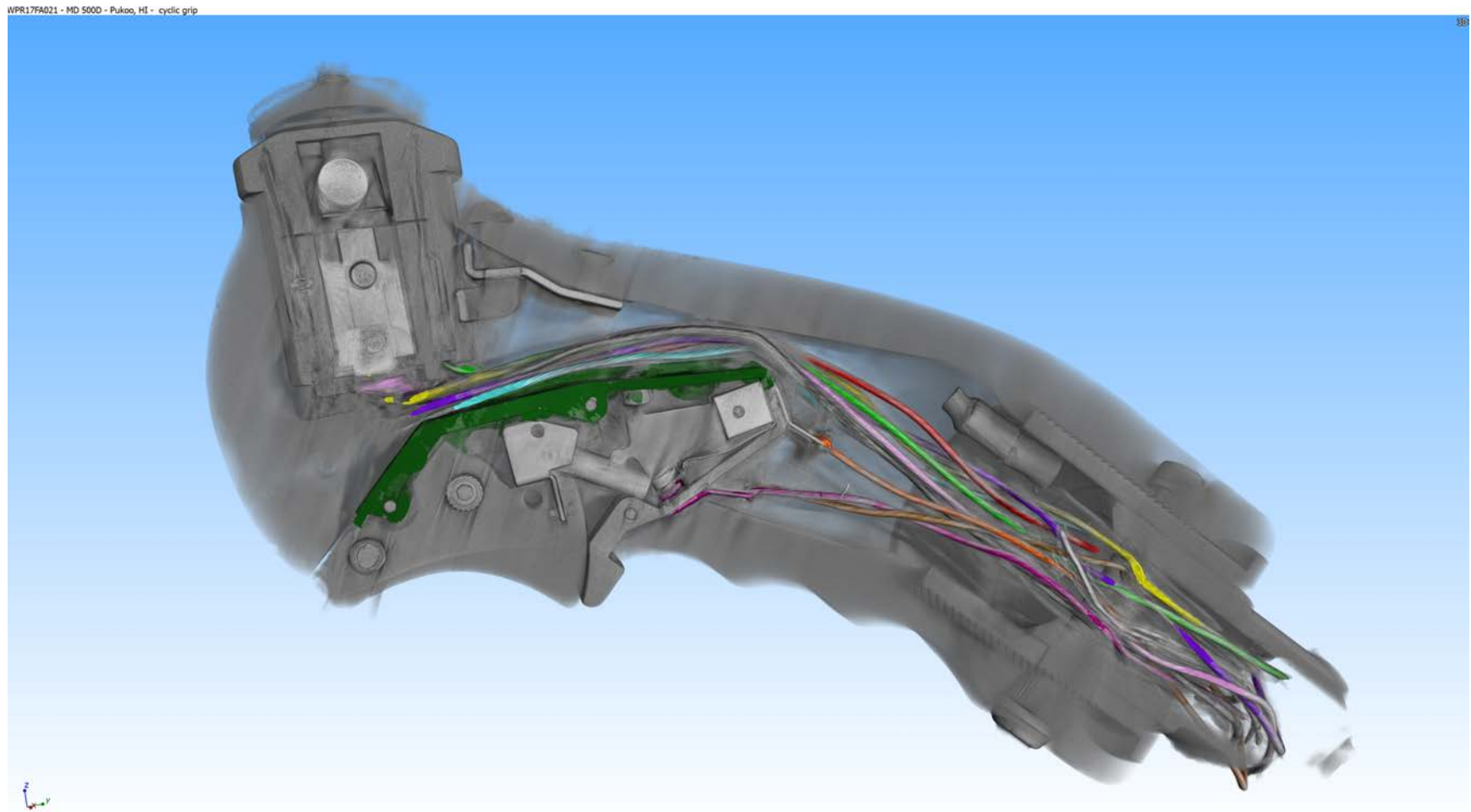


Figure 6
Cyclic grip – overview – left side – regions of interest identified with grip digitally cut down the middle

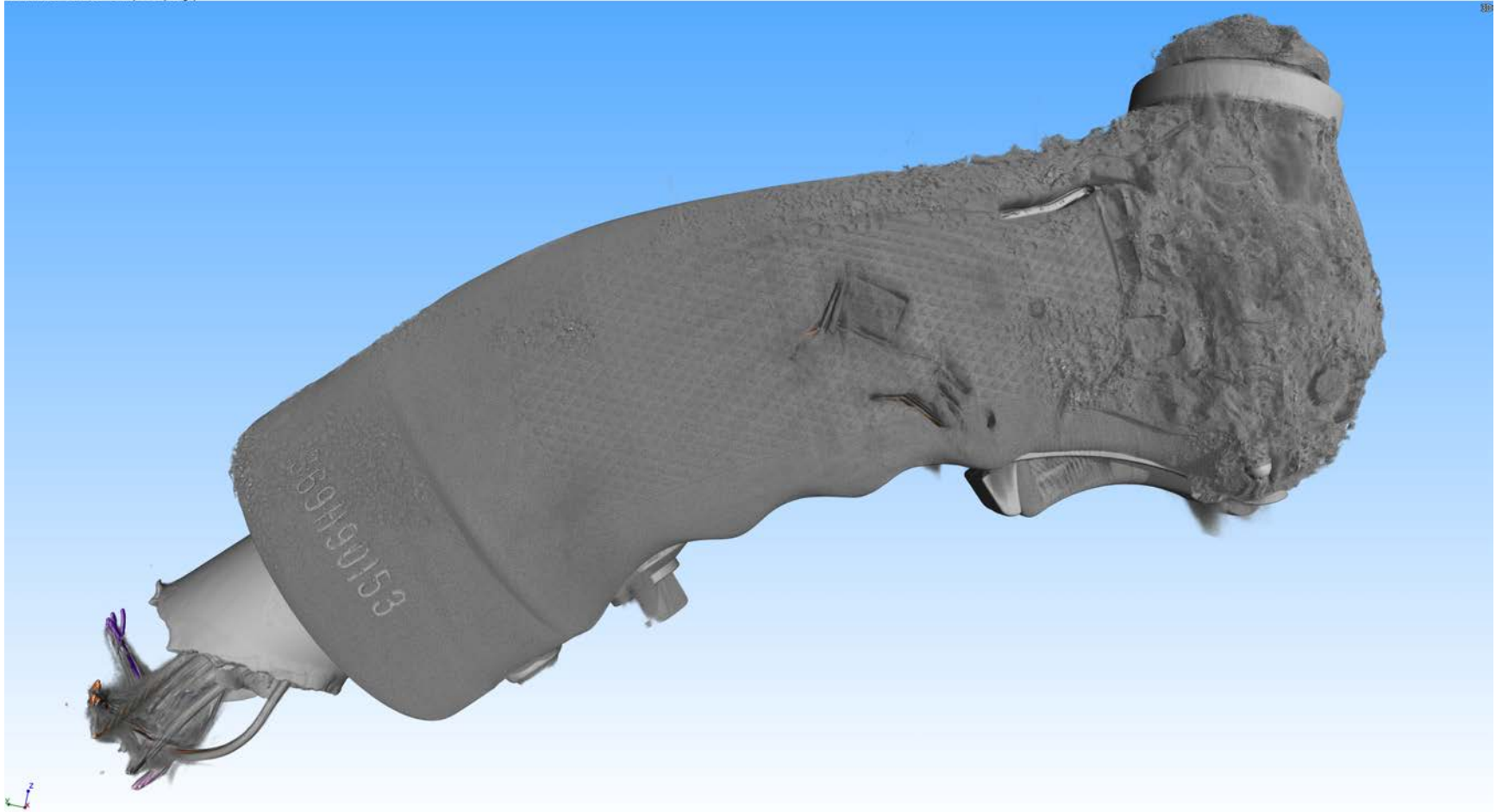


Figure 7
Cyclic grip – overview – right side - exterior

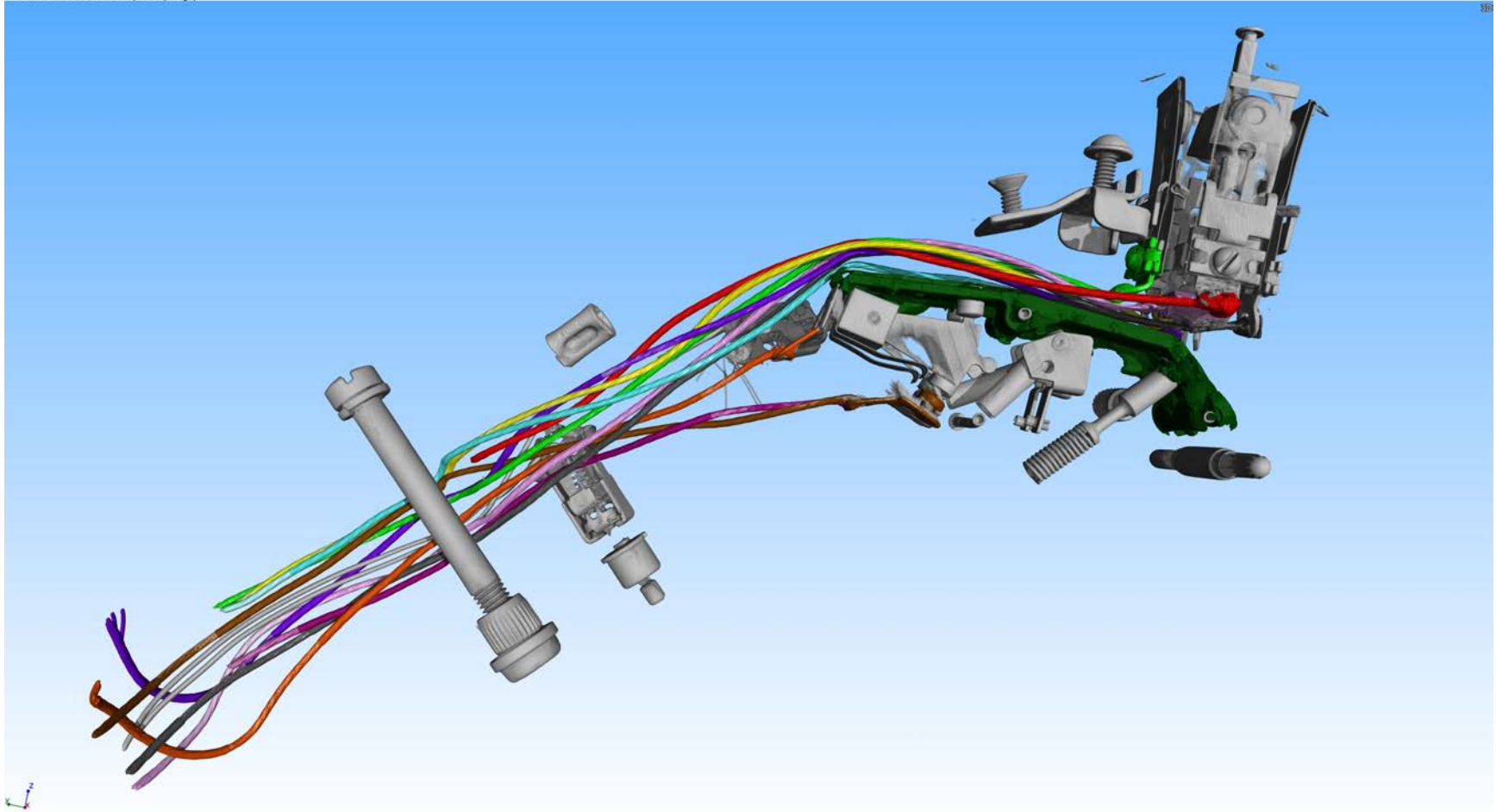


Figure 8
Cyclic grip – overview – right side – no exterior

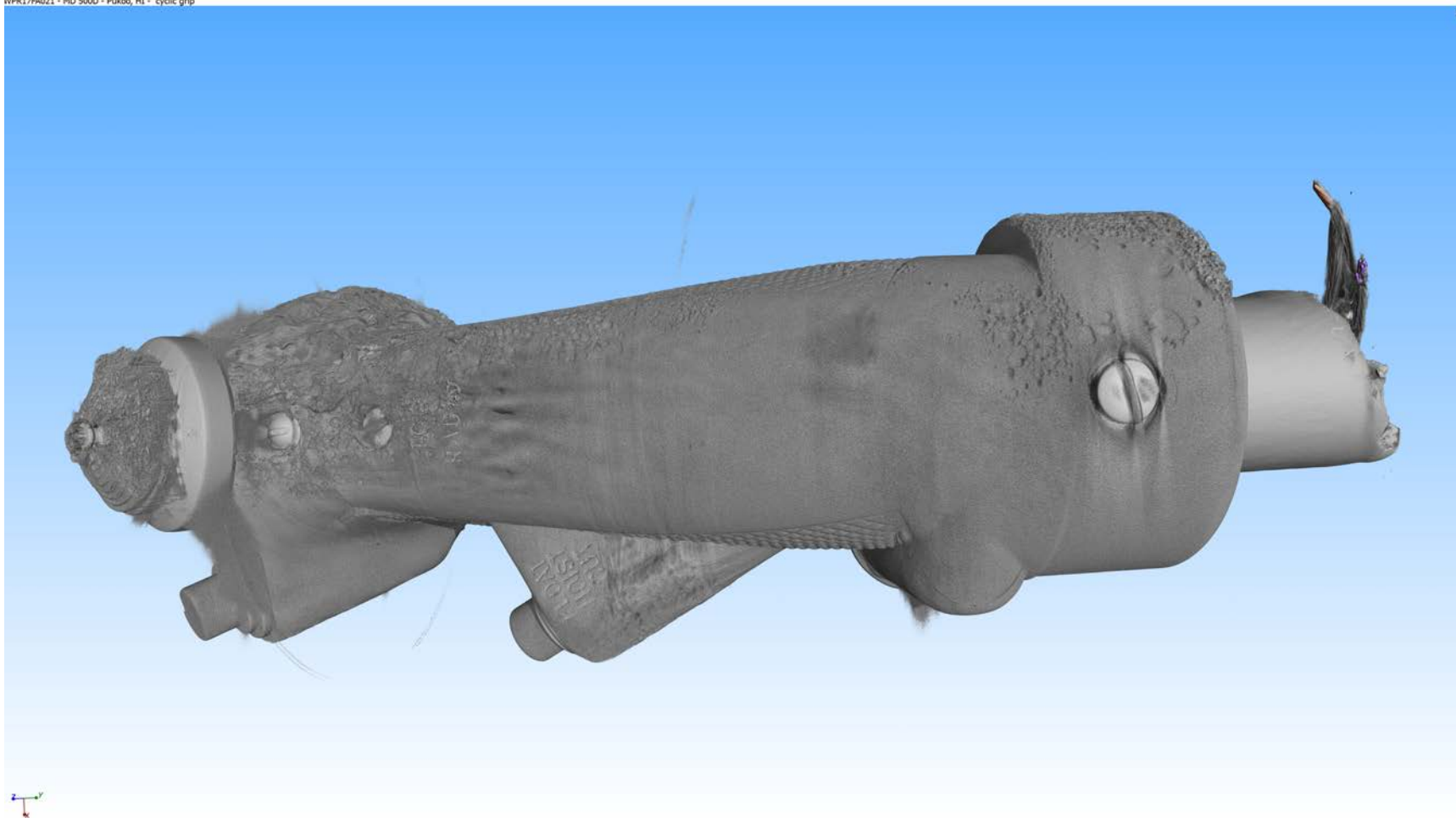


Figure 9
Cyclic grip – overview – aft side - exterior

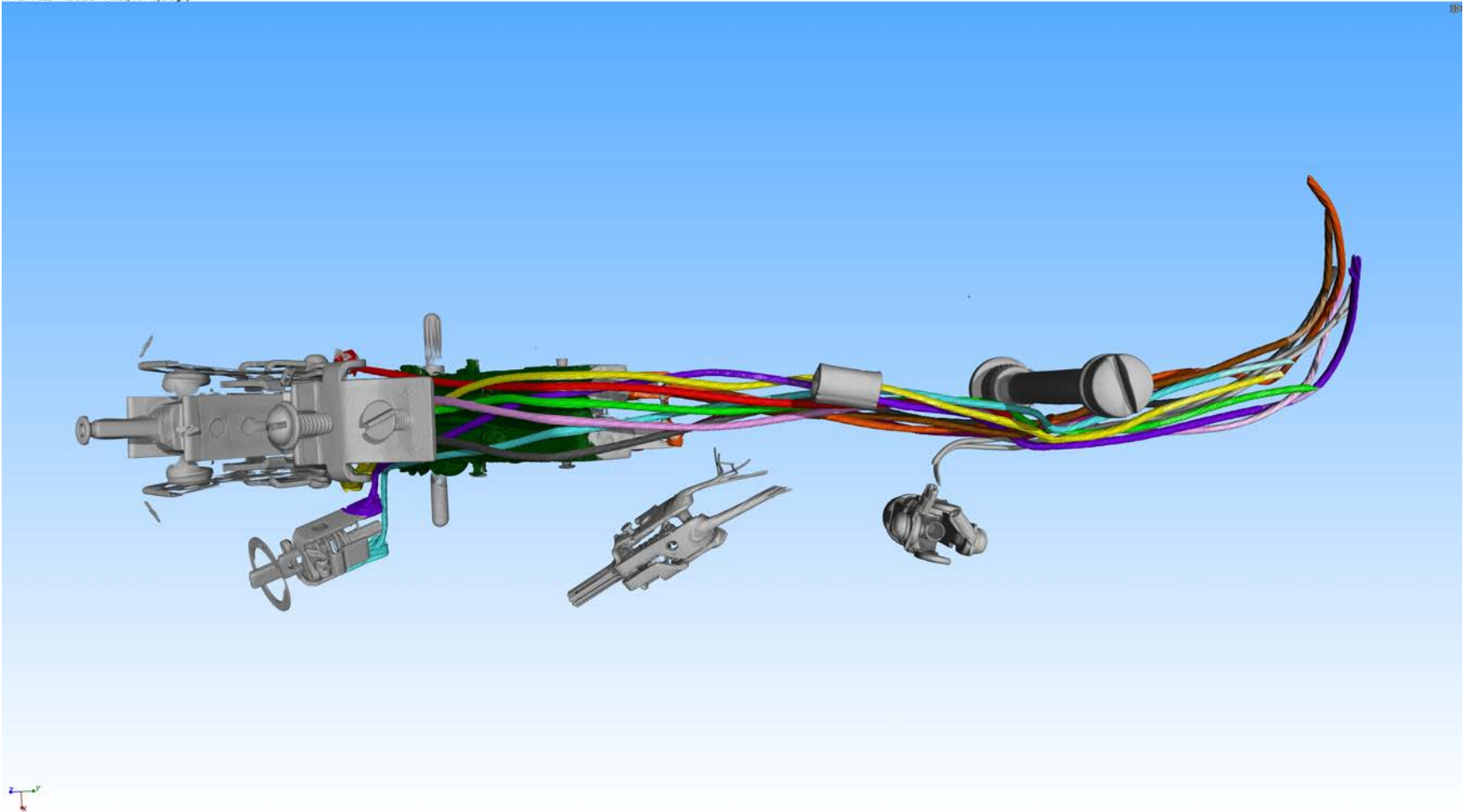


Figure 10
Cyclic grip – overview – aft side – no exterior

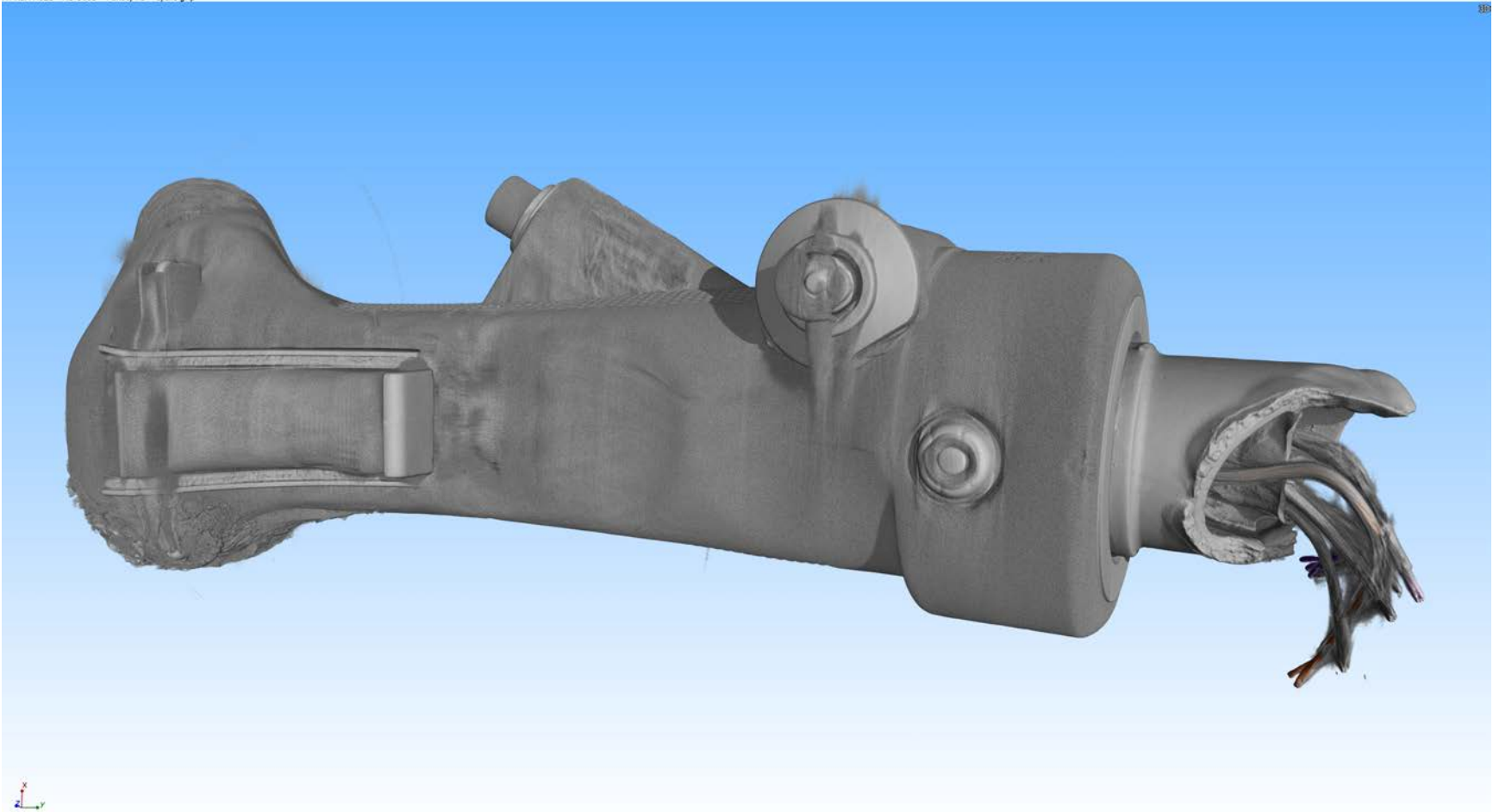


Figure 11
Cyclic grip – overview – front side - exterior

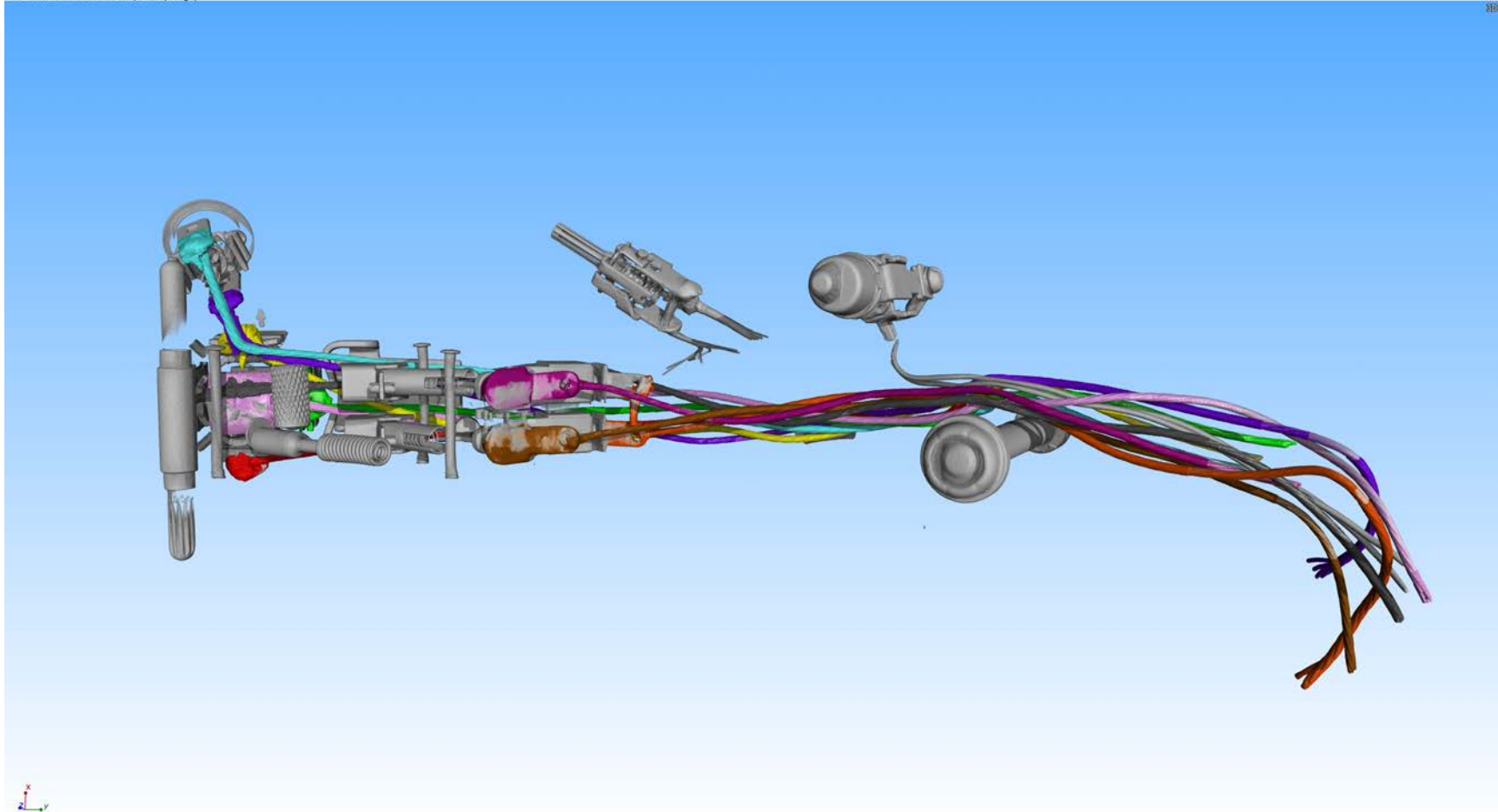


Figure 12
Cyclic grip – overview – front side – no exterior

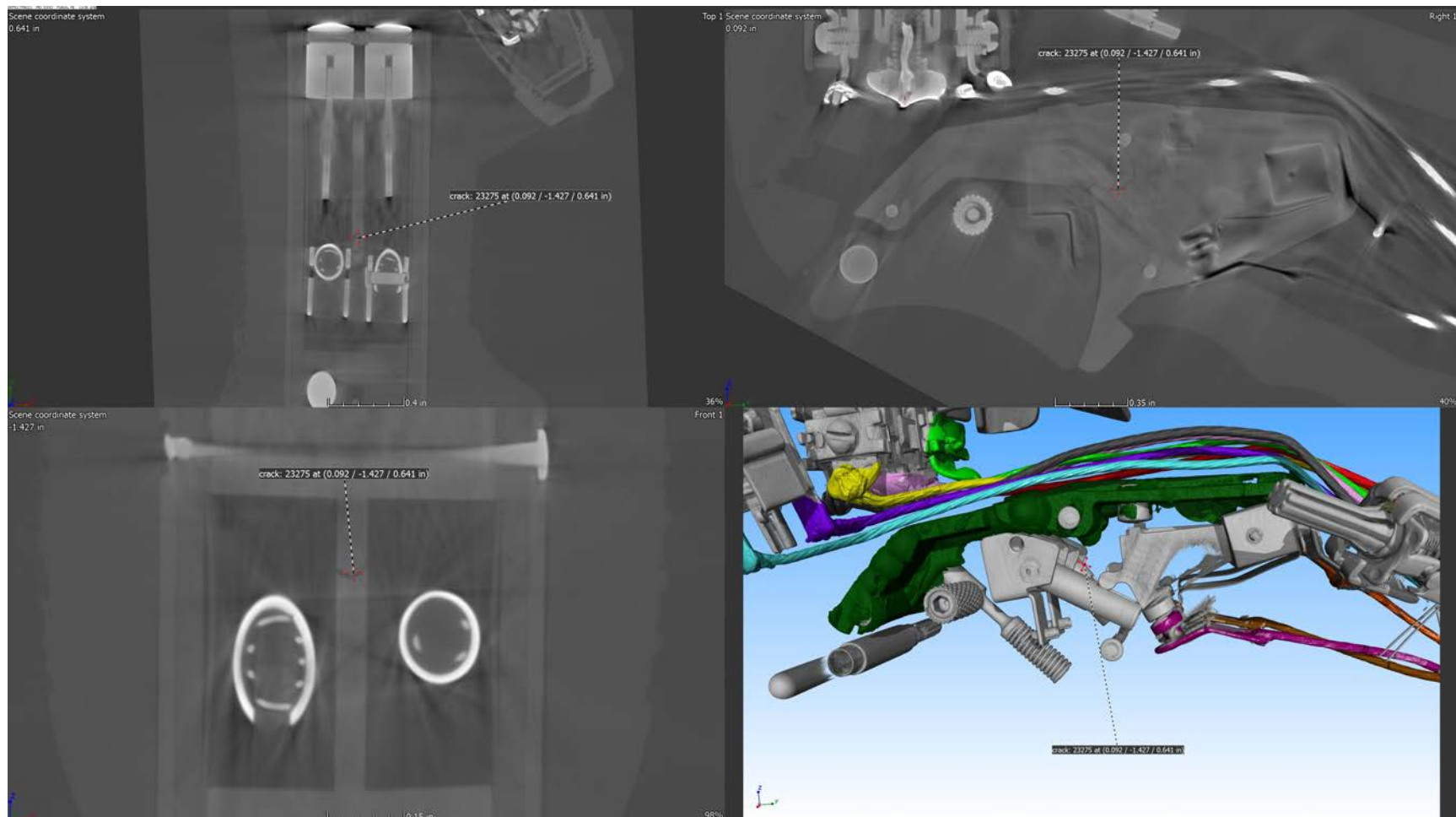


Figure 13
Cyclic grip – crack 1 in trigger switch structure

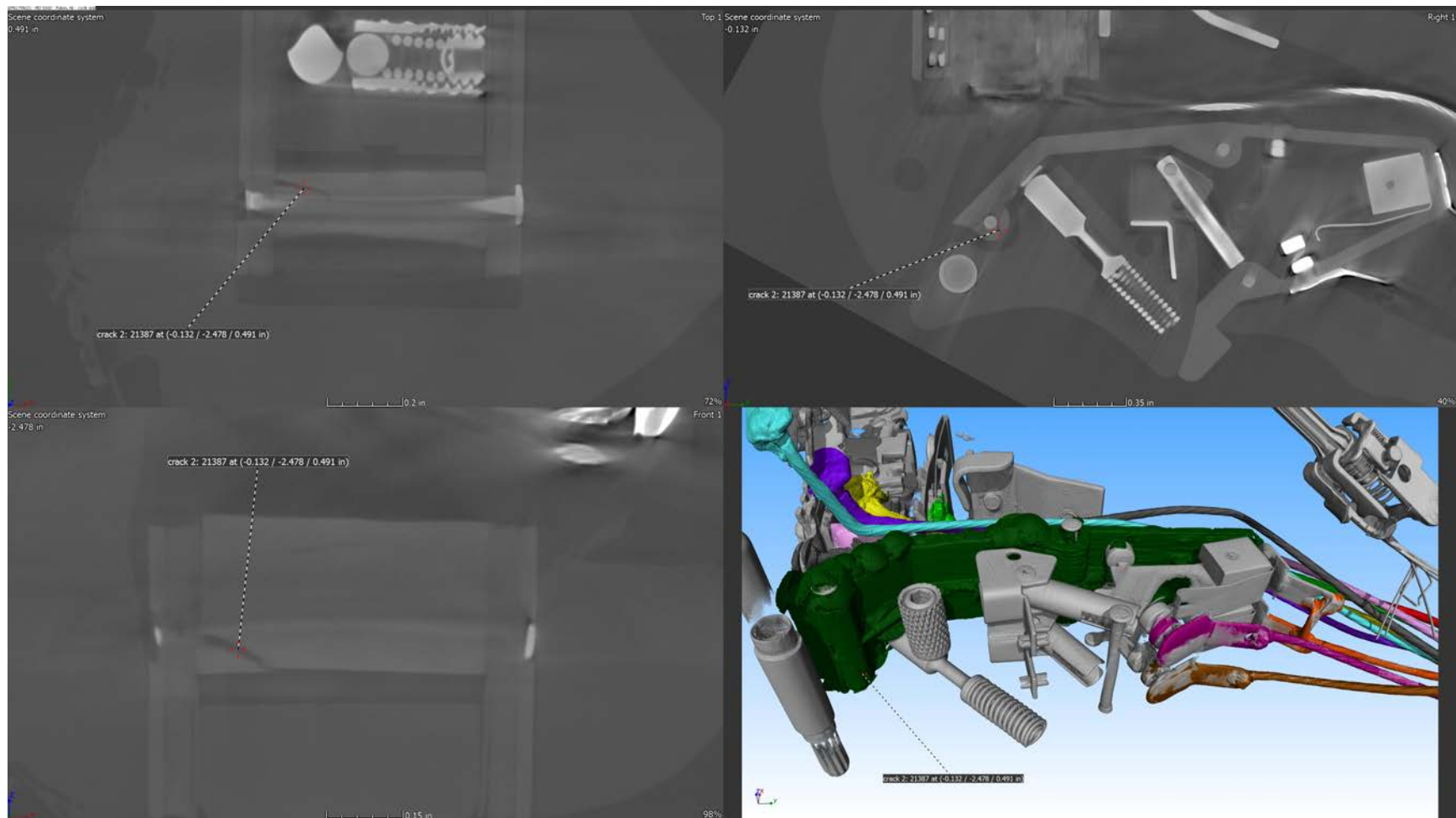


Figure 14
Cyclic grip – crack 2 in trigger switch structure

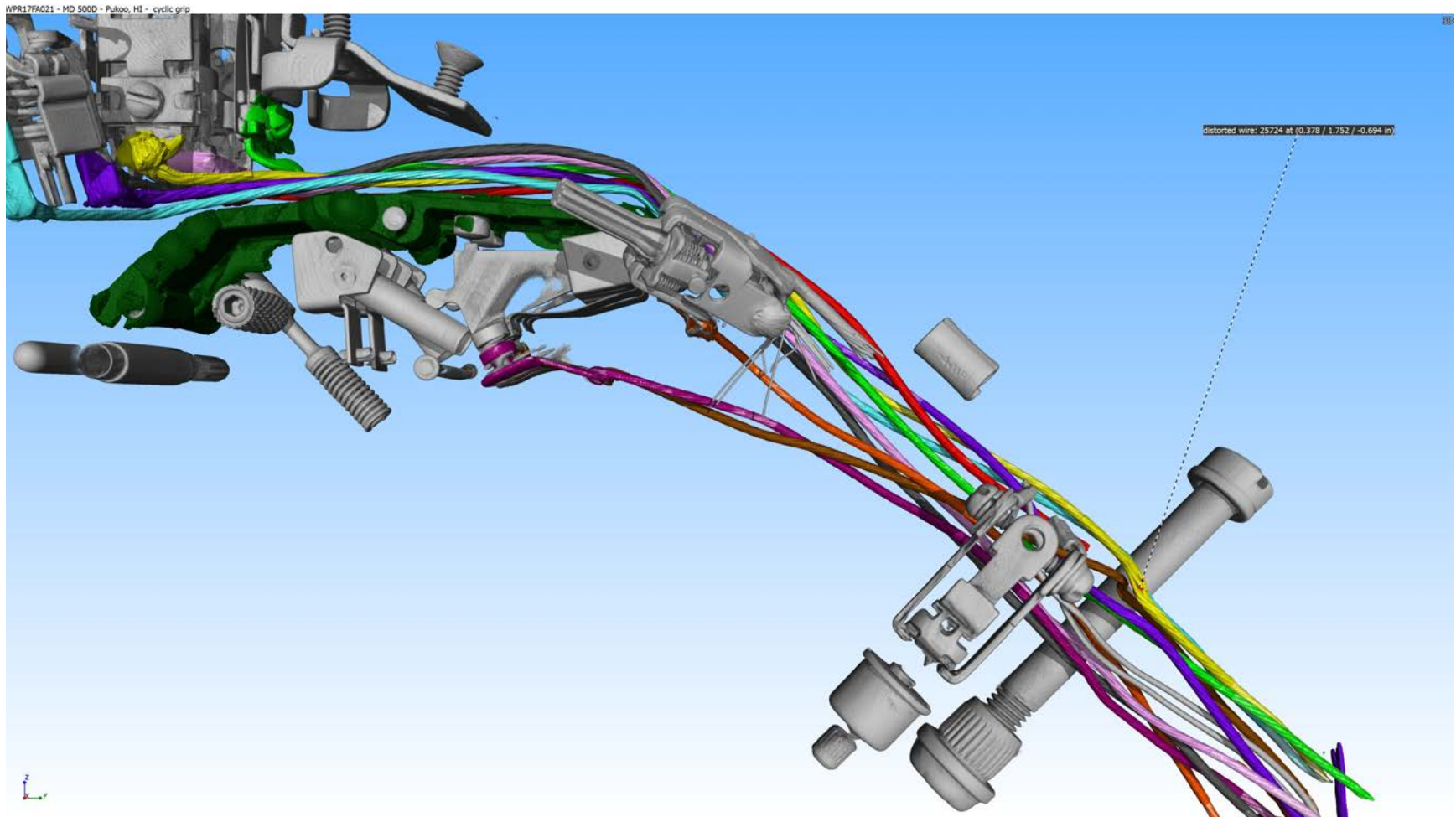


Figure 15
Cyclic grip – distorted wire core strands

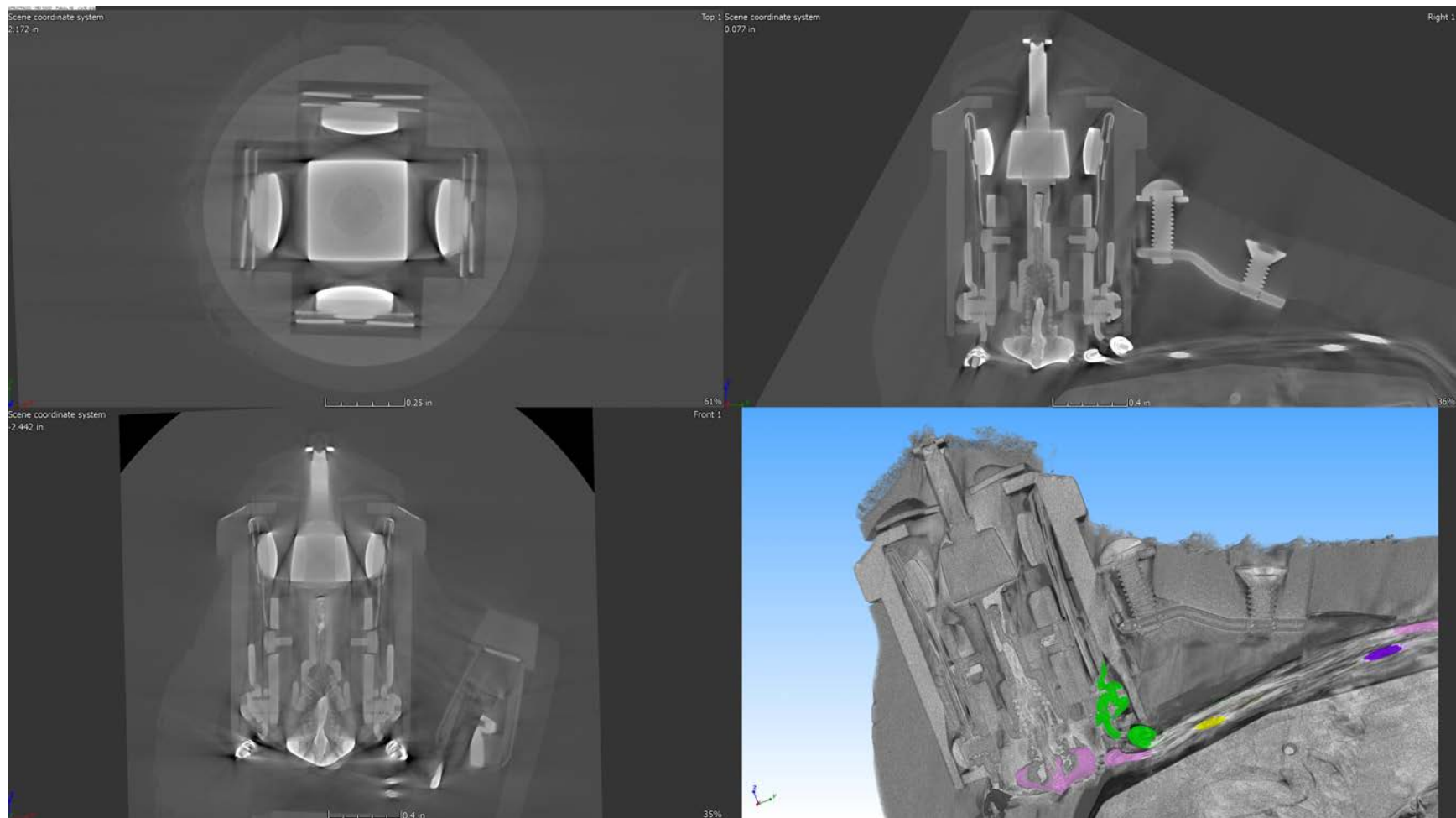


Figure 16
Cyclic grip – trim switch cross section

WPR17FA021 - MD 500D - Pukoo, HI - cyclic grip

Scene coordinate system

0.134 in

Right 1

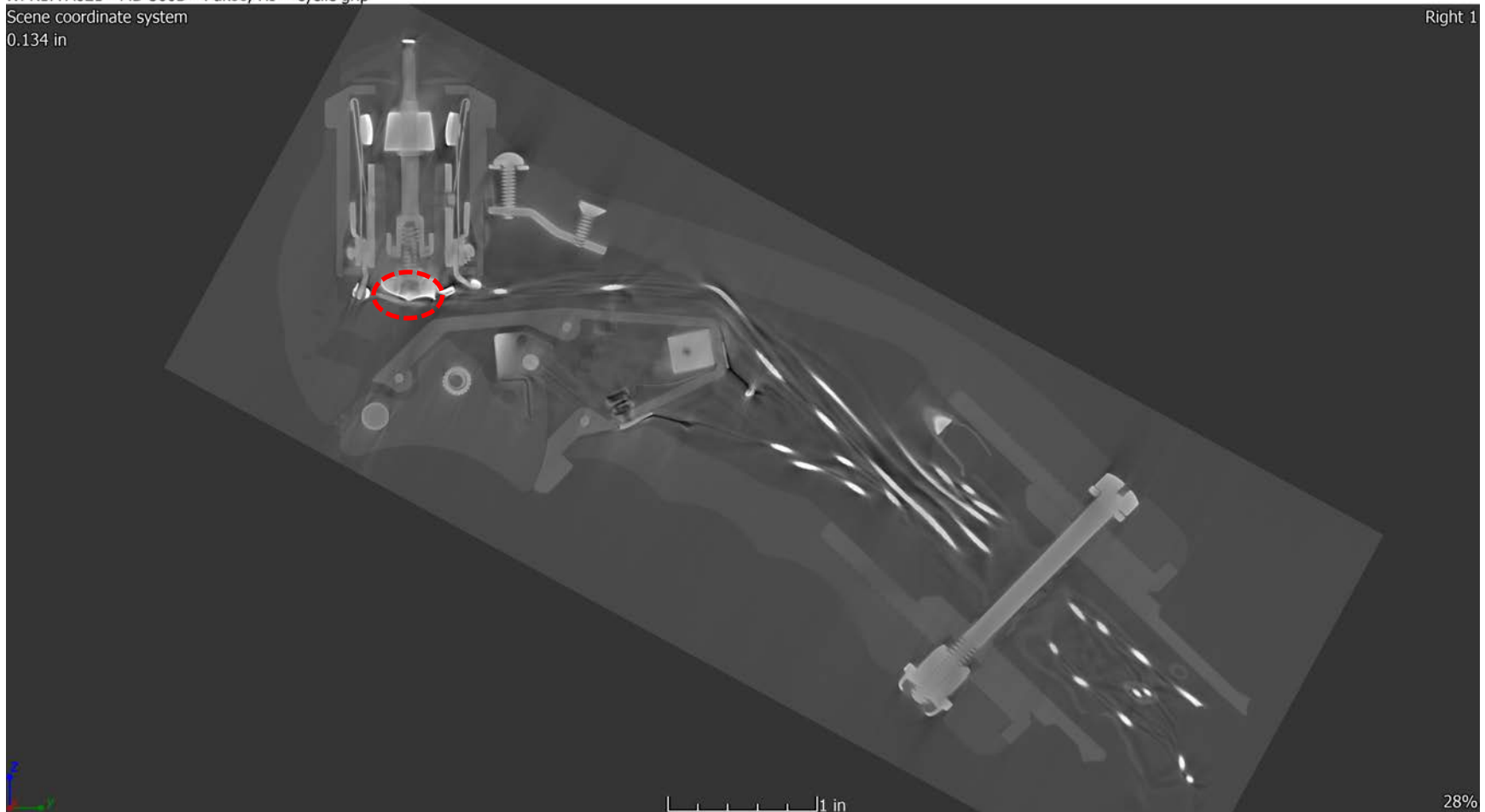


Figure 17
Cyclic grip – possible wire to solder contact point

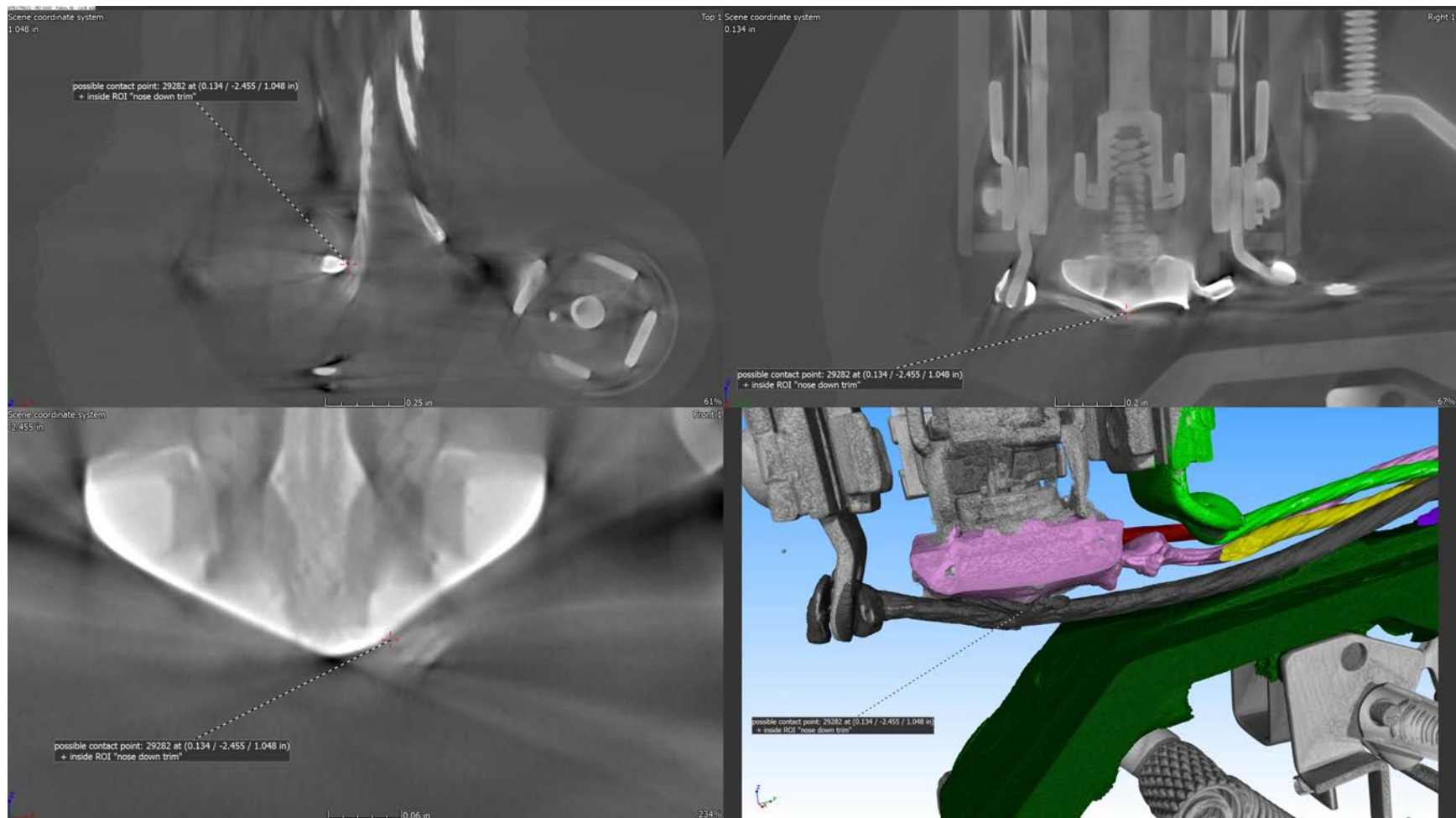


Figure 18
Cyclic grip – possible wire to solder contact point – multiple views

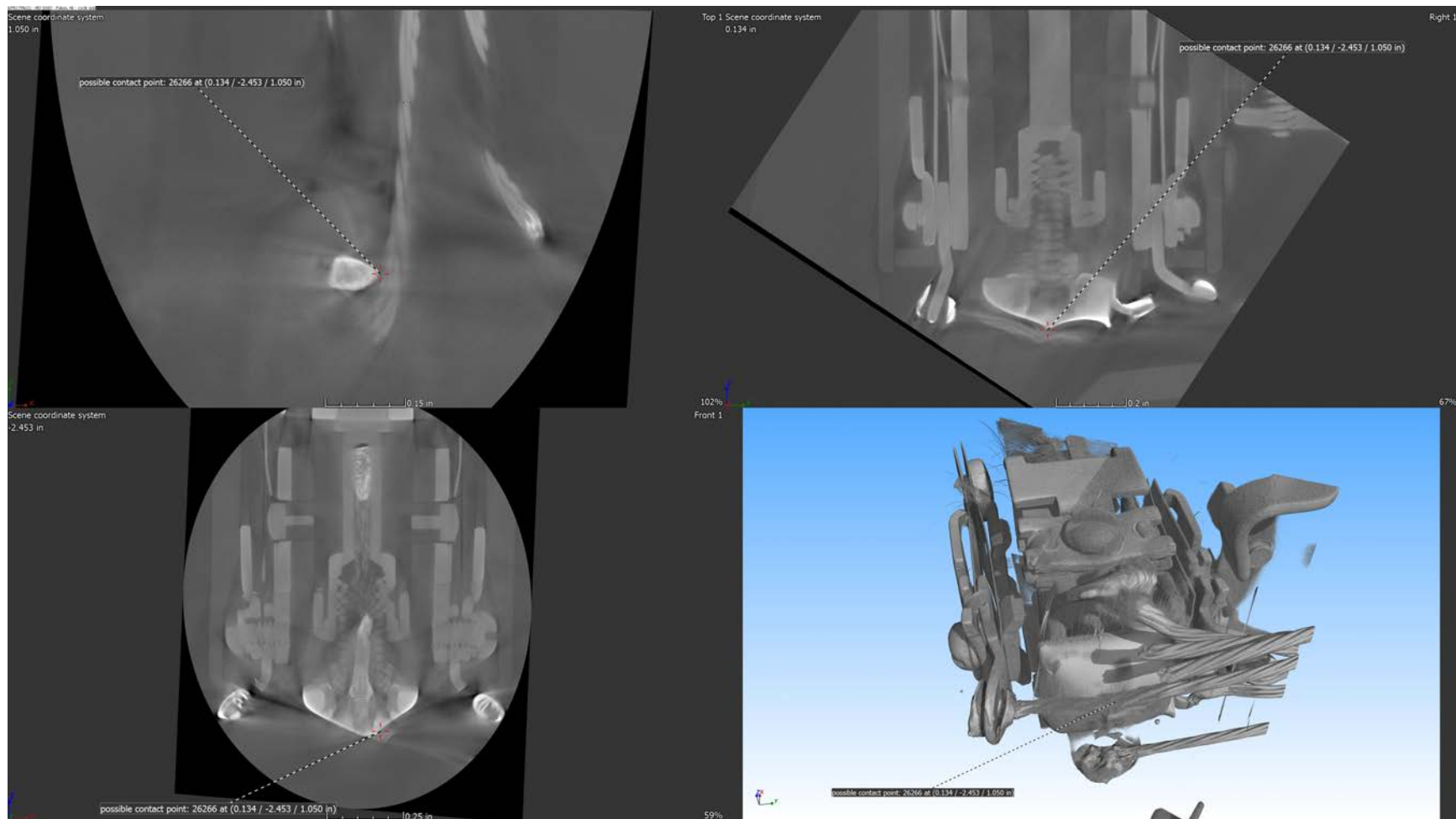


Figure 19
Cyclic grip – target CT - possible wire to solder contact point

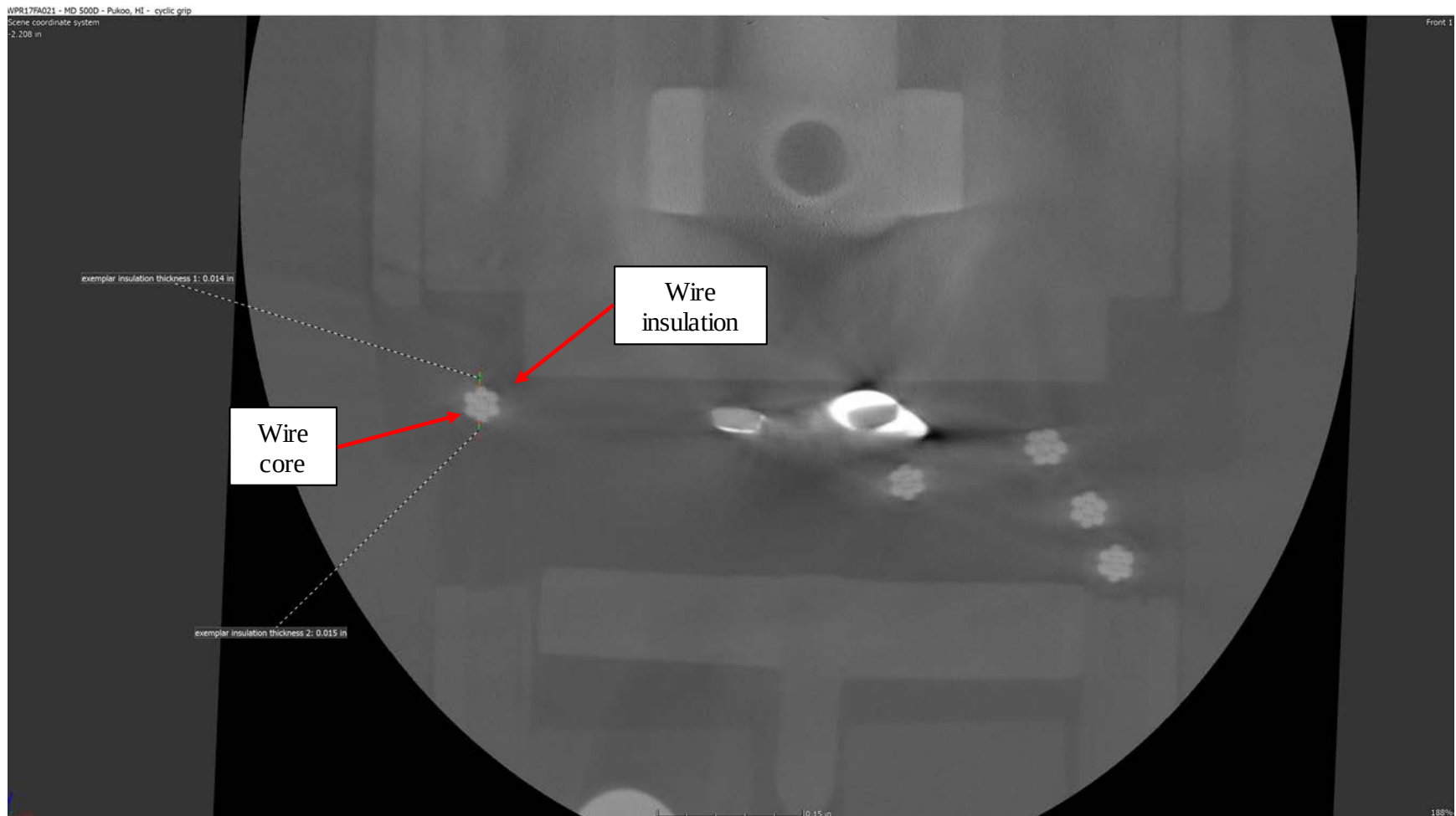


Figure 20
Cyclic grip – target CT – wire insulation thickness measurement

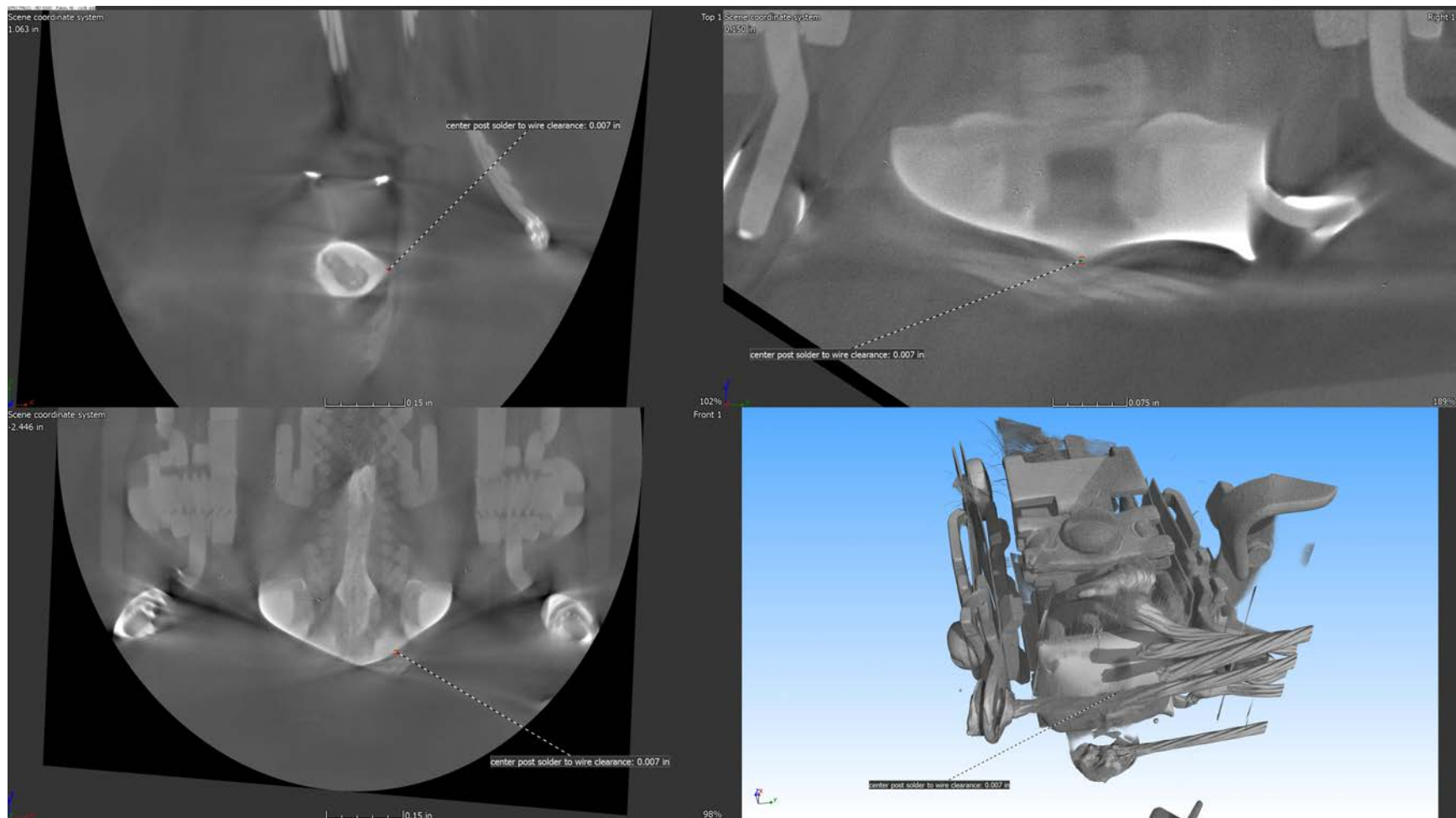


Figure 21
Cyclic grip – target CT – solder to wire core clearance measurement

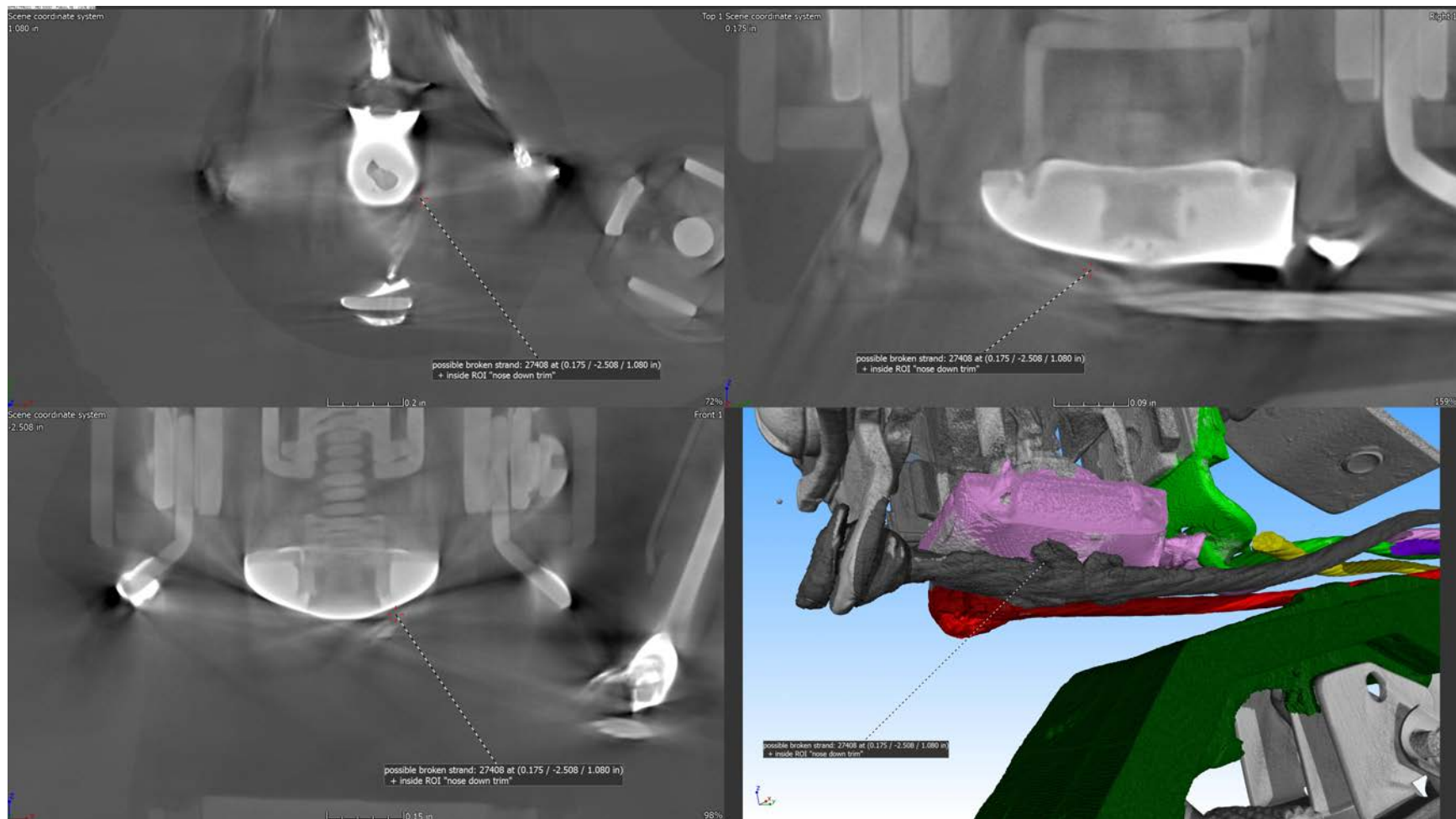


Figure 22
Cyclic grip – possible broken wire strand

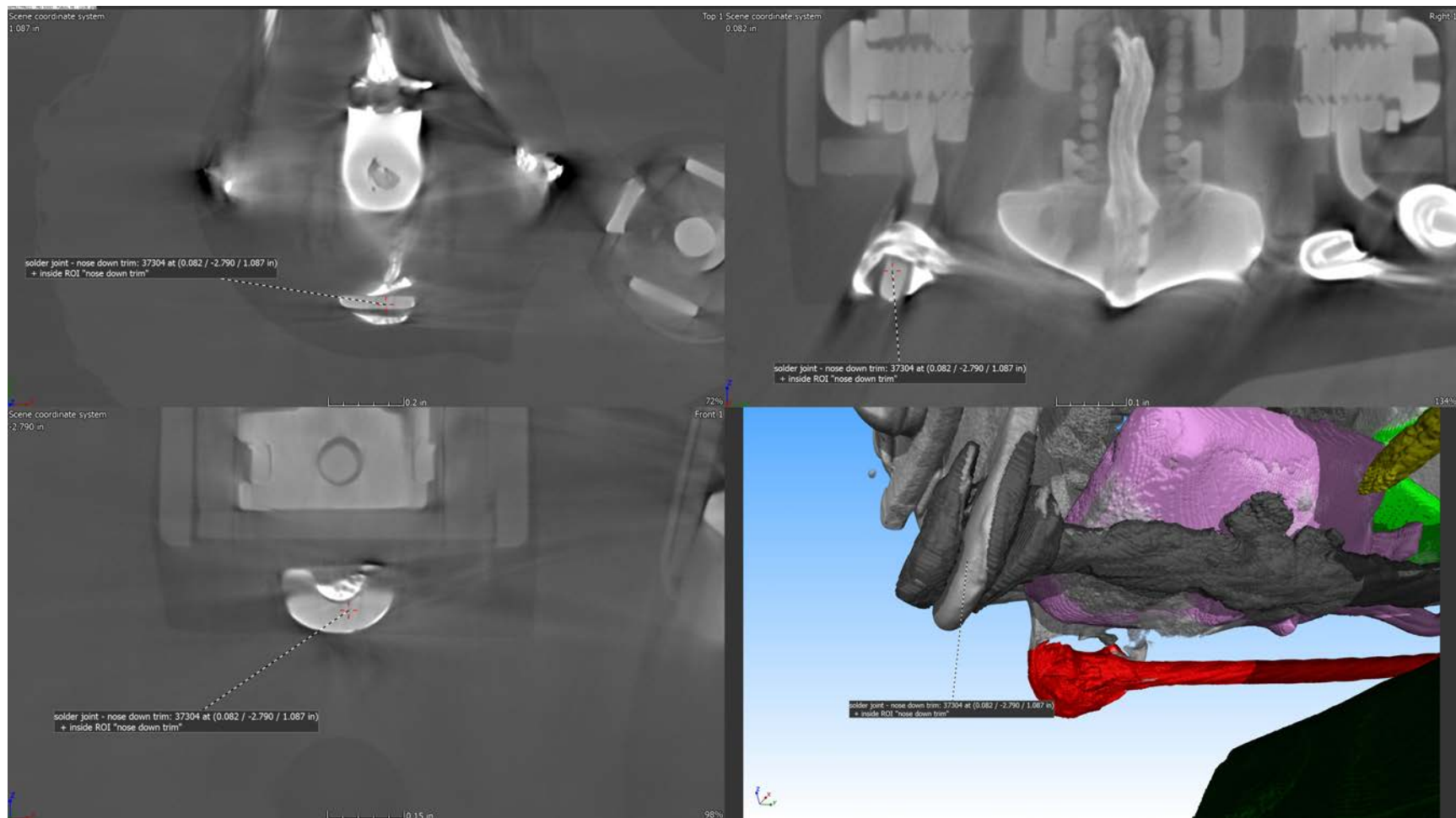


Figure 23
Cyclic grip – solder joint – nose down trim

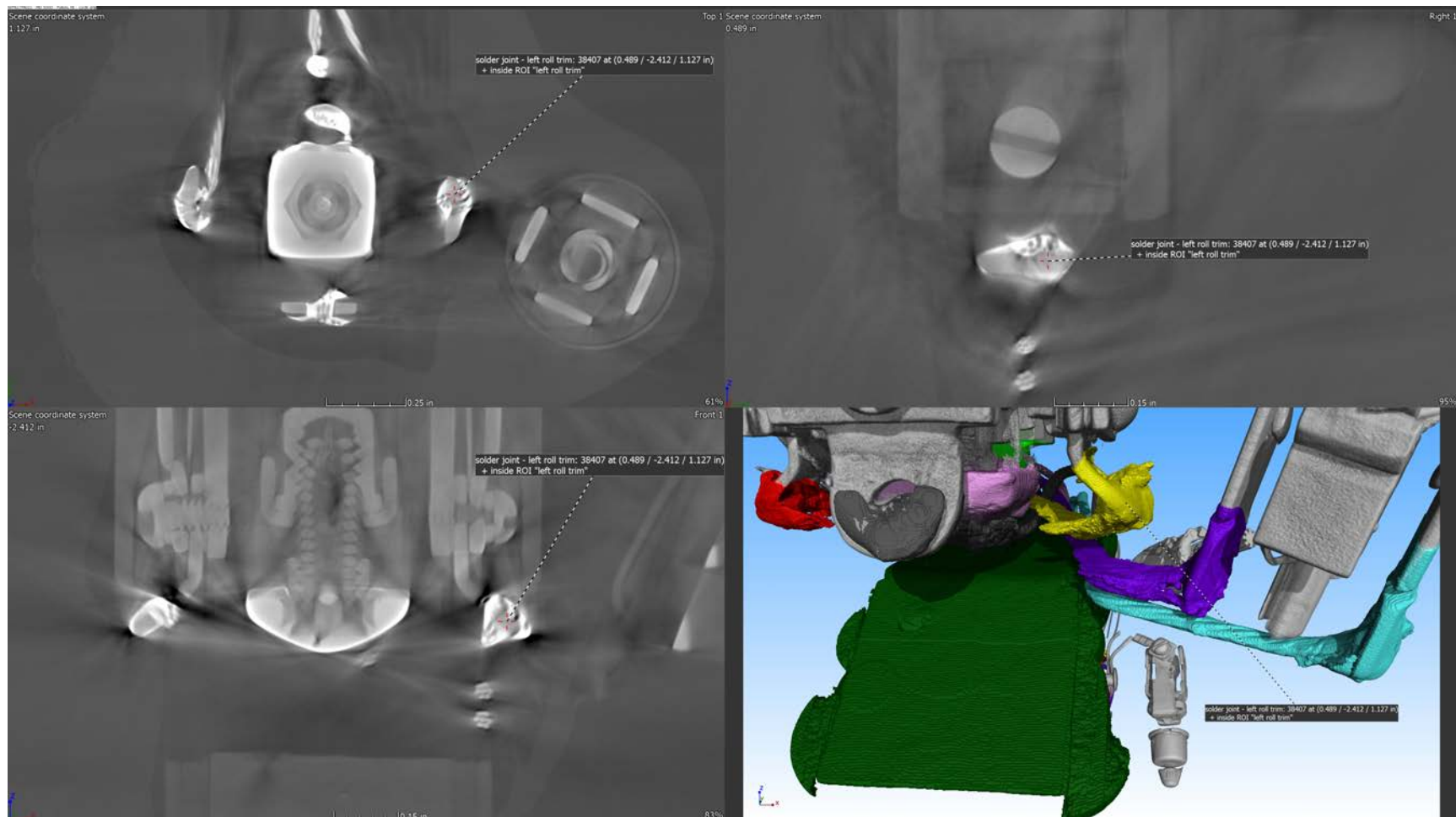


Figure 24
Cyclic grip – solder joint – left roll trim

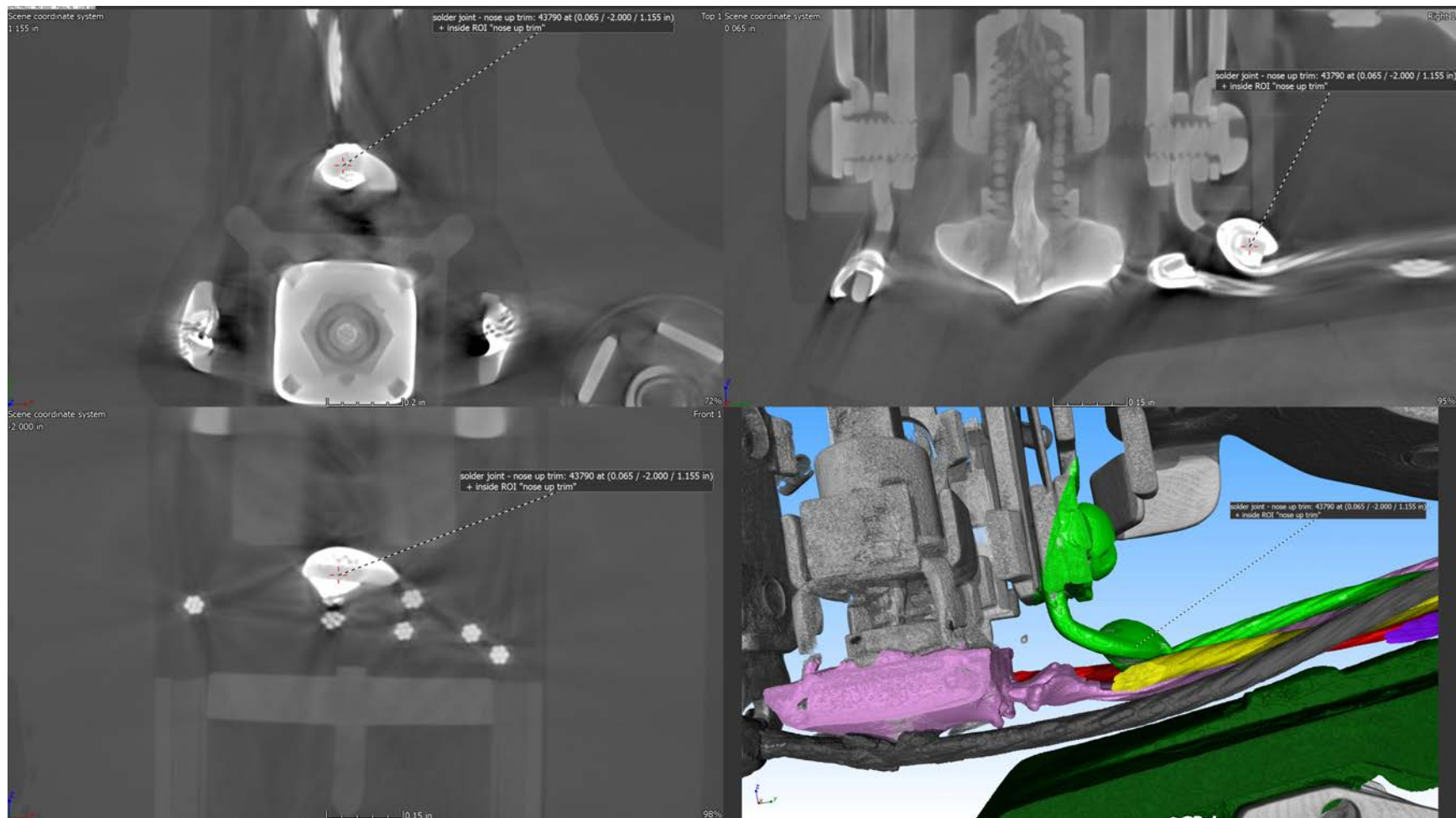


Figure 25
Cyclic grip – solder joint – nose up trim

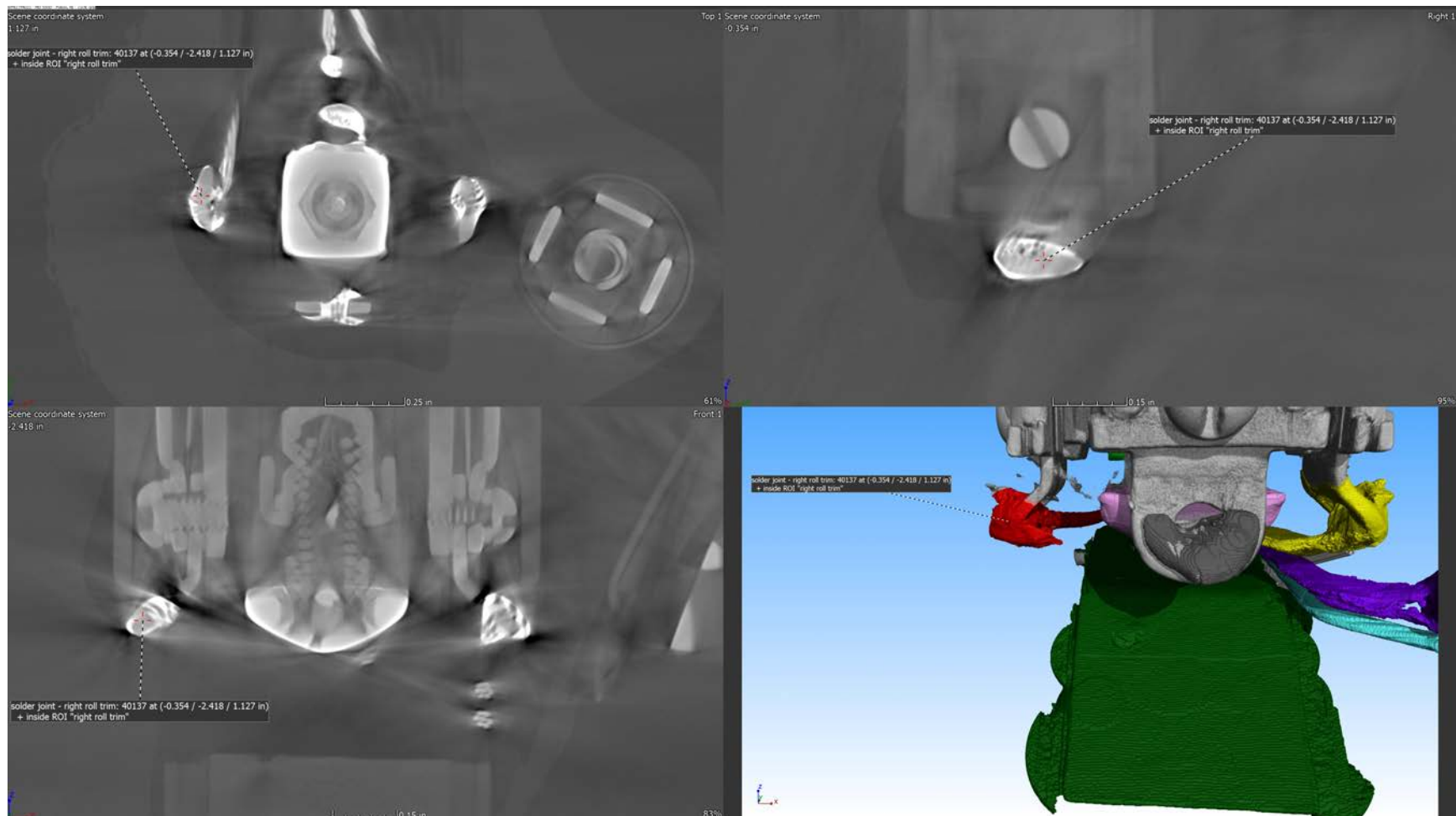


Figure 26
Cyclic grip – solder joint – right roll trim

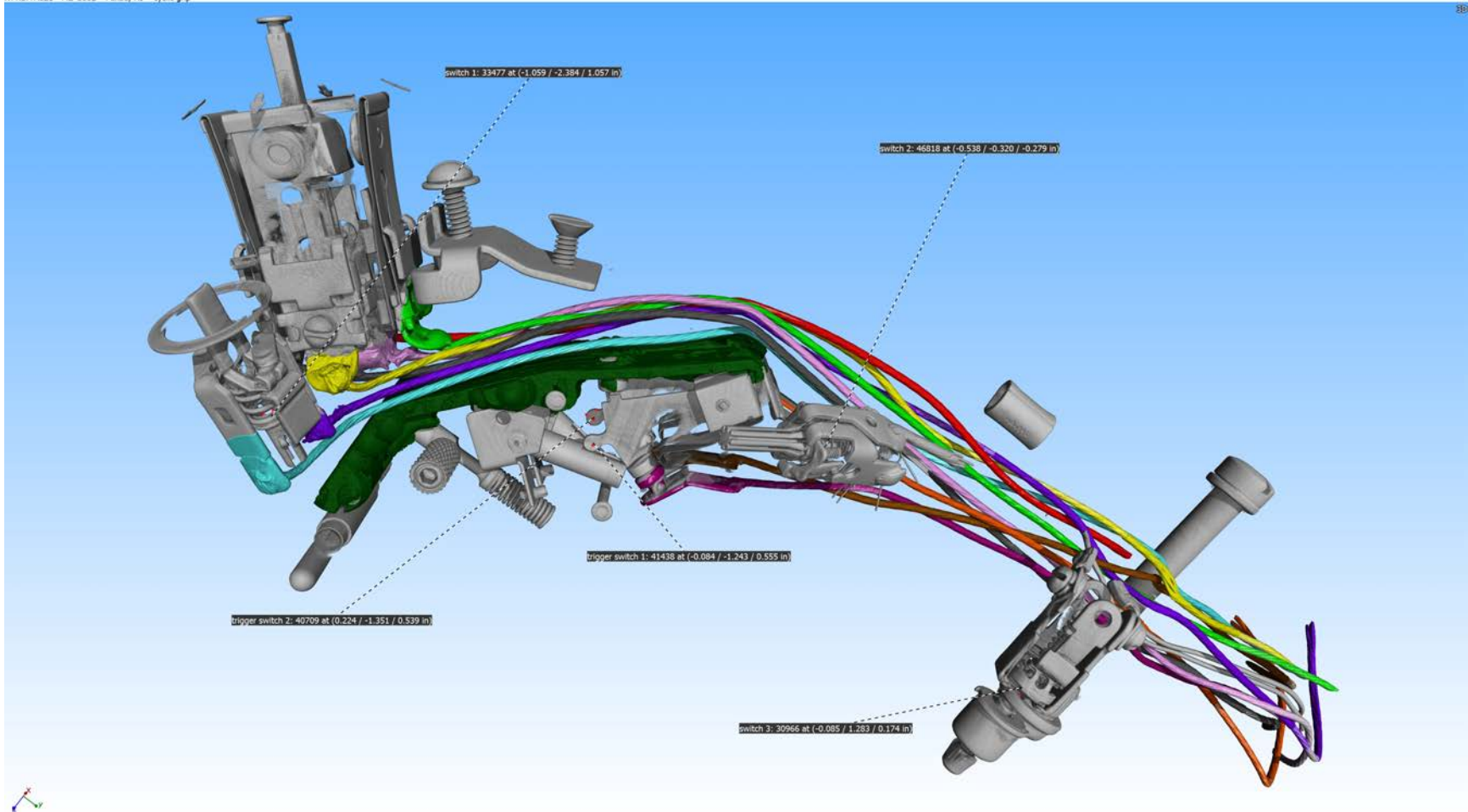


Figure 27
Cyclic grip – switch nomenclature overview

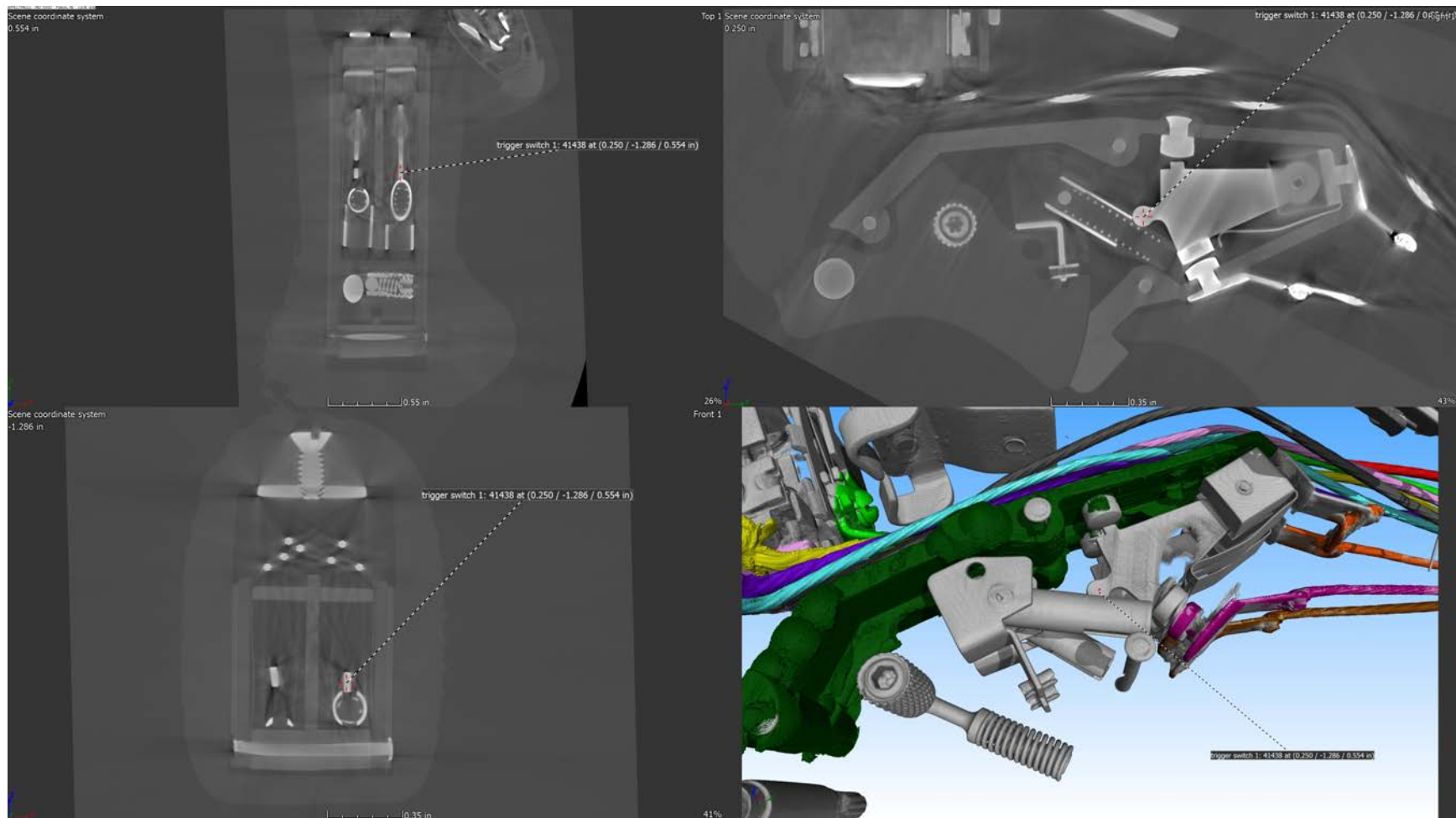


Figure 28
Cyclic grip – trigger switch 1

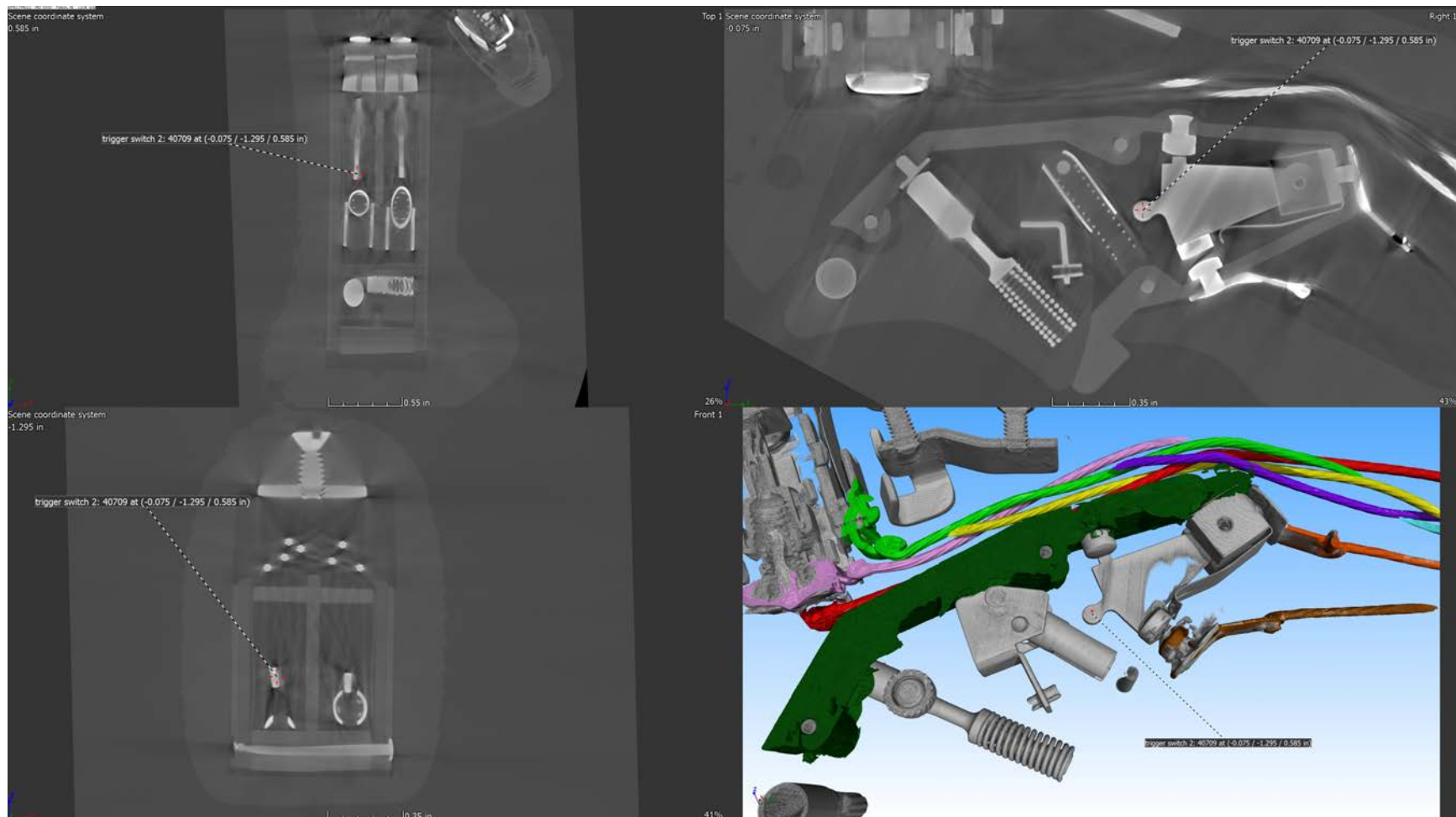


Figure 29
Cyclic grip – trigger switch 2

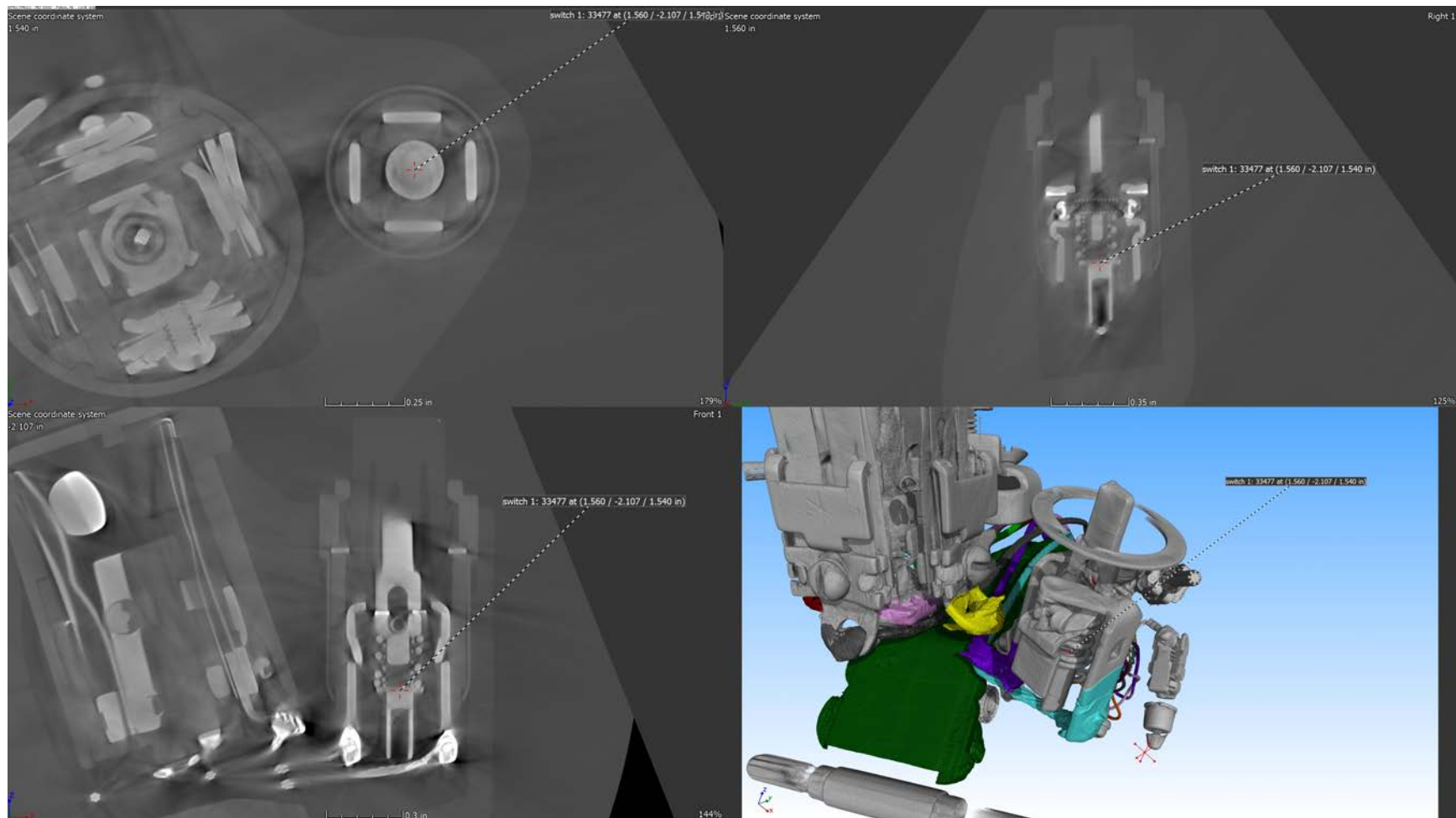


Figure 30
Cyclic grip – switch 1

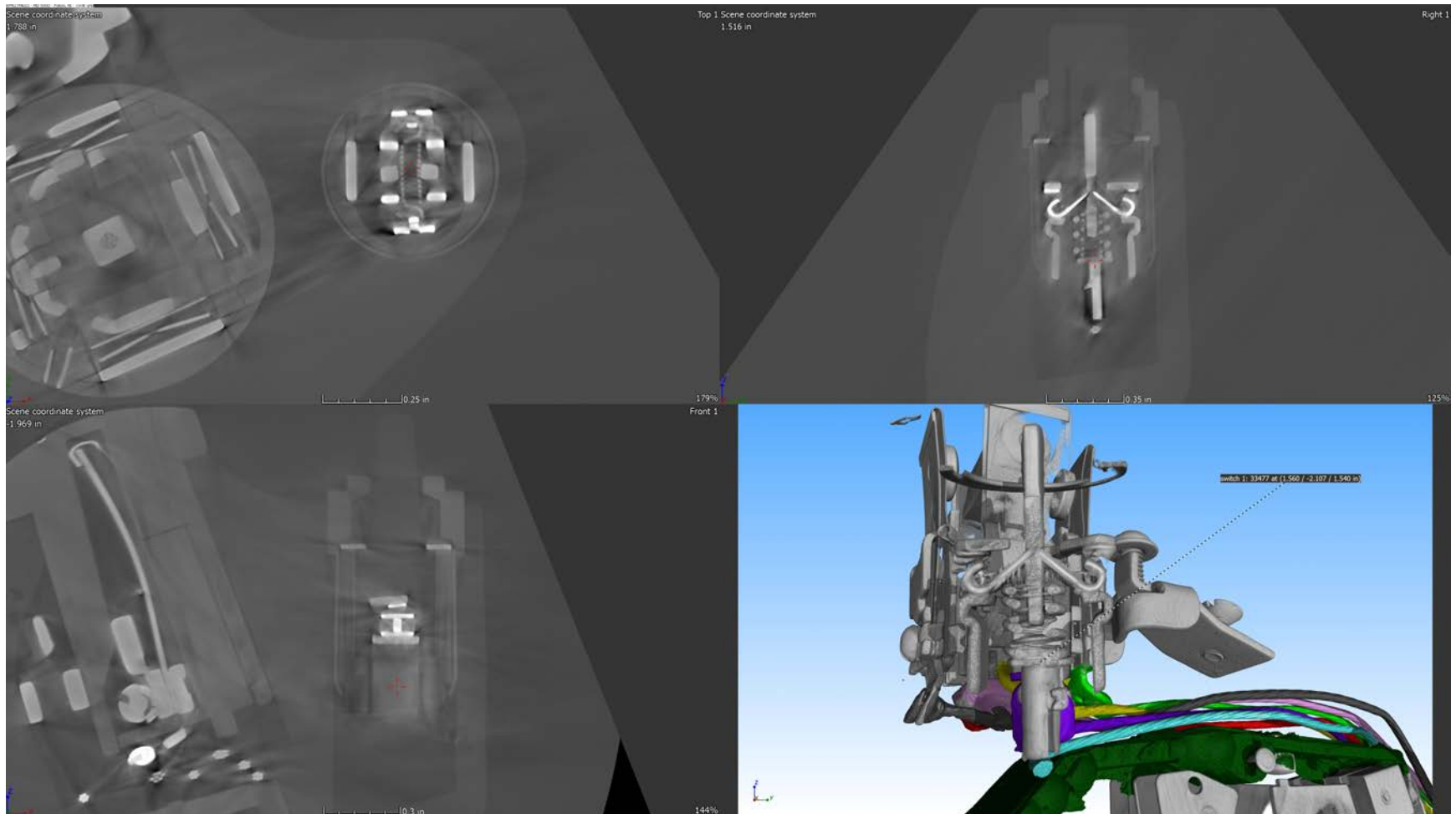


Figure 31
Cyclic grip – switch 1 contacts and spring

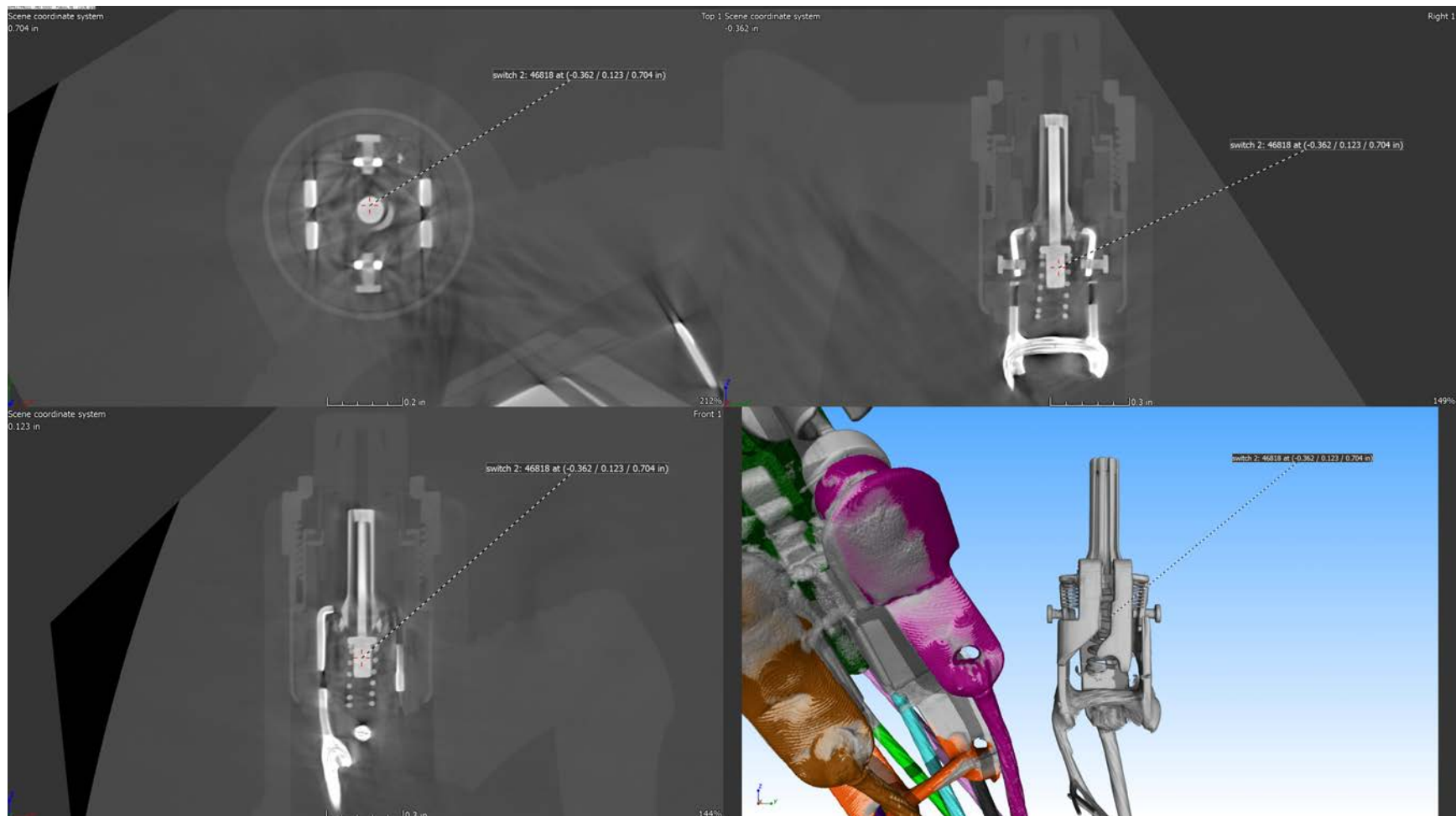


Figure 32
Cyclic grip – switch 2

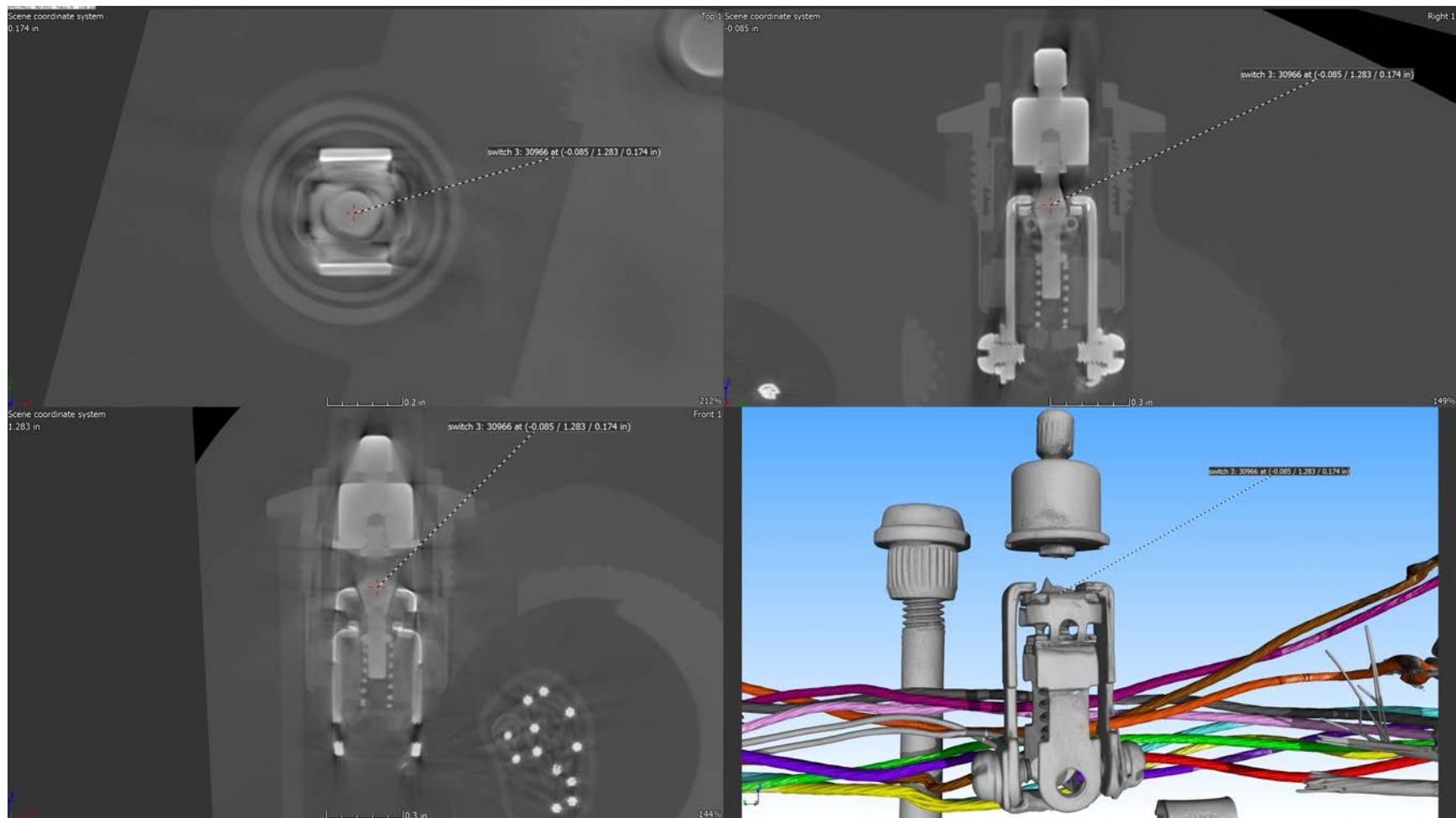


Figure 33
Cyclic grip – switch 3

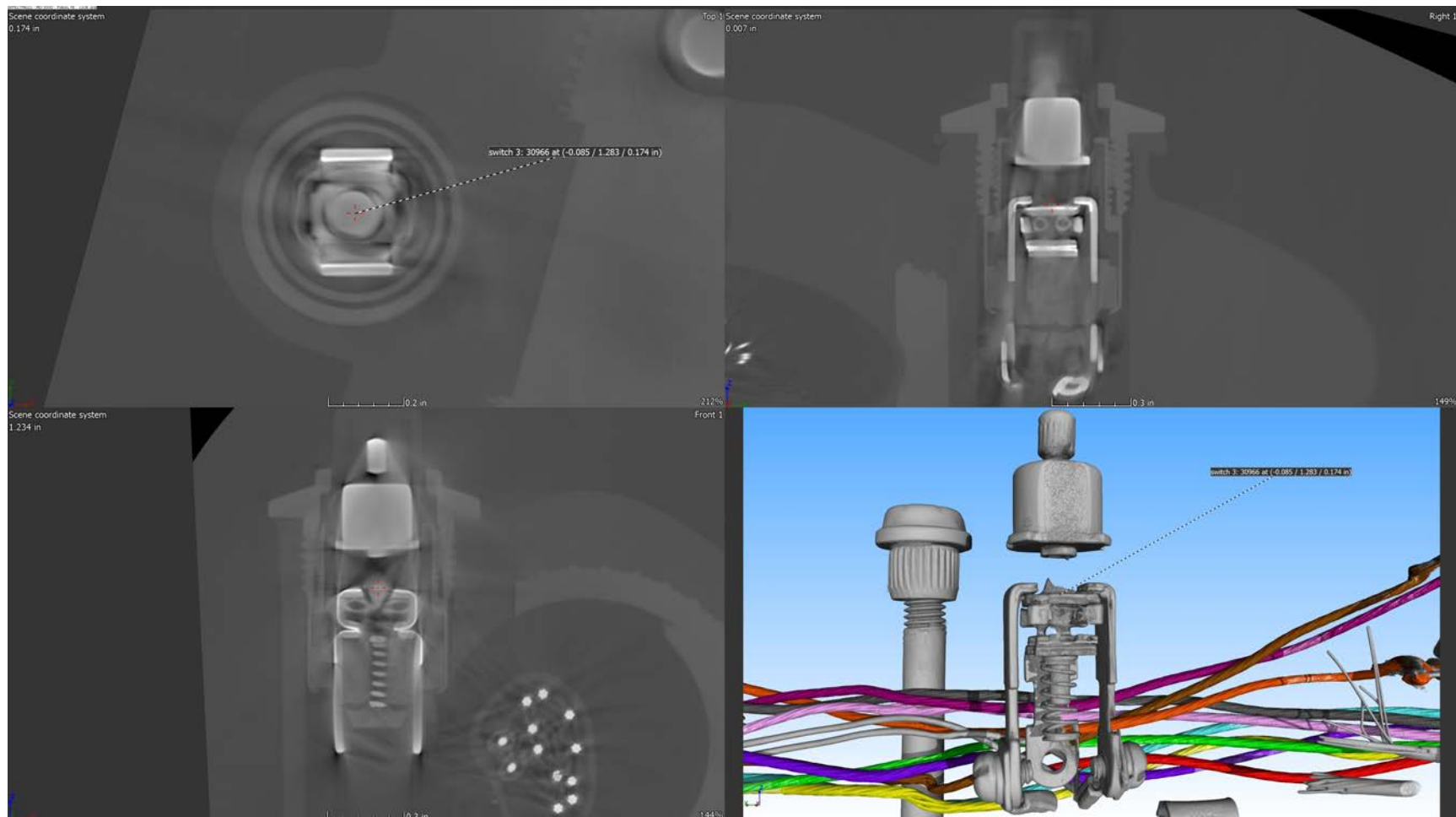


Figure 34
Cyclic grip – switch 3 contacts

Scott Warren
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