NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

October 25, 2016

Computed Tomography Specialist's Factual Report

ERA-16-FA-150

A. ACCIDENT

Location:	Ocala, Florida
Date:	April 9, 2016
Time:	0850 eastern daylight time
Vehicle:	Mooney M20K, N96398

B. GROUP

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

C. SUMMARY

On April 9, 2016, about 0850 eastern daylight time, a Mooney M20K, N96398, was substantially damaged during a forced landing following a loss of engine power after takeoff from Ocala International Airport (OCF), Ocala, Florida. The commercial pilot was fatally injured, and the passenger was seriously injured. Visual meteorological conditions prevailed and no flight plan was filed for the flight intended for Lakeland Regional Airport (LAL), Lakeland, Florida. The personal flight was conducted under the provisions of Title 14 Code of Federal Regulations Part 91.

The internal configuration of the fuel selector valve was documented using radiographic images that were collected from June 23-30, 2016 in Chicago, Illinois. A total of 2,869 computed tomography (CT) slice images were examined, processed, and analyzed by the NTSB to evaluate the components.

Review of the images by the NTSB indicated that:

1. The valve upper openings (closest to the valve handle) were in a position where all three valve ports were open to each other;

2. The valve lower openings (furthest from the valve handle) were in a position where only two of the valve ports were open to each other;

3. There was a crack indication in the safety wire conduit;

4. The valve placard structure was in a position that did not match the current valve position;

5. The valve was in a position that was rotated approximately 29 degrees away from the full "Left Tank" position and approximately 53 degrees away from the full "Right Tank" position;

6. The valve shaft structure had a rotational clearance of approximately 66 degrees relative to contacting the safety wire conduit.

D. DETAILS OF THE INVESTIGATION

1.0 General

The fuel selector valve was subjected to x-ray computed tomography (CT) scanning to document its internal condition. The scanning was conducted from June 23-30, 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 and the Actis 500/450 standard focus CT system.

For the CT scans, the component was loaded into the imaging unit and placed on a turntable. It 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 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 a reconstruction algorithm.

The fuel selector valve was scanned using a total of 2,869 slices. The total size of the combined data sets was 19.3 Gb. The valve was scanned completely twice using different imaging systems in order to better capture the internal configuration of the valve with both high resolution (microfocus) and high contrast (standard focus). In addition, a smaller region of the valve was scanned using target CT techniques to provide the highest possible resolution in that area. 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

	Microfocus scan – Fuel selector valve	Microfocus scan – Fuel selector valve target CT	Standard focus scan – Fuel selector valve
Number of slices	1768	568	533
Voxel Size - X Direction (mm)	0.059	0.03	0.16
Voxel Size - Y Direction (mm)	0.059	0.03	0.16
Voxel Size - Z Direction (mm)	0.06	0.03	0.16
Image Projections per Revolution	3600	3600	1400
Exposure time (ms)	285.58	285.58	285.58
Frames to Avg (frames per projection)	2	2	2
X-ray Source Voltage (kV)	223	223	450
X-ray Source Current (mA)	0.51	0.50	2
Source Filter Material	Brass	Brass	Brass, Copper
Source Filter Thickness (mm)	1	1	Brass - 7.5 Copper – 2.0
Image Matrix Size (pixels)	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 fuel selector valve were examined for any signs of missing or damaged parts, contamination, obstructed passages or any other anomalies.

Specific results (including example images) are presented in subsequent sections of this report.

2.0 Computed Tomography Results

The computed tomography (CT) results for the fuel selector valve are shown in figures 1 through 28. Review of the images indicated:

1. The valve upper openings (closest to the valve handle) were in a position where all three valve ports were open to each other;

2. The valve lower openings (furthest from the valve handle) were in a position where only two of the valve ports were open to each other;

3. There was a crack indication in the safety wire conduit;

4. The valve placard structure was in a position that did not match the current valve position;

5. The valve was in a position that was rotated approximately 29 degrees away from the full "Left Tank" position and approximately 53 degrees away from the full "Right Tank" position;

6. The valve shaft structure had a rotational clearance of approximately 66 degrees relative to contacting the safety wire conduit.

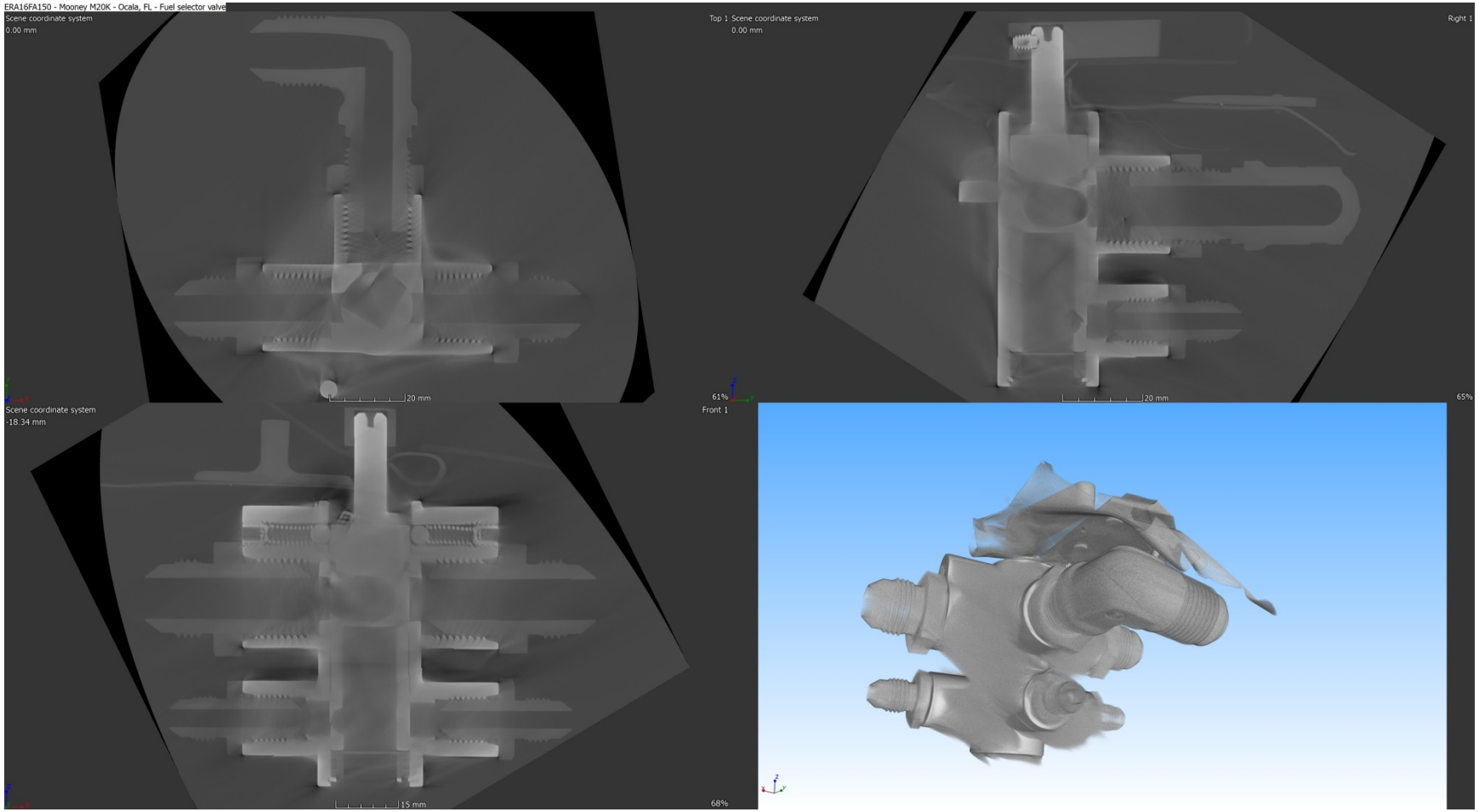

Figure 1
Fuel selector valve – microfocus – overall view

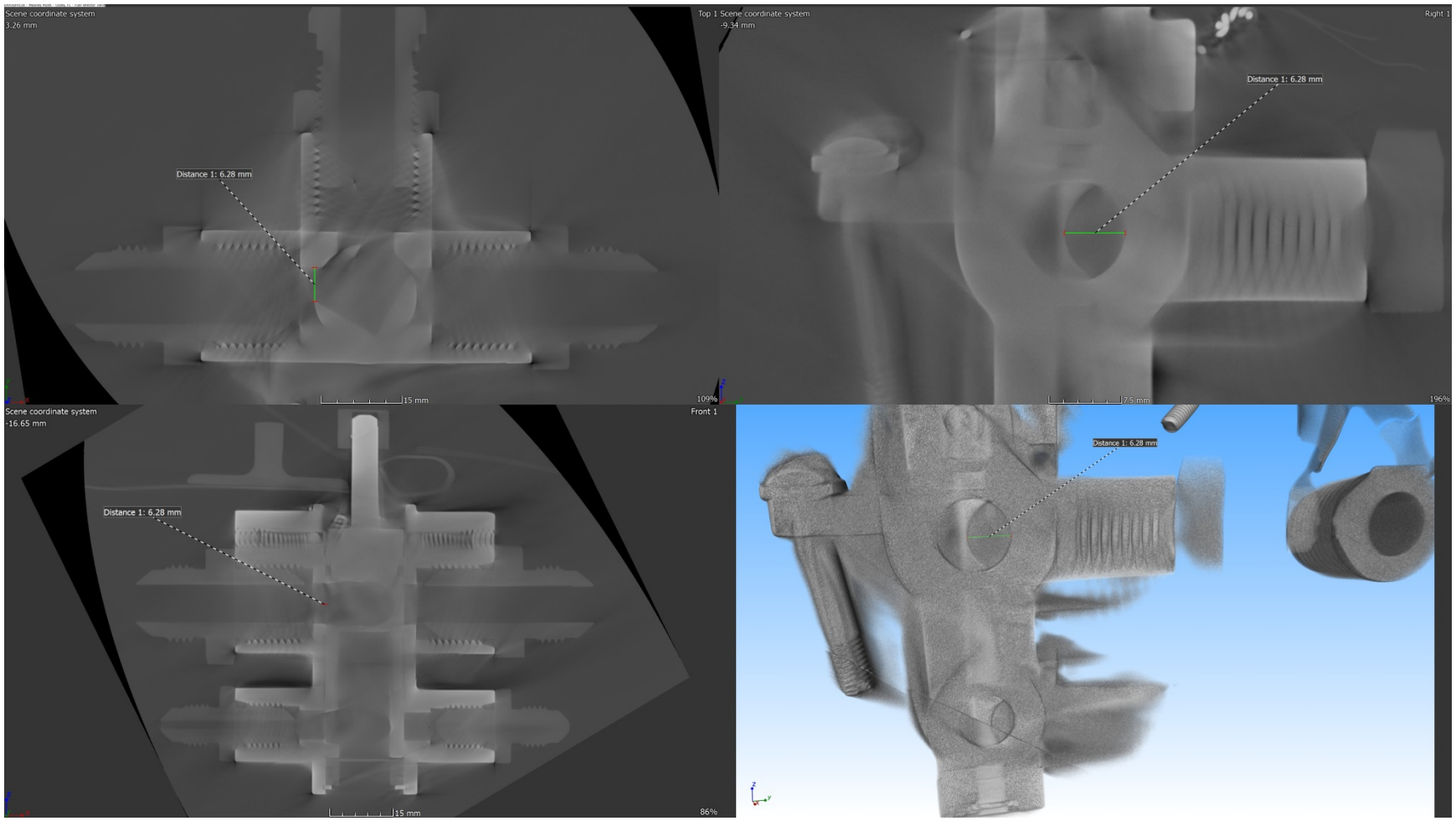

Figure 2
Fuel selector valve – microfocus – upper opening dimension (6.28 mm)

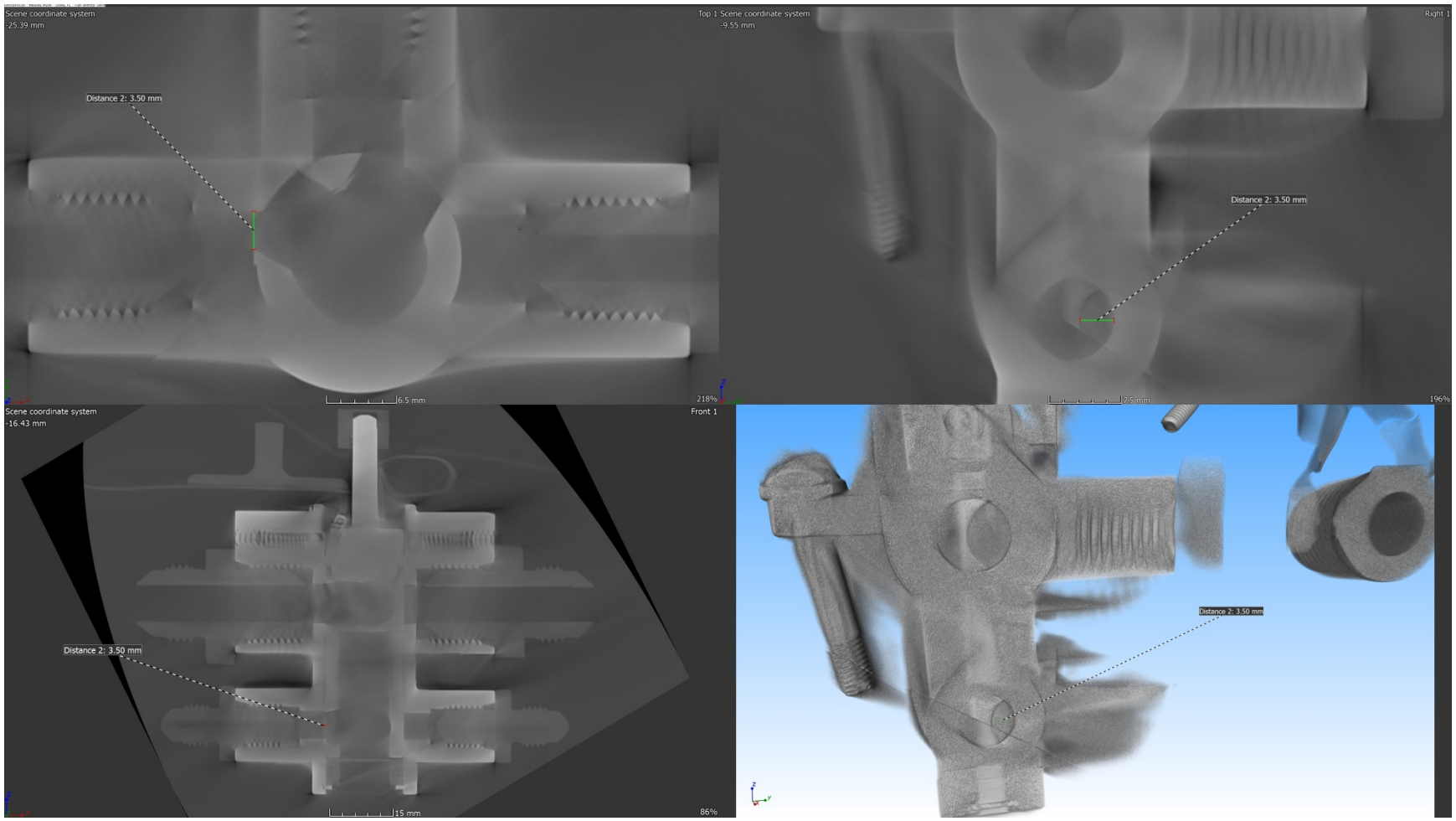

Figure 3

Fuel selector valve – microfocus – lower opening dimension (3.50 mm)

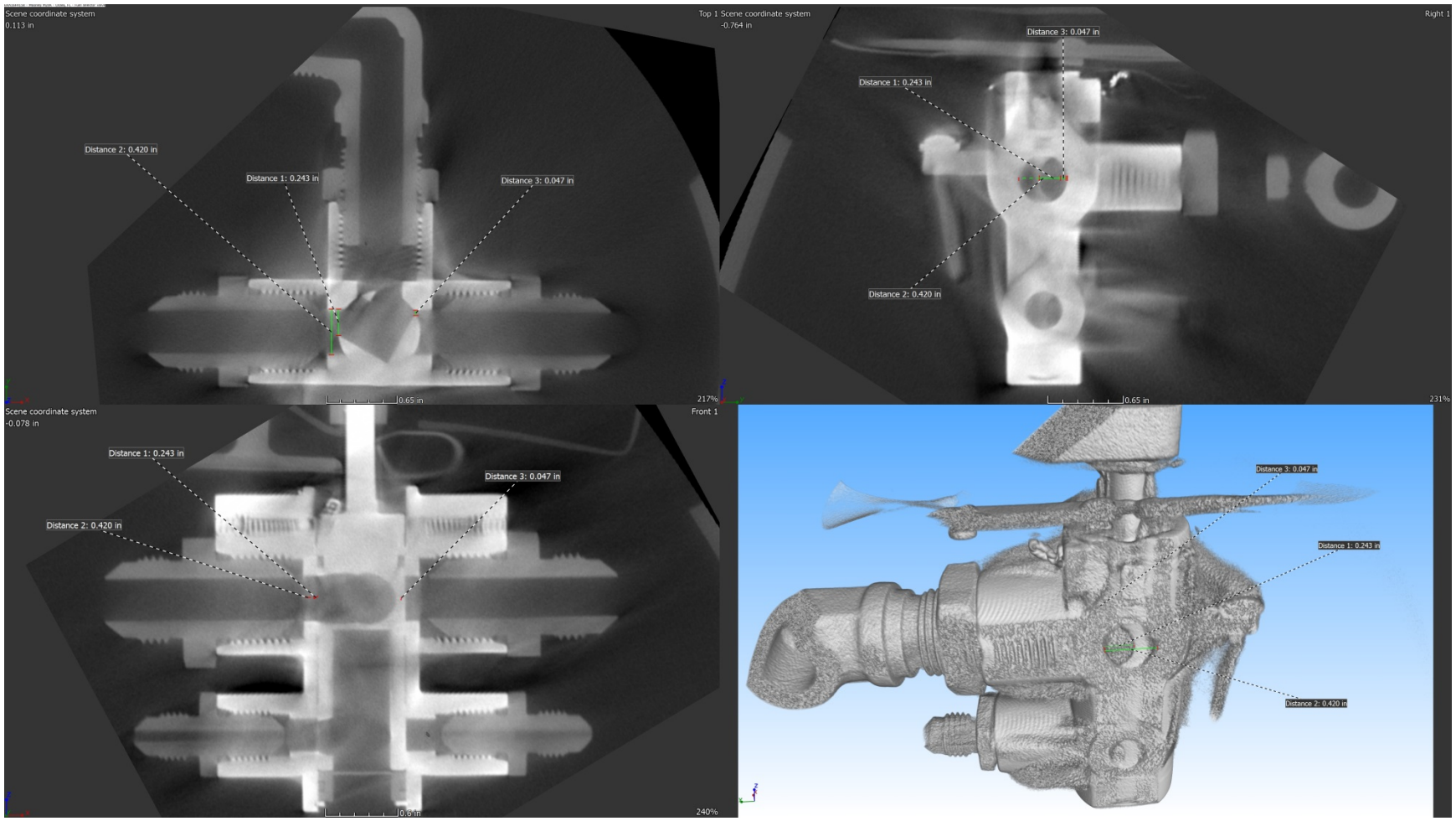

Figure 4

Fuel selector valve – standard focus – upper opening – overview of dimensions

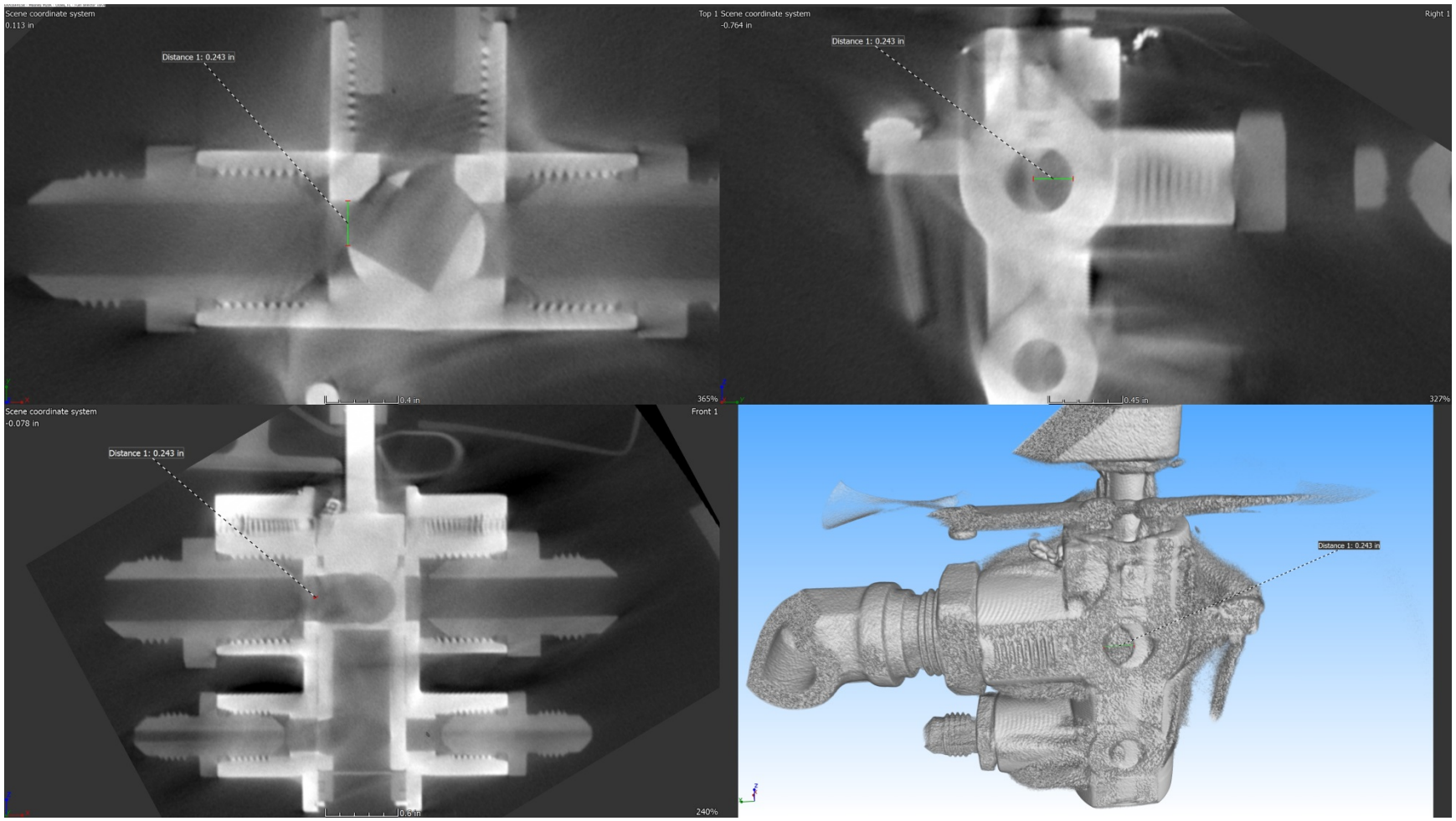

Figure 5
Fuel selector valve – standard focus – upper opening – dimension 1

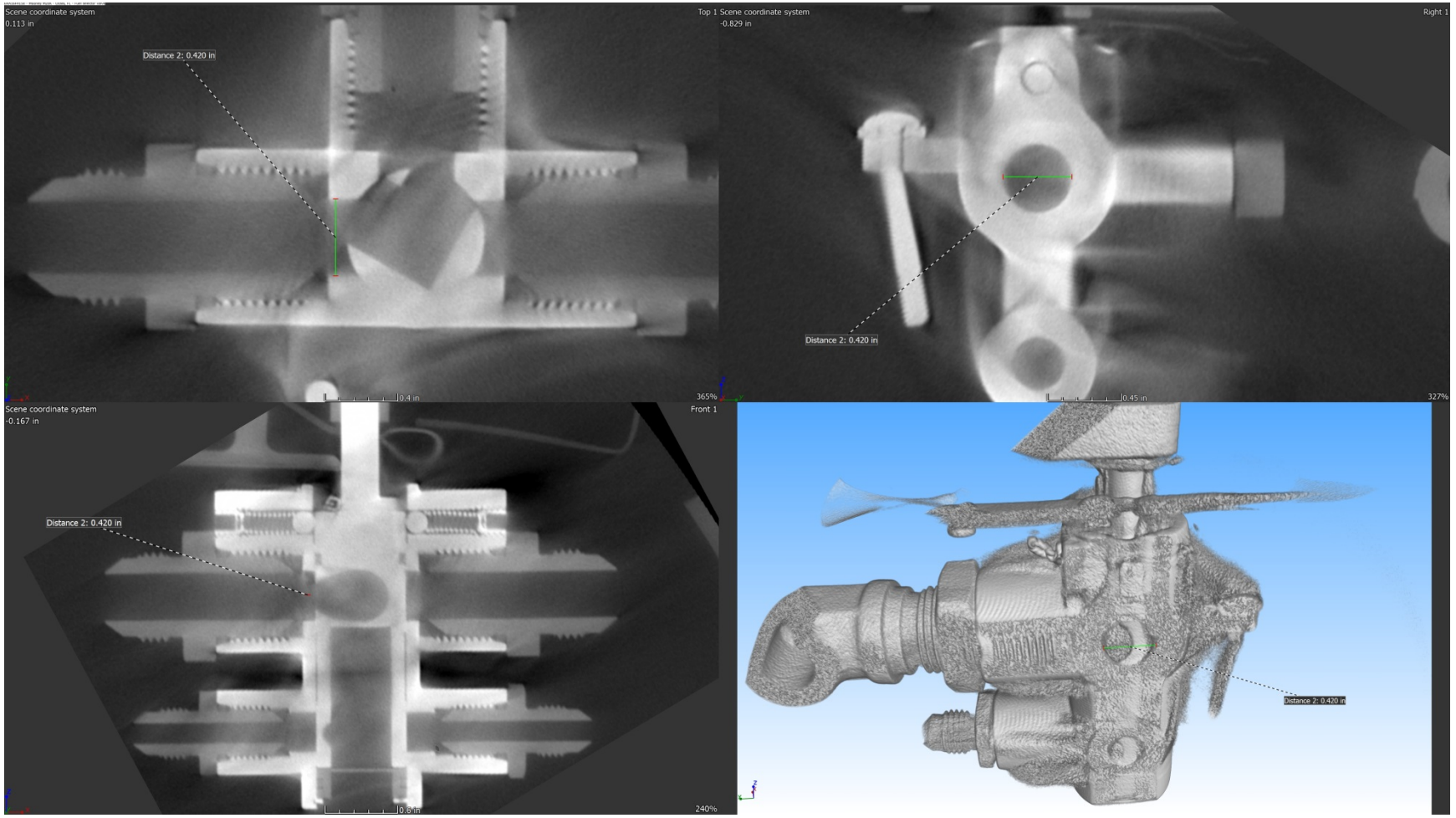

Figure 6
Fuel selector valve – standard focus – upper opening – dimension 2

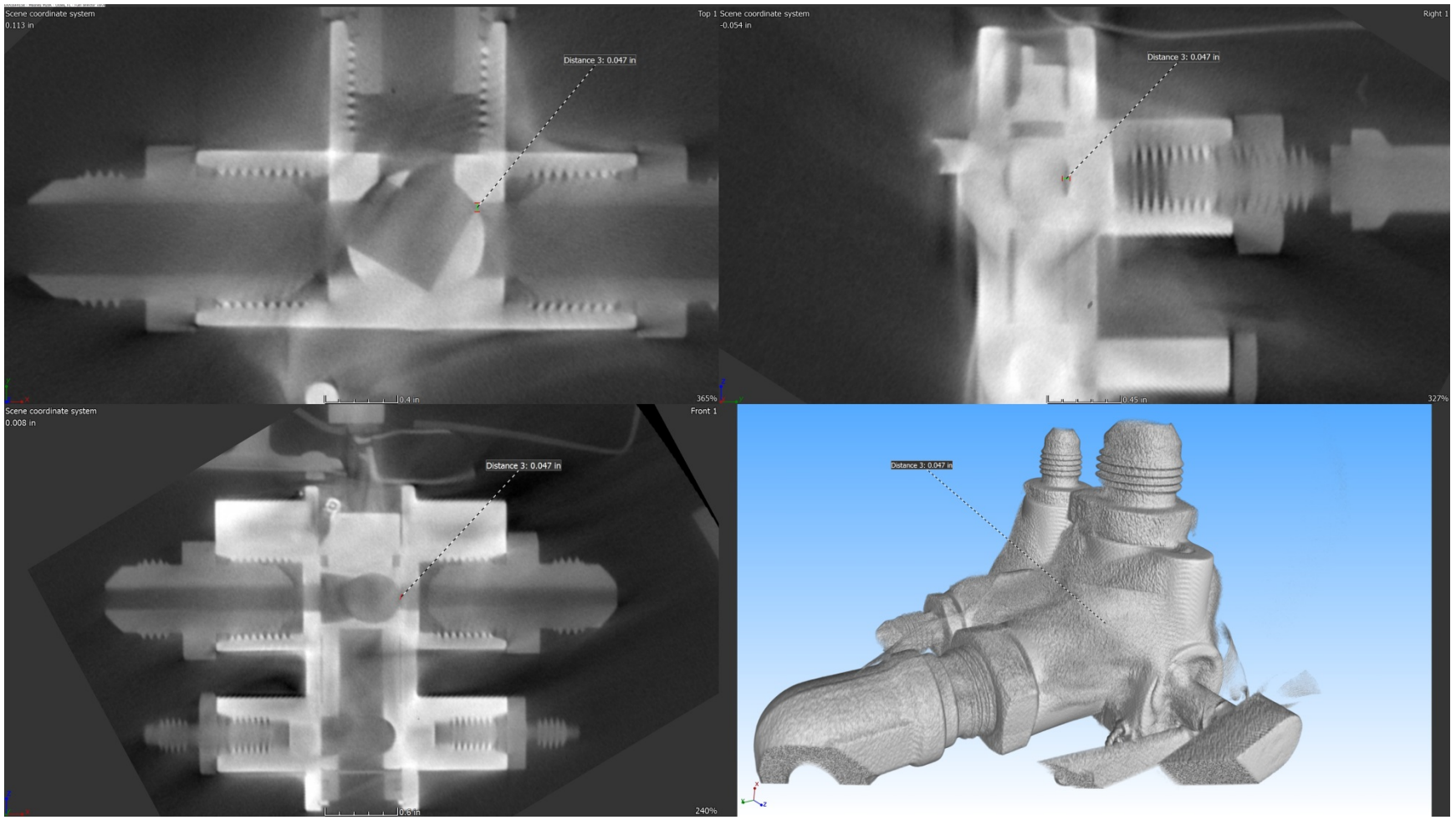

Figure 7
Fuel selector valve – standard focus – upper opening – dimension 3

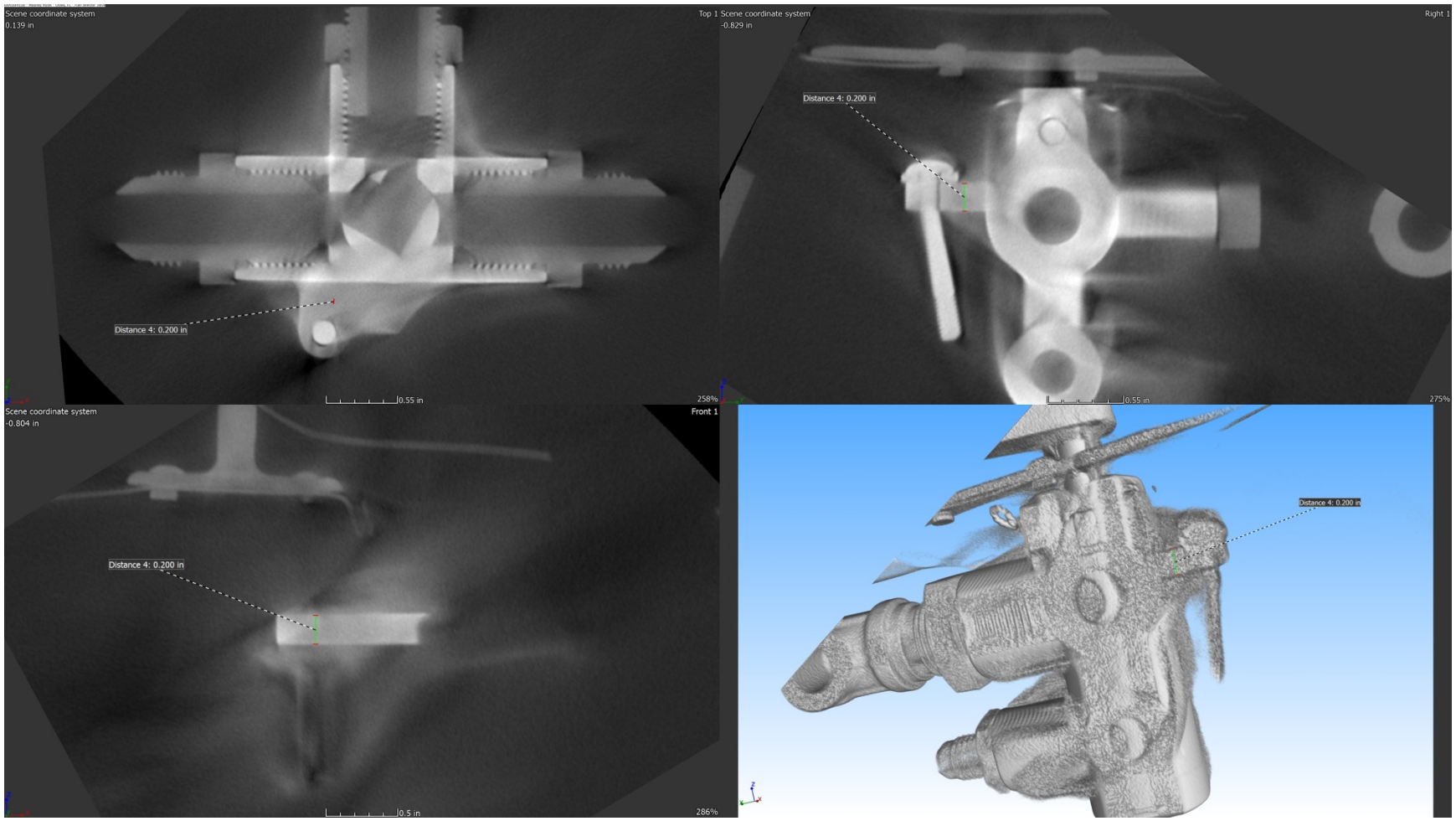

Figure 8
Fuel selector valve – standard focus – dimension matched to drawing dimension[1]

[1] This dimension was measured to determine if the CT software measurement tool was calibrated properly. On the valve drawing, this dimension was also listed as 0.200 inches.

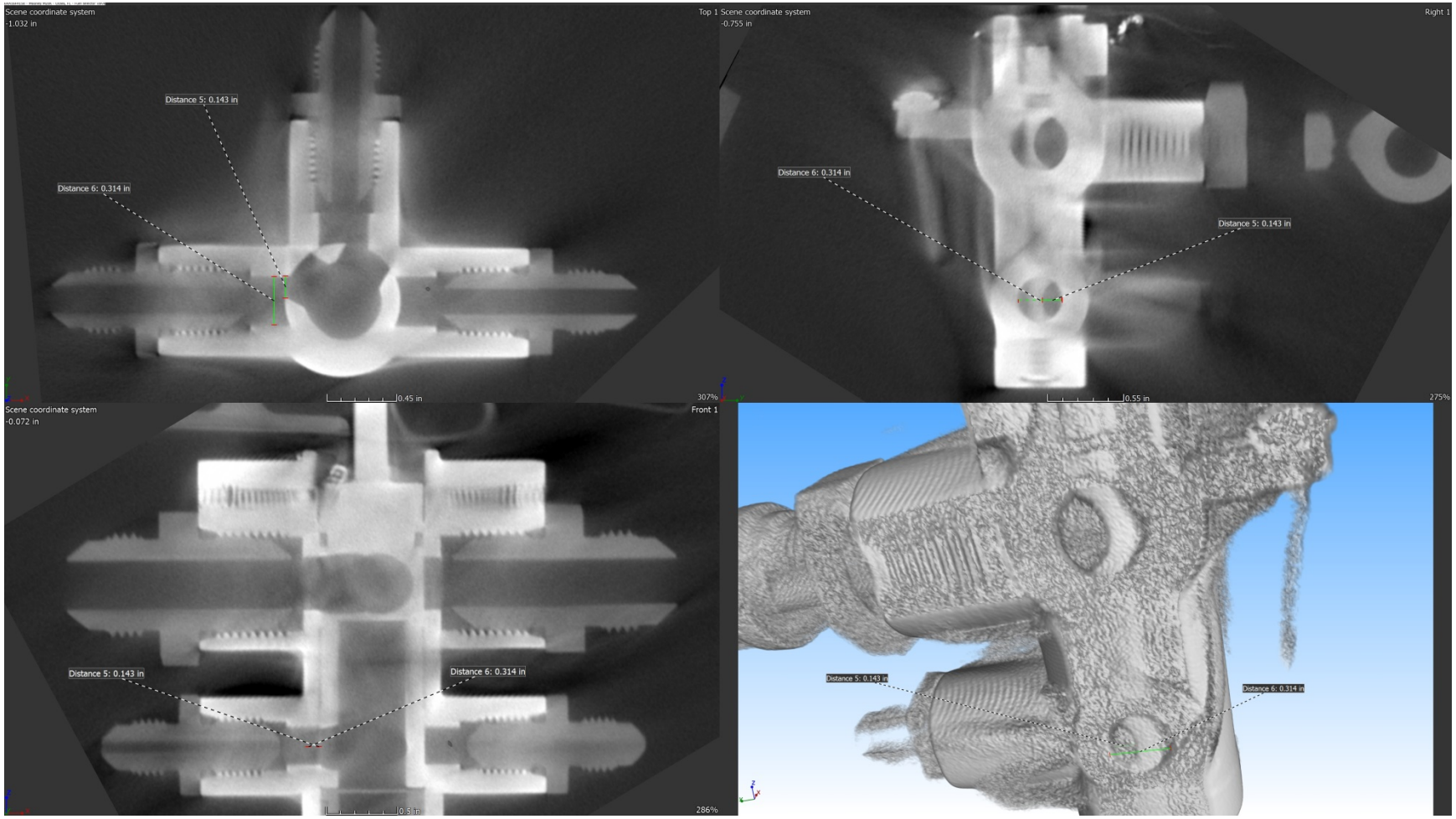

Figure 9

Fuel selector valve – standard focus – lower opening – overview of dimensions

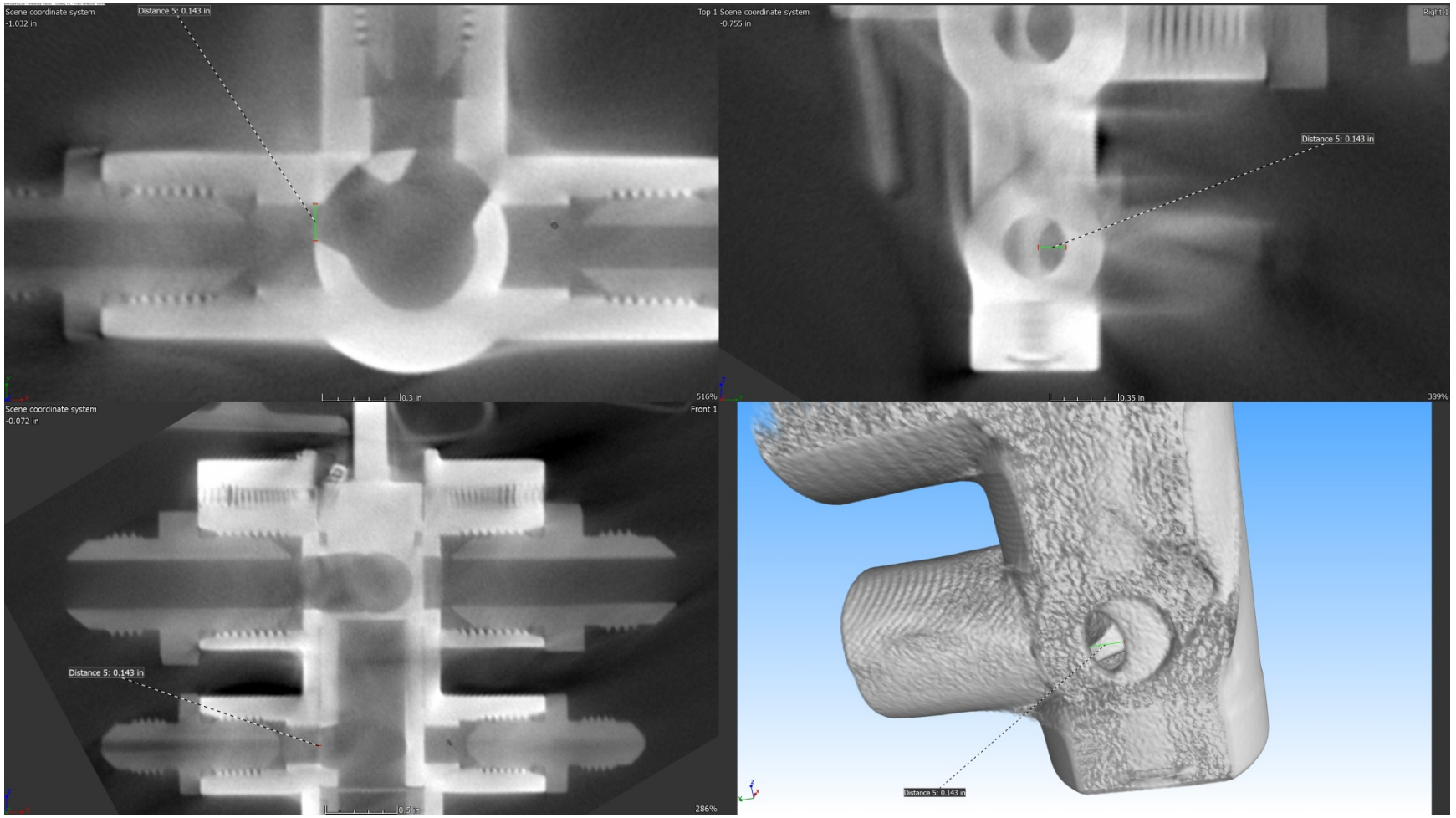

Figure 10
Fuel selector valve – standard focus – lower opening – dimension 1

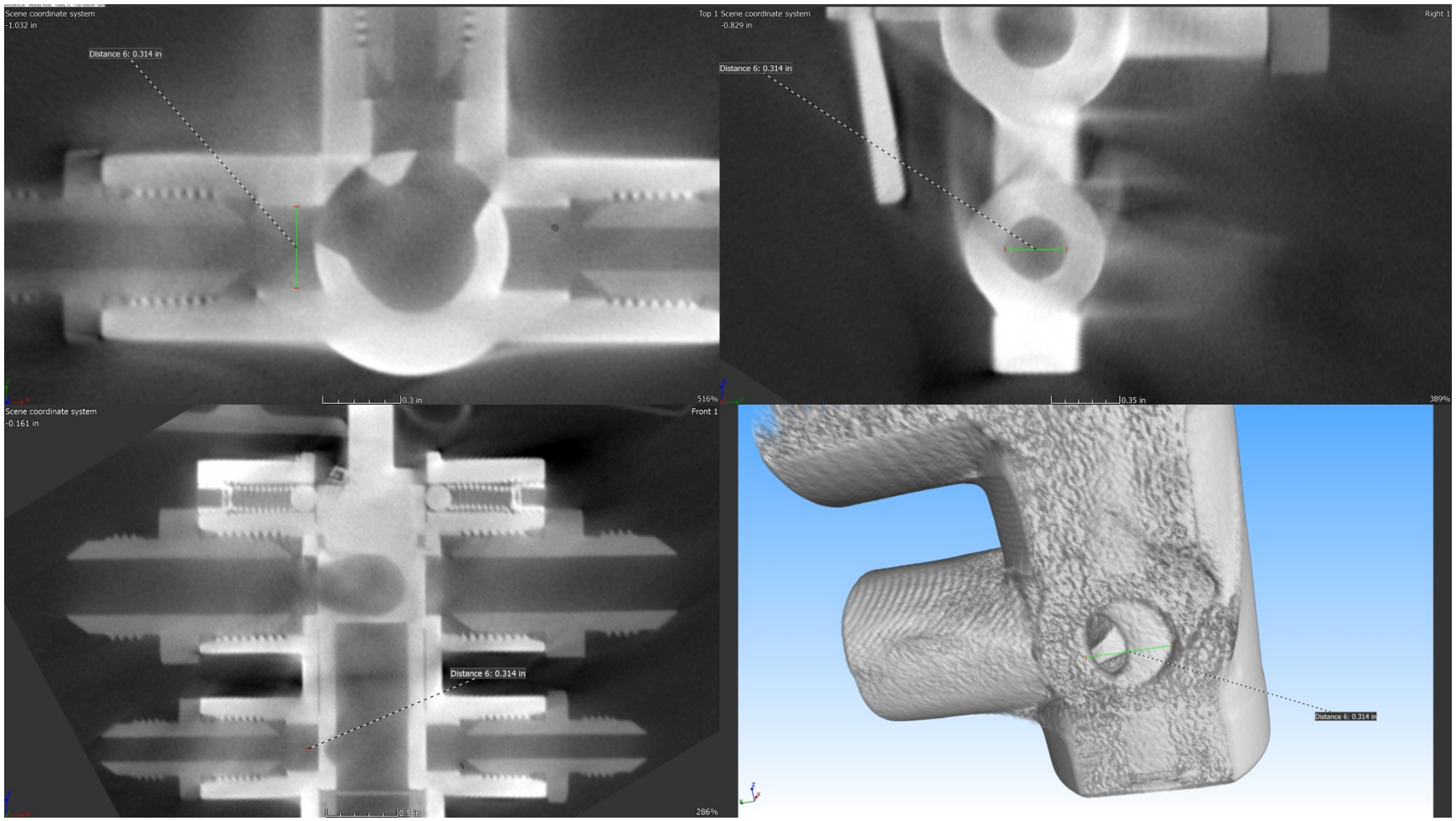

Figure 11
Fuel selector valve – standard focus – lower opening – dimension 2

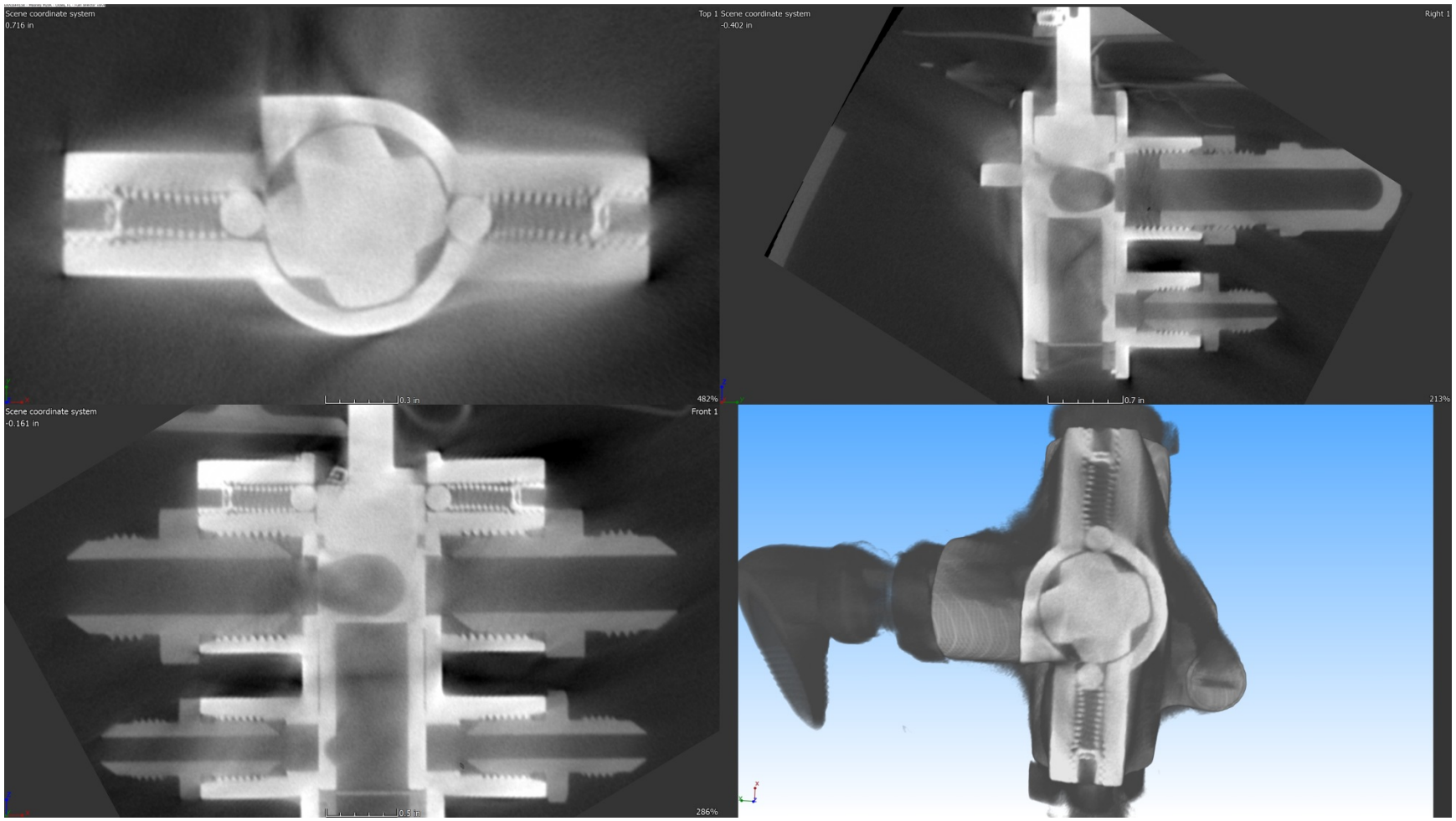

Figure 12
Fuel selector valve – standard focus – ball and spring mechanism

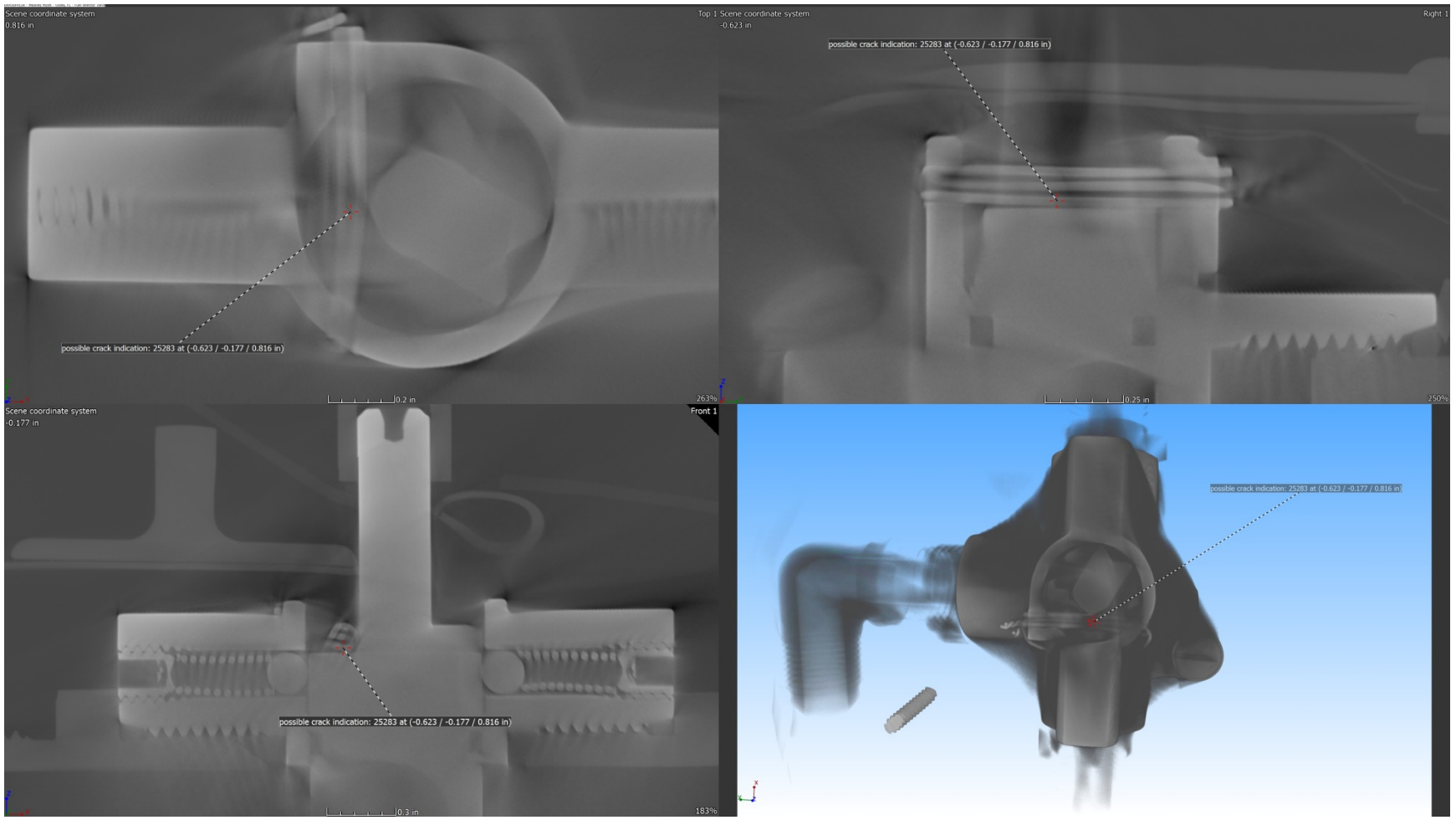

Figure 13
Fuel selector valve – microfocus – possible crack indication

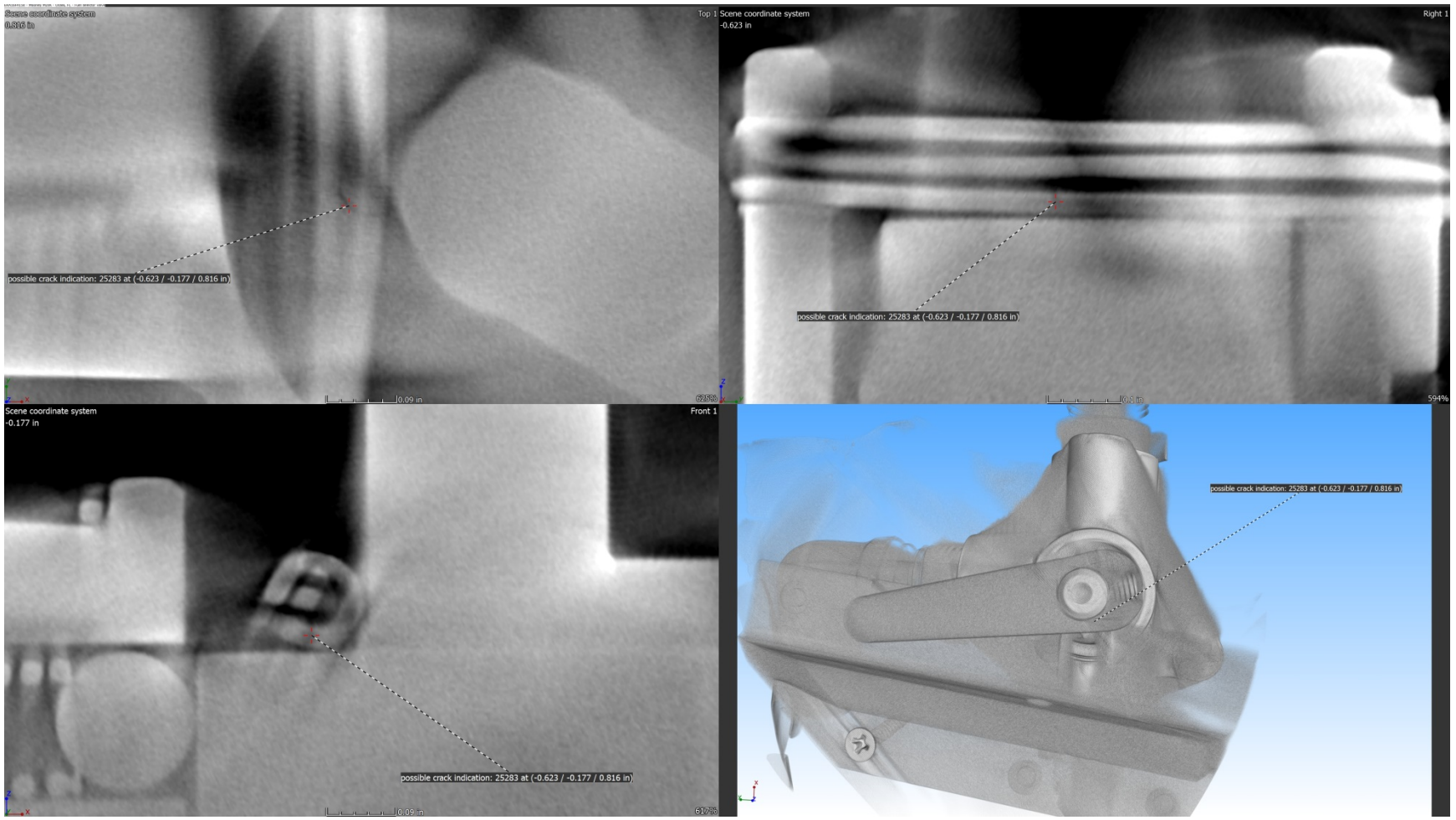

Figure 14
Fuel selector valve – microfocus – possible crack indication – close up with enhanced contrast

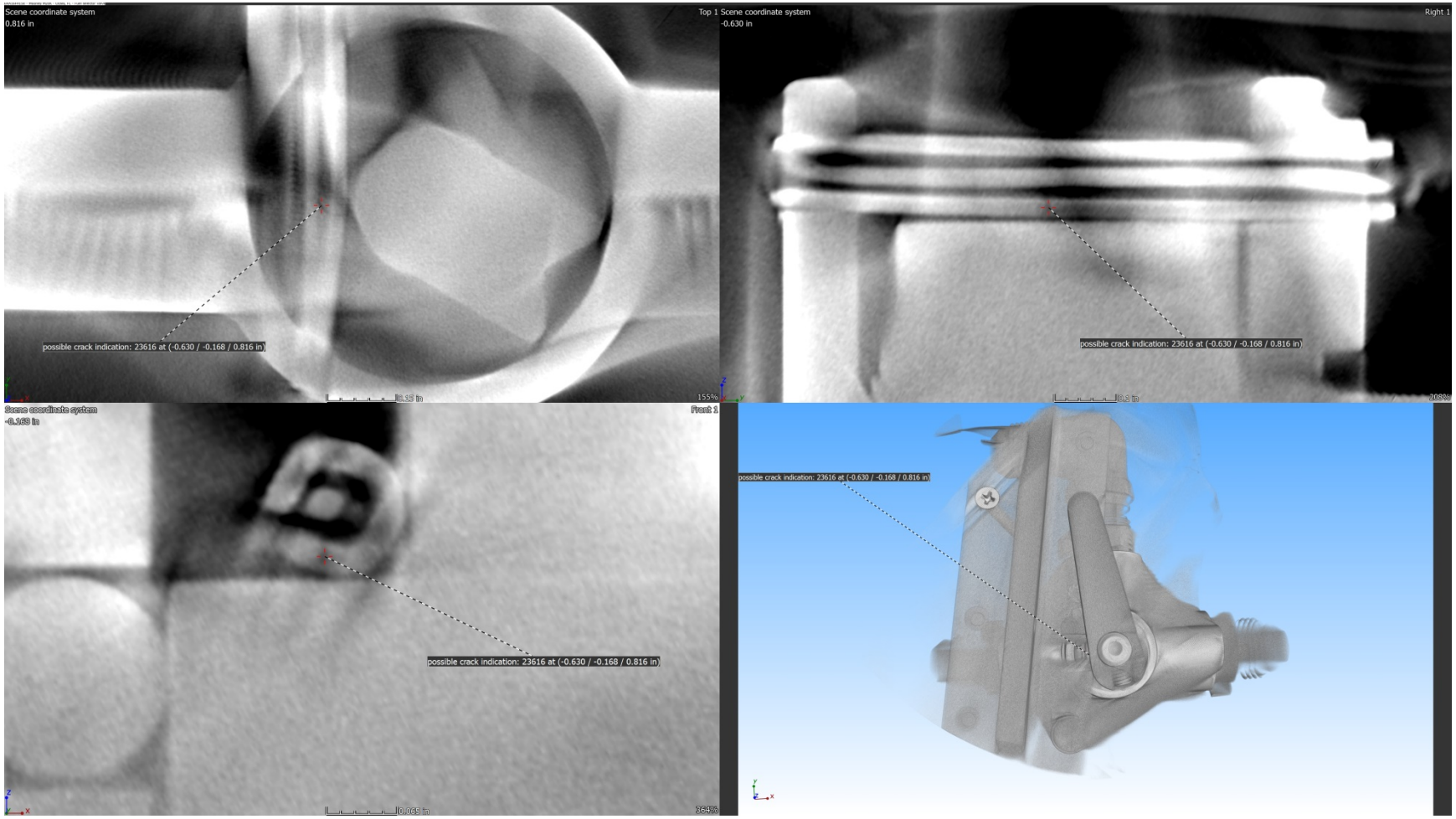

Figure 15
Fuel selector valve – microfocus – possible crack indication – close up with enhanced contrast 2

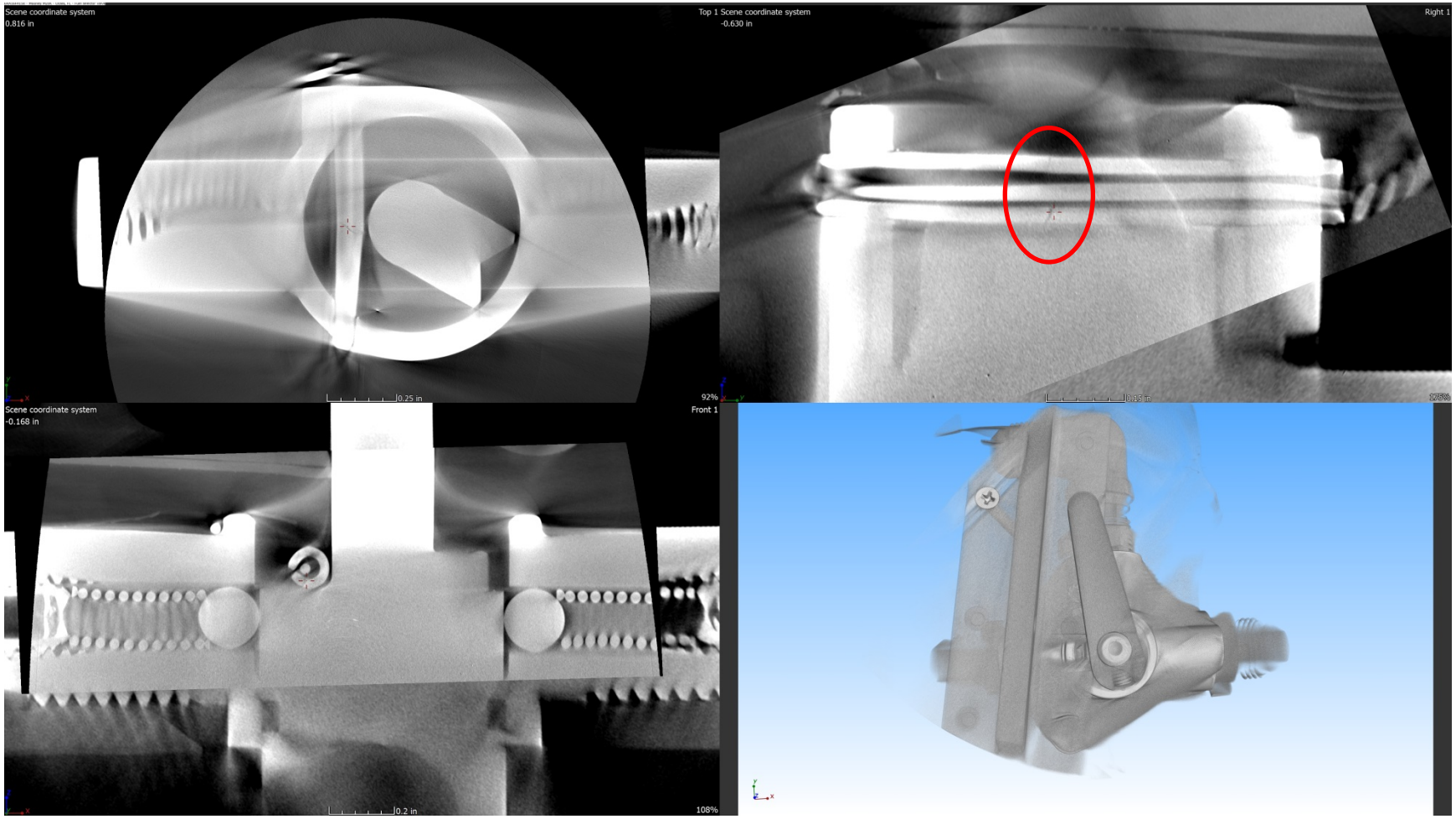

Figure 16
Fuel selector valve – target CT – possible crack indication

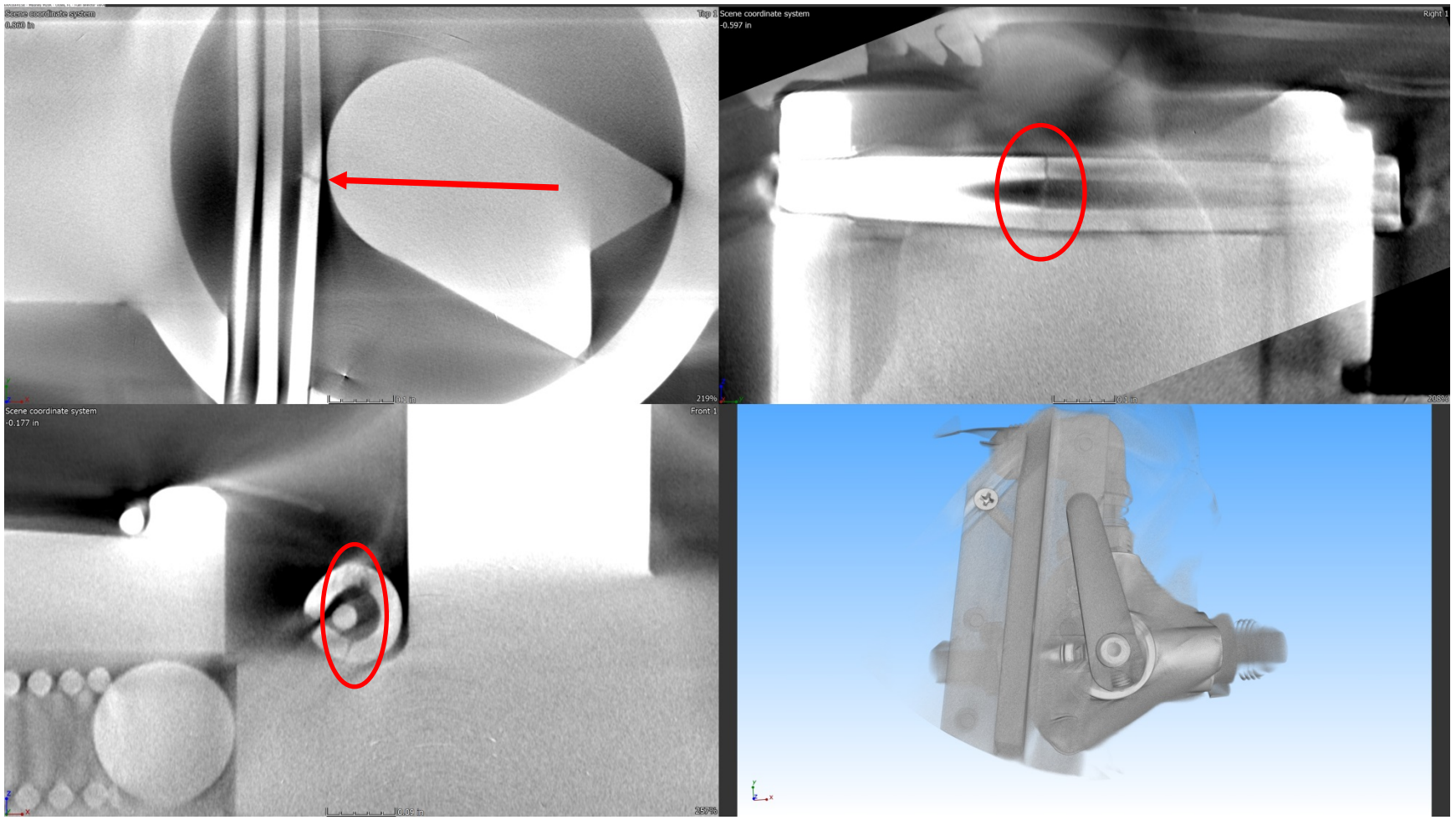

Figure 17
Fuel selector valve – target CT – possible crack indication – close up view

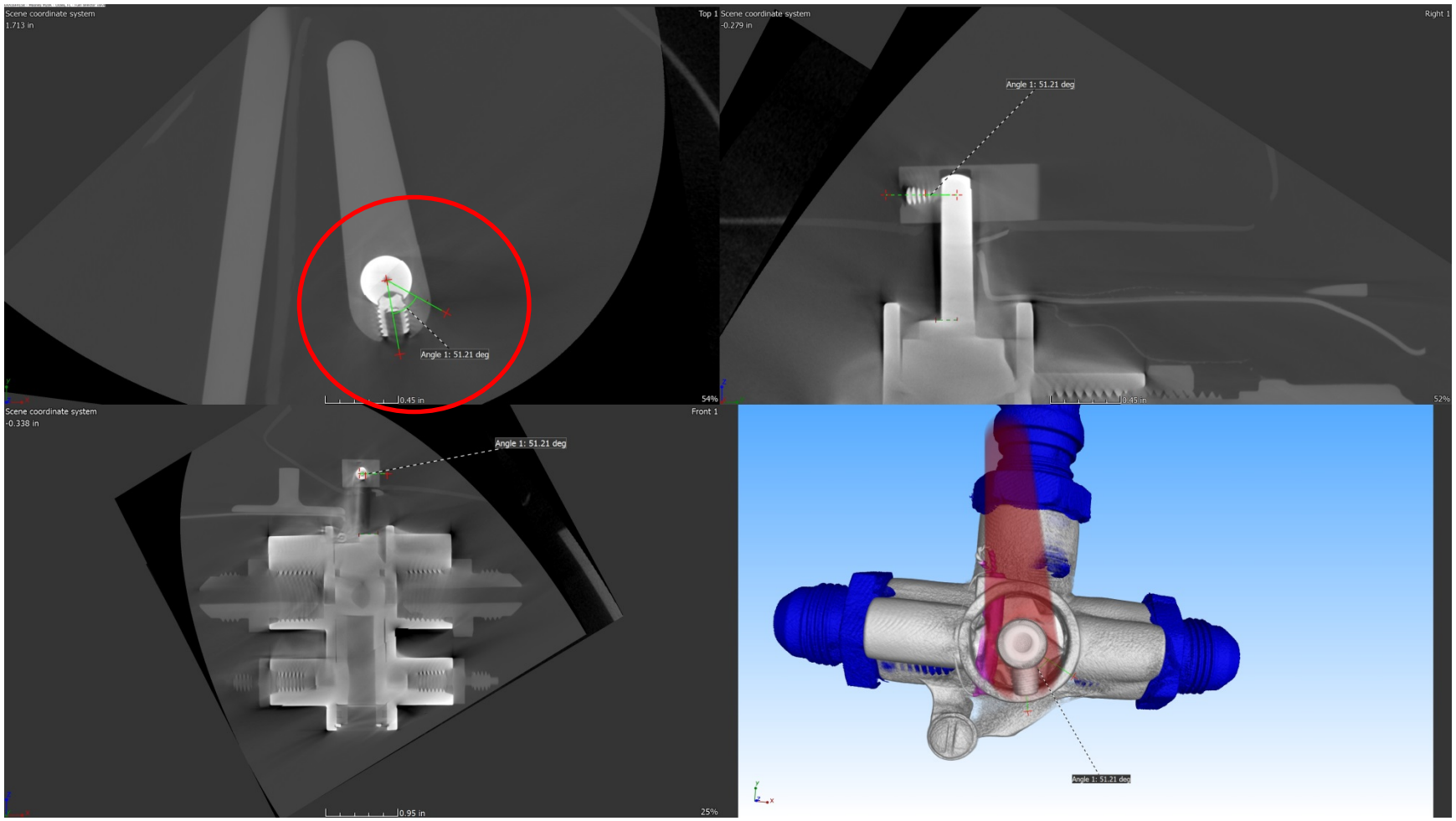

Figure 18
Fuel selector valve – standard focus – angle between shaft orientation and handle

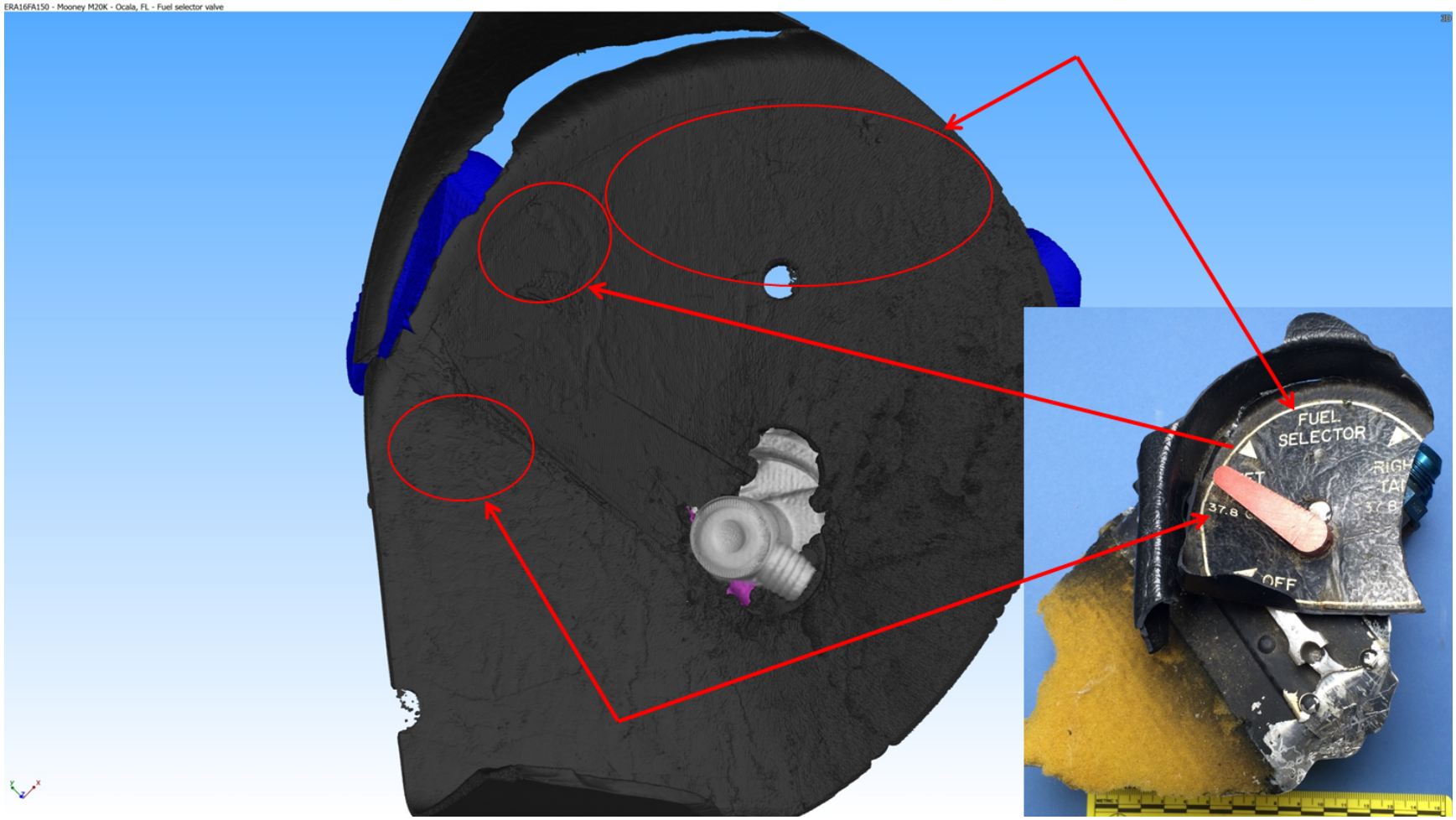

Figure 19
Fuel selector valve – standard focus – placard with markings[2]

[2] Note – high viewer zoom levels may be required to see the placard markings in the CT image.

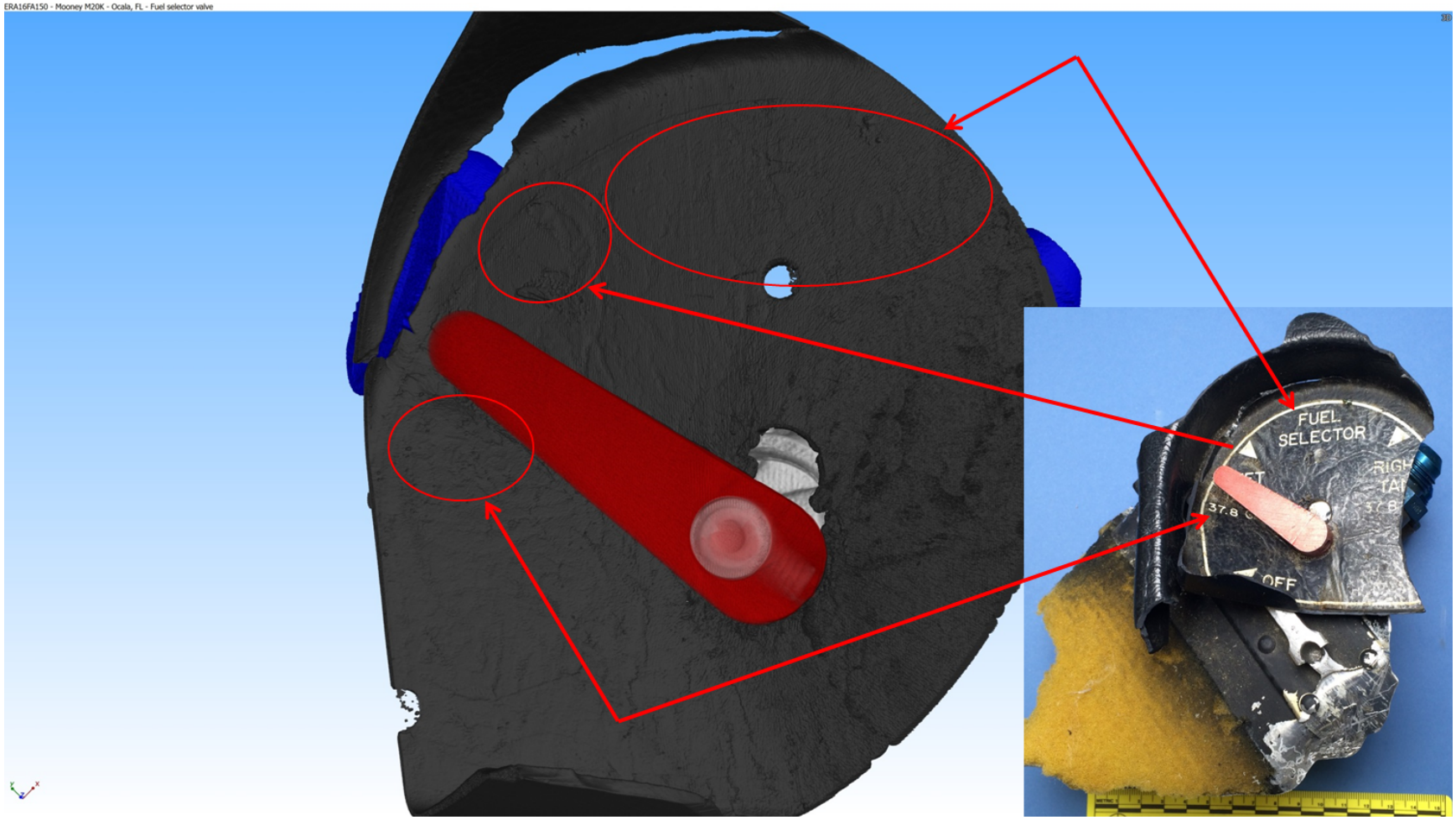

Figure 20
Fuel selector valve – standard focus – placard with markings and handle

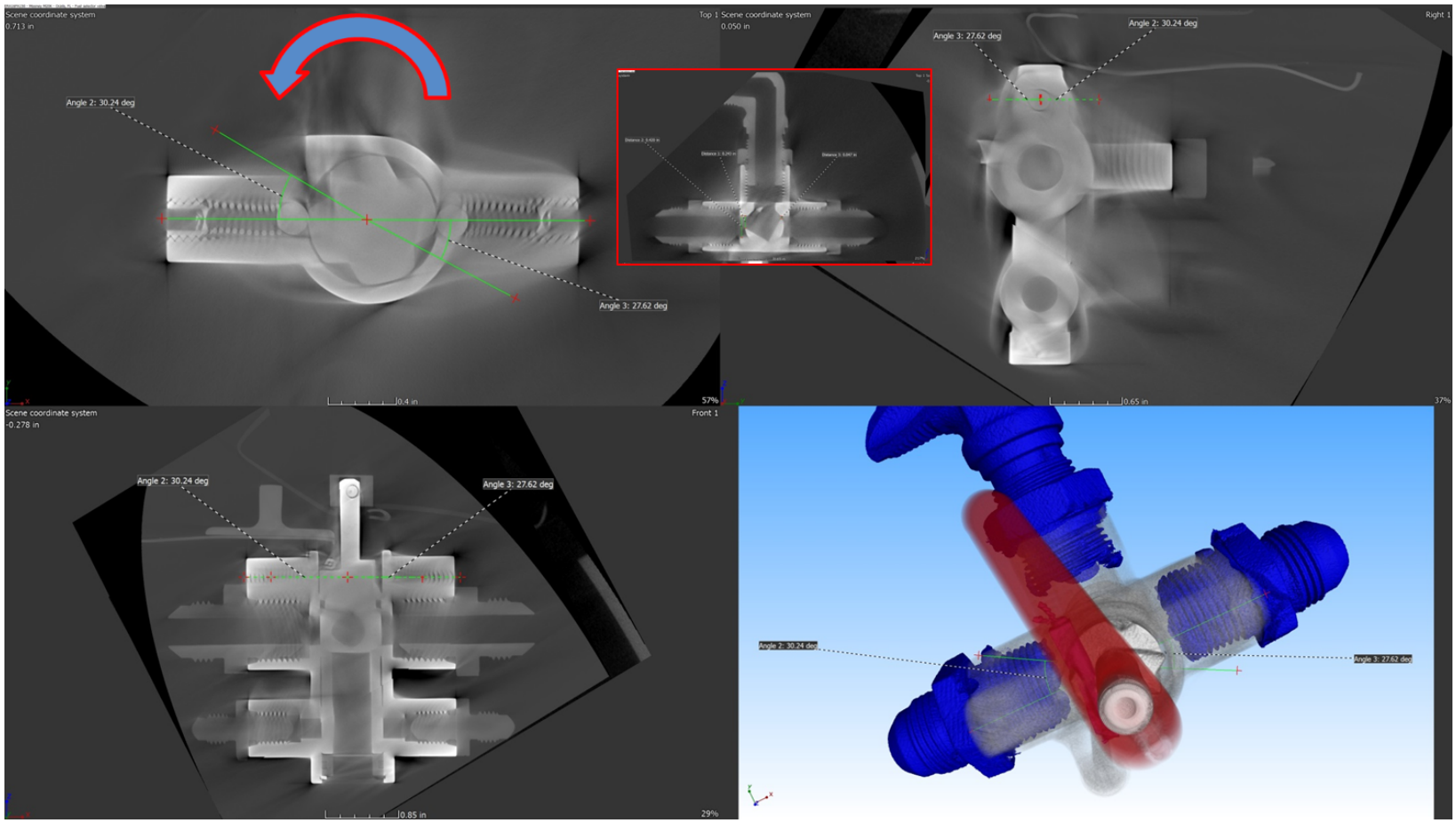

Figure 21

Fuel selector valve – standard focus – counter-clockwise rotation required for the valve to be in the full "Left Tank" position[3]

[3] Note: The angle required to move both valve shaft detents to align with the balls was measured, and they were approximately the same. The average value of the two measurements indicated that the current position of the valve was approximately 29 degrees away from the full "Left tank" position. A valve cross section image is also shown in the figure and is bordered in red.

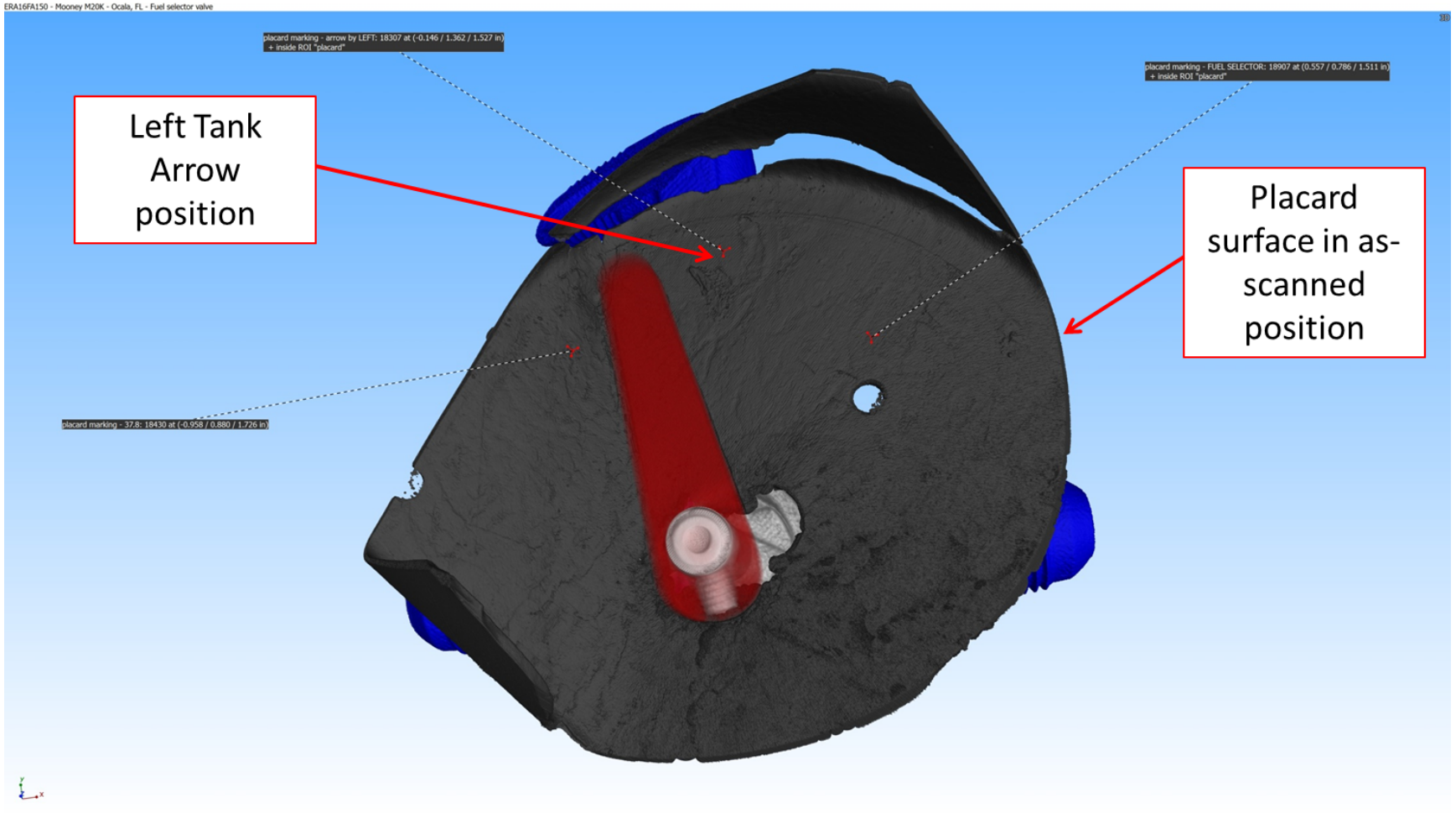

Figure 22
Fuel selector valve – 3D – placard with markings in the "as scanned" position prior to virtual rotation

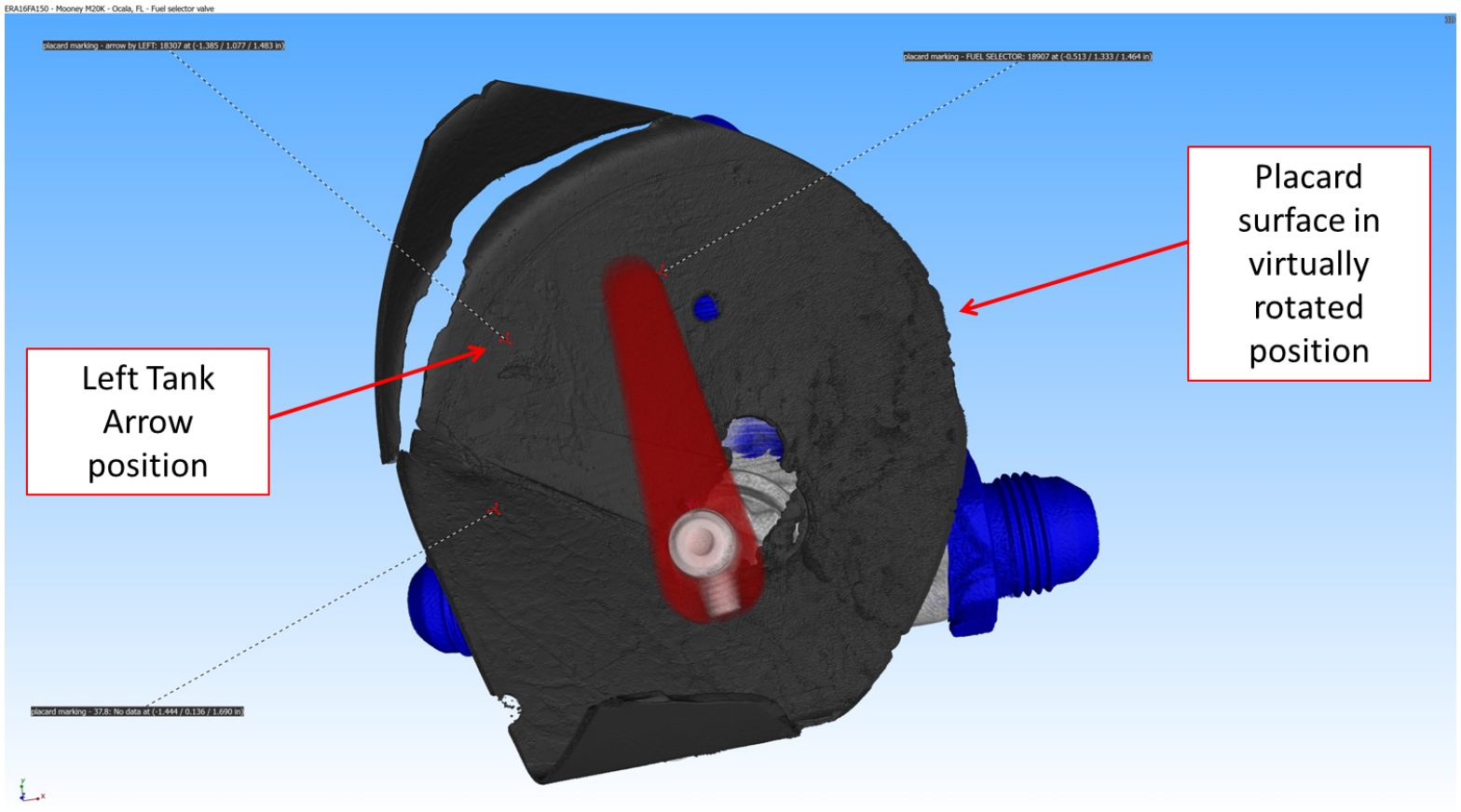

Figure 23
Fuel selector valve – 3D – placard with markings after the virtual rotation which placed the handle 29 degrees away from the "Left Tank" position[4]

[4] Figures 22 and 23 were created to show how the placard would appear if it corresponded to the internal valve position.
Figure 22 shows the placards in the "as-scanned" position. Software was then used to virtually rotate the placard structure so that the handle was approximately 29 degrees away from the full "Left Tank" position. Figure 23 shows the placard structure in the "virtually rotated" position.

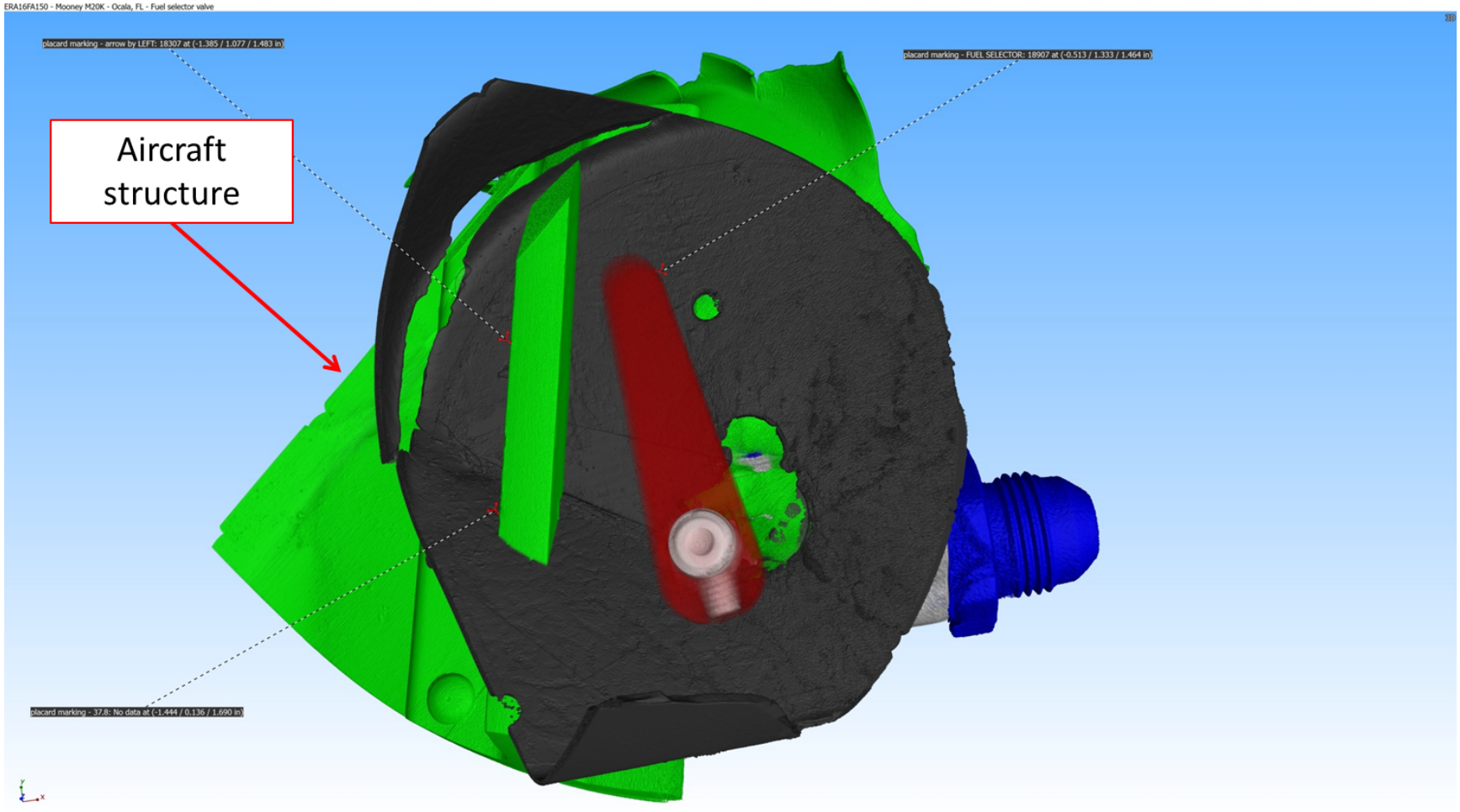

Figure 24

Fuel selector valve – 3D – placard with markings after the virtual rotation of 29 degrees including aircraft structure[5]

[5] Note that the aircraft structure would interfere with the placard structure in this orientation.

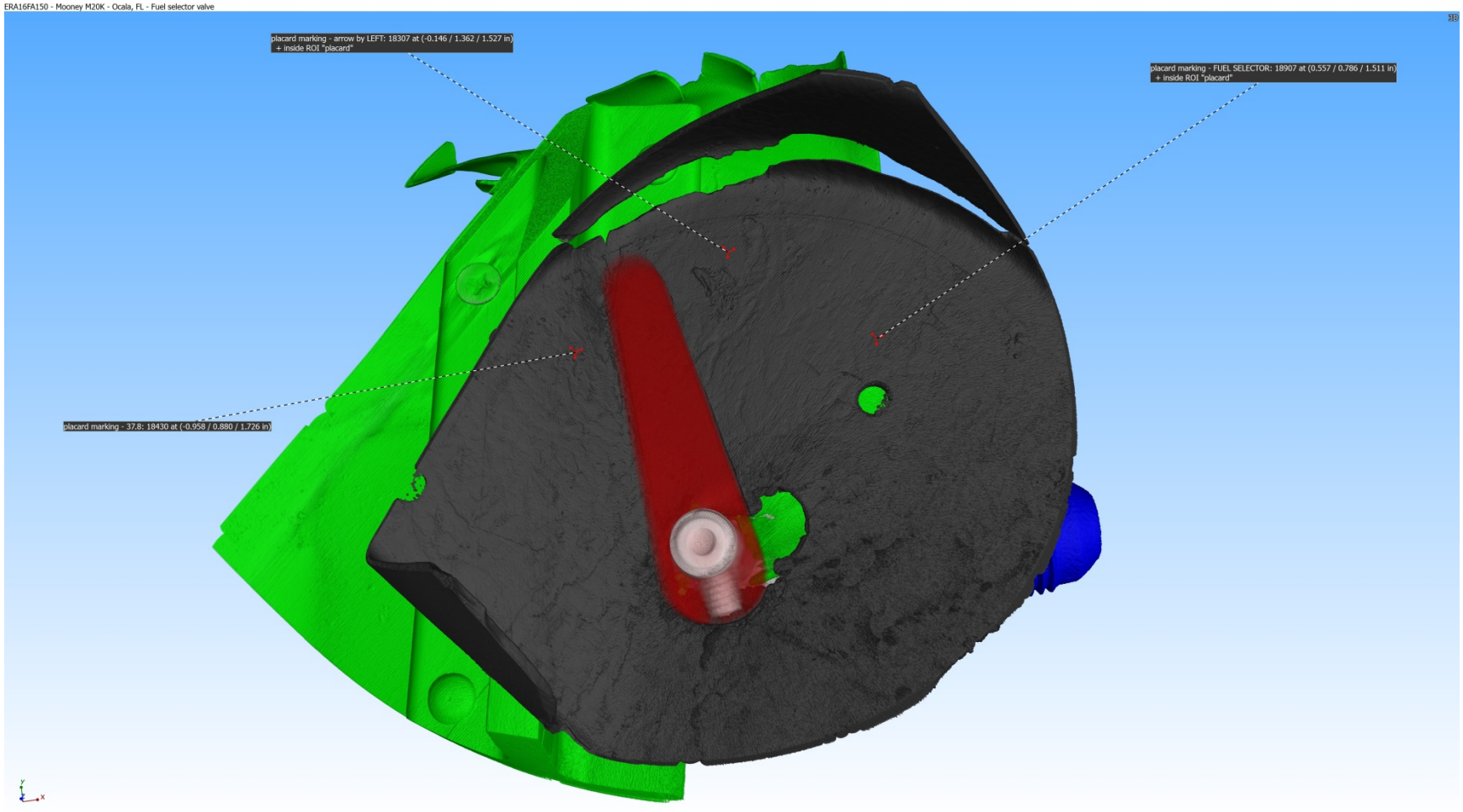

Figure 25
Fuel selector valve – 3D – placard with markings in the "as-scanned" position including aircraft structure[6]

[6] Note that the aircraft structure does not interfere with the placard structure in this orientation.

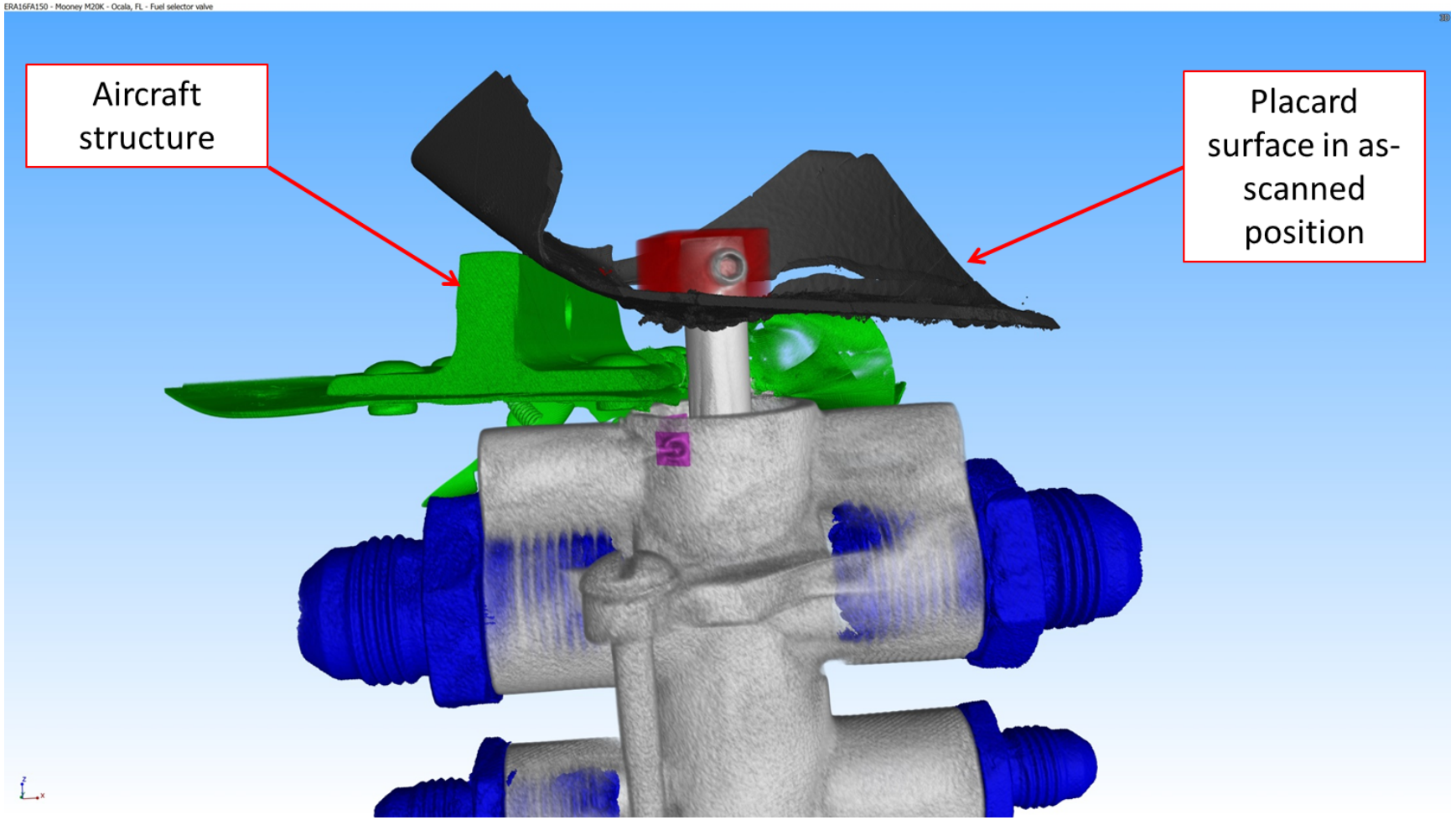

Figure 26
Fuel selector valve – 3D – placard with markings in the "as-scanned" position including aircraft structure – side view

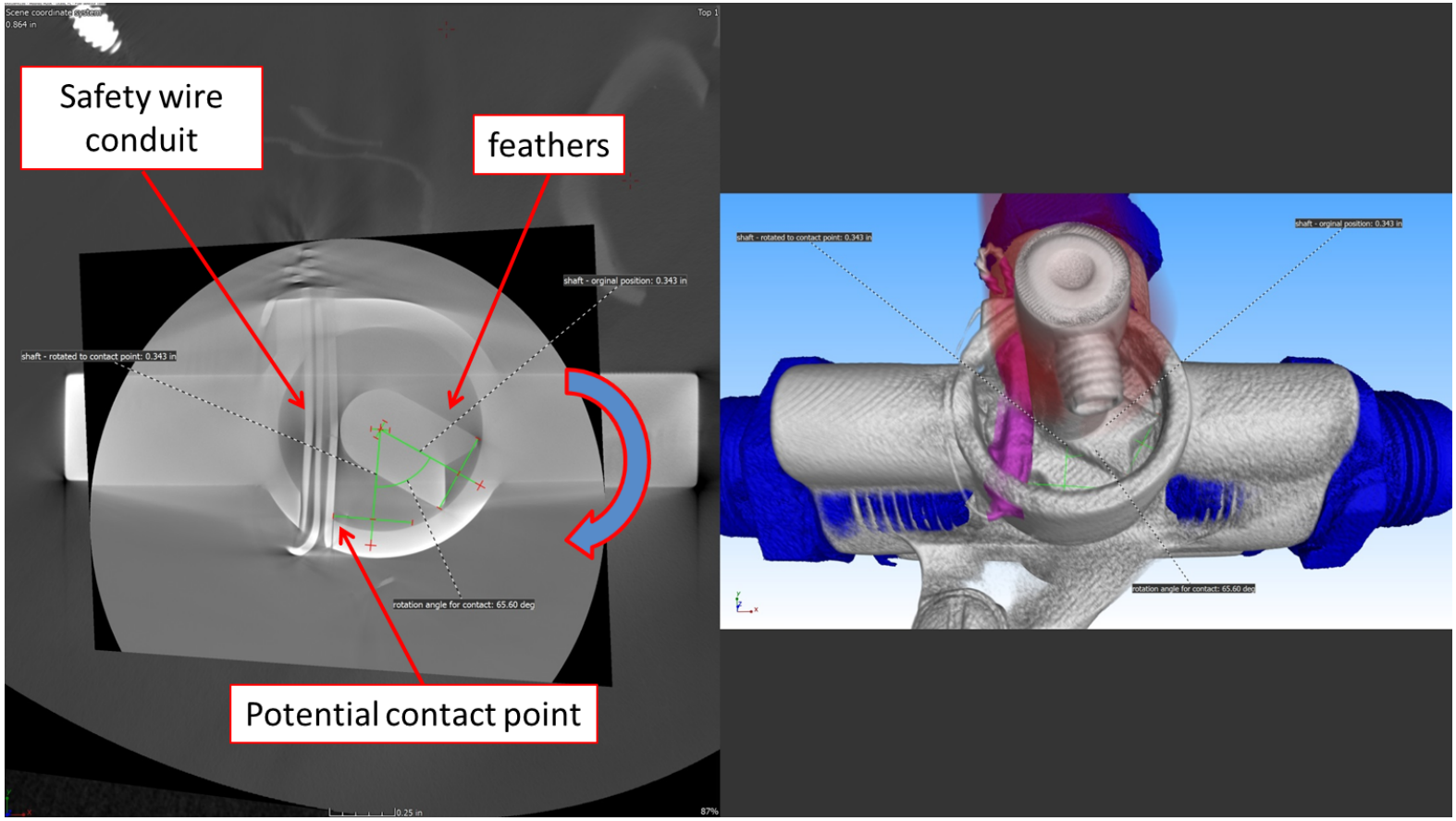

Figure 27

Fuel selector valve – standard focus – rotation required for the valve shaft structure ("feathers") to contact the safety wire conduit[7]

[7] To determine this measurement, software was used to create a set of calipers with one end on the valve shaft center of rotation and the other end on the ends of the shaft structure (feathers). Then, holding these dimensions constant, the calipers were rotated clockwise until the end representing the lower left end of the shaft assembly contacted the safety wire conduit. This measurement indicated that the valve could rotate approximately 66 degrees before the shaft assembly contacted the conduit.

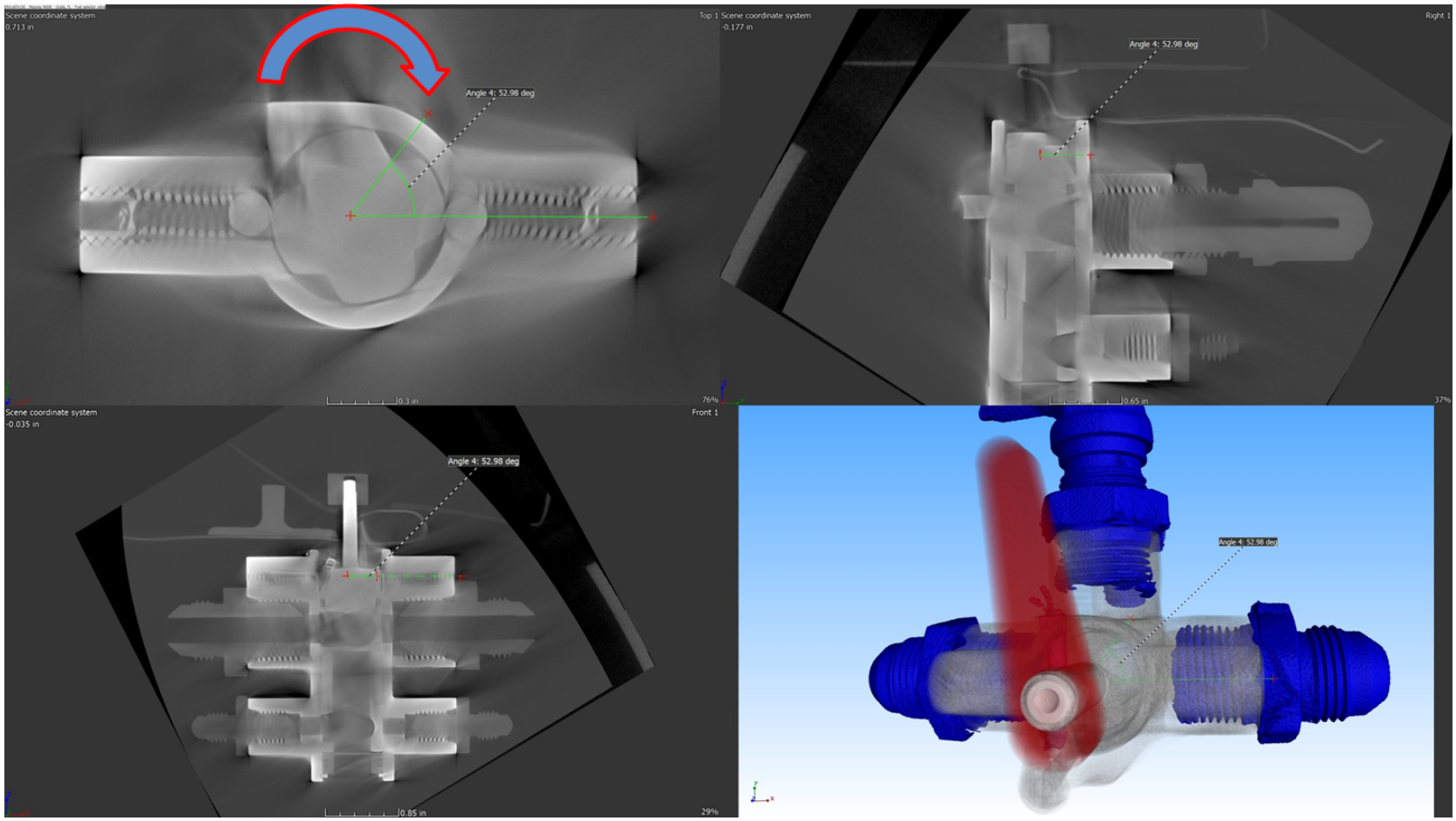

Figure 28

Fuel selector valve – standard focus – clockwise (CW) rotation required for the valve to be in the full "Right Tank" position[8]

[8] Note that after moving approximately 53 degrees CW, the valve balls would be in the detents for the full "Right Tank" position.

Scott Warren
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