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

October 28, 2015

Computed Tomography Specialist's Factual Report

ERA14FA300

A. ACCIDENT

Operator:	Synfuels Holdings Finance LLC
Location:	Huntsville International Airport-Carl T. Jones Field, Huntsville, Alabama
Date:	June 18, 2014
Time:	1424 central daylight time
Vehicle:	Israel Aircraft Industries 1124A, N793BG

B. GROUP

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

C. SUMMARY

On June 18, 2014, about 1424 central daylight time, an Israel Aircraft Industries 1124A, N793BG, crashed into a field during takeoff from Huntsville International Airport-Carl T. Jones Field, Huntsville, Alabama. The airline transport rated check pilot, airline transport rated pilot, and airline transport rated pilot-passenger were fatally injured; the airplane was destroyed by impact and a post-crash fire. The airplane was registered to and operated by SynFuels Holdings Finance LLC, under the provisions of 14 Code of Federal Regulations (CFR) Part 91 pilot proficiency flight. Visual meteorological conditions prevailed at the time and no flight plan was filed for the flight, which was originating at the time of the accident.

The internal configurations of the left and right thrust reverser actuators and the left and right thrust reverser control valves were documented using radiographic images that were collected from May 14, 2015 through July 24, 2015 in Chicago, Illinois. A total of 21,714 computed tomography (CT) slices were examined, processed, and analyzed by the NTSB to evaluate the components.

Review of the images indicated that the left thrust reverser actuator appeared to be in the extended position and the pawls appeared to be extended out over the piston sleeve; the left thrust reverser actuator switch moving contacts appeared to be in contact with the lower switch arm (i.e. the arm on the plug side of the switch); the right thrust reverser actuator was in a non-extended position and the pawls were retracted within the piston sleeve; the right thrust reverser actuator switch moving contacts appeared to be in contact with the upper switch arm (i.e. the arm on the plunger side of the switch); a difference in a piston ring end and slot configurations existed between the two pistons; a crack was noted in the right thrust reverser actuator switch housing; no indications of particles or other obstructions were noted in either the left or right thrust reverser control valve passages; the moving seals within the left and right thrust reverser control valves were both indicated to be in contact with their respective mating surfaces although in some areas, a material consistent with hydraulic fluid obscured the actual seal to surface contact area.

D. DETAILS OF THE INVESTIGATION

1.0 General

The left and right thrust reverser actuators and the left and right thrust reverser control valves were subjected to x-ray computed tomography (CT) scanning to document their internal conditions. The scanning was conducted from May 14, 2015 through July 24, 2015. The scans were performed by Varian Medical Systems, Inc under the direction of the NTSB using a combination of the Varian Actis 500/225 microfocus CT system and the Actis 500/450 standard focus CT system.

For the CT scans, each 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 fan 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 components were scanned using a total of 21,714 slices. The total size of the combined data sets was 169.74 Gb. The actuator was scanned multiple times with different scanning protocols using both the microfocus imaging system and the standard focus imaging systems. The microfocus scans provided the best possible spatial resolution, but this type of imaging was constrained to a lower power level that resulted in streaking artifacts within the images. The standard focus scans used a higher power level (with a lower spatial resolution), but these higher power levels eliminated the streak artifacts and had an inherently higher contrast resolution. Target CT imaging using the microfocus system was used for selected areas to get the highest possible resolution. 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

	Standard focus scan (left and right thrust reverser actuators)	Standard focus scan (left and right thrust reverser control valves)	Microfocus CT (right thrust reverser control valve)	Microfocus target CT (right thrust reverser control valve shaft)	Microfocus target CT (right thrust reverser actuator switches)	Microfocus target CT (left thrust reverser control valve shaft)	Microfocus target CT (left thrust reverser actuator switches)
Number of slices	Left - 546 Right - 546	Left - 344 Right - 334	1472	4301	4568	4435	5168
Voxel Size - X Direction (mm)	0.073	0.076	0.072	0.016	0.022	0.016	0.022
Voxel Size - Y Direction (mm)	0.073	0.076	0.072	0.016	0.022	0.016	0.022
Voxel Size - Z Direction (mm)	0.40	0.40	0.085	0.03	0.03	0.03	0.03
Image Projections per Revolution	1440	1440	2520	1440	1800	1440	1800
Exposure time (ms)	32	32	285.58	285.58	285.58	285.58	285.58
Frames to Avg (frames per projection)	2	2	2	2	2	2	2
X-ray Source Voltage (kV)	450	450	221	221	221	221	221
X-ray Source Current (mA)	2	2	0.490	0.490	0.490	0.490	0.490
Source Filter Material	Brass	Brass	Brass	Brass	Brass	Brass	Brass
Source Filter Thickness (mm)	2	2	1	1	1	1	0.5
Image Matrix Size (pixels)	2048 x 2048	2048 x 2048	2048 x 2048	2048 x 2048	2048 x 2048	2048 x 2048	2048 x 2048

Each data set of slice images was examined, processed, and analyzed by the NTSB using the VGStudioMax software package to create 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 actuator 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 thrust reverser actuators and control valves are shown in figures 1 through 39. Review of the images indicated:

1. The left thrust reverser actuator appeared to be in the extended position and the pawls appeared to be extended out over the piston sleeve;

2. The left thrust reverser actuator switch moving contacts appeared to be in contact with the lower switch arm (i.e. the arm on the plug side of the switch);

3. The right thrust reverser actuator was in a non-extended position and the pawls were retracted within the piston sleeve;

4. The right thrust reverser actuator switch moving contacts appeared to be in contact with the upper switch arm (i.e. the arm on the plunger side of the switch);

5. A difference in a piston ring end and slot configurations existed between the pistons of the left and right thrust reverser actuators. In the right thrust reverser actuator, the ring end was contained within the slot. In the left thrust reverser actuator, the ring end was not contained within the slot;

6. A crack was noted in the right thrust reverser actuator switch housing;

7. No indications of particles or other obstructions were noted in either the left or right thrust reverser control valve passages;

8. The moving seals within the left and right thrust reverser control valves were both indicated to be in contact with their respective mating surfaces. In some areas, a material consistent with hydraulic fluid obscured the actual seal to surface contact area.

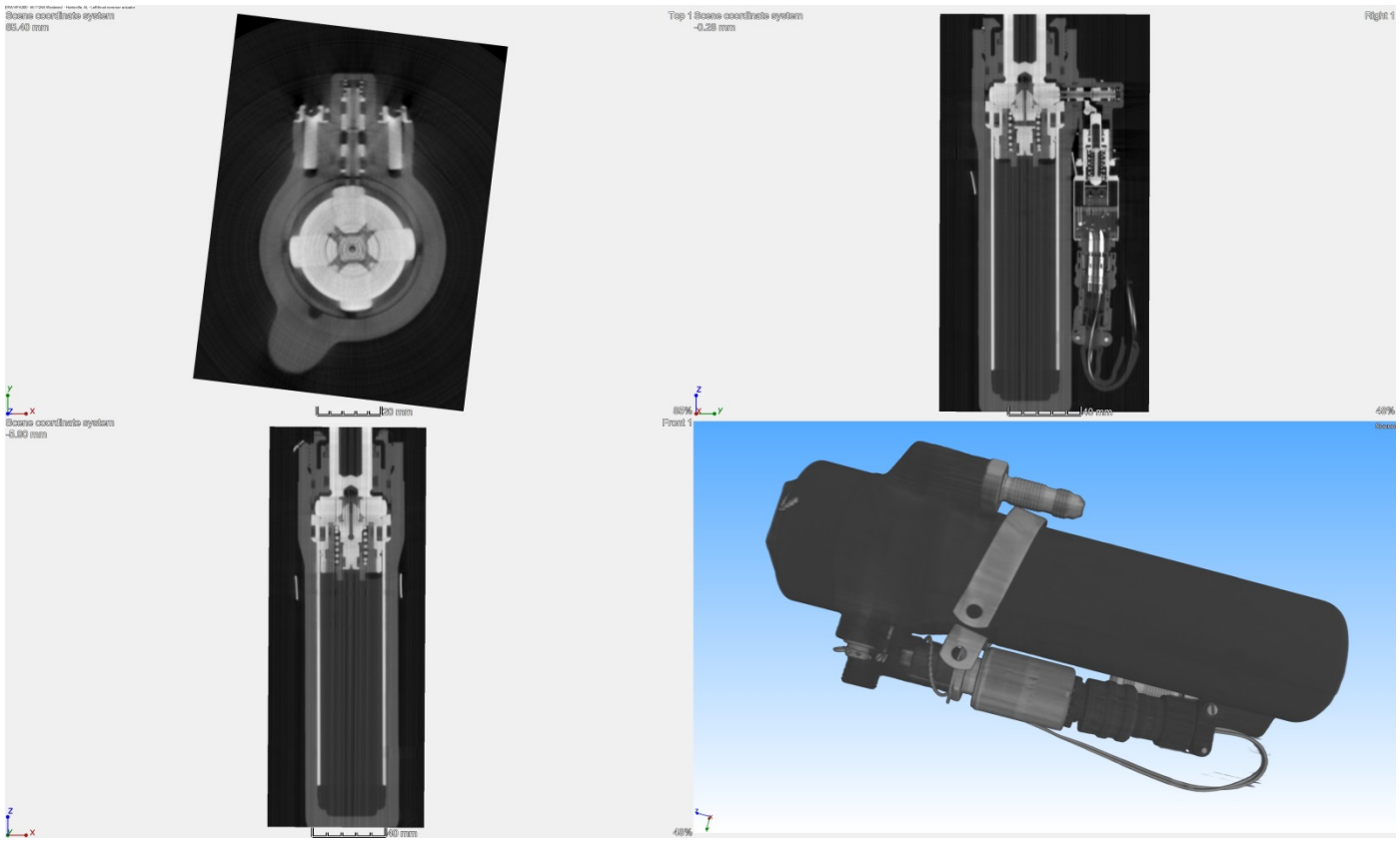

Figure 1
Left thrust reverser actuator – standard focus – overall cross section

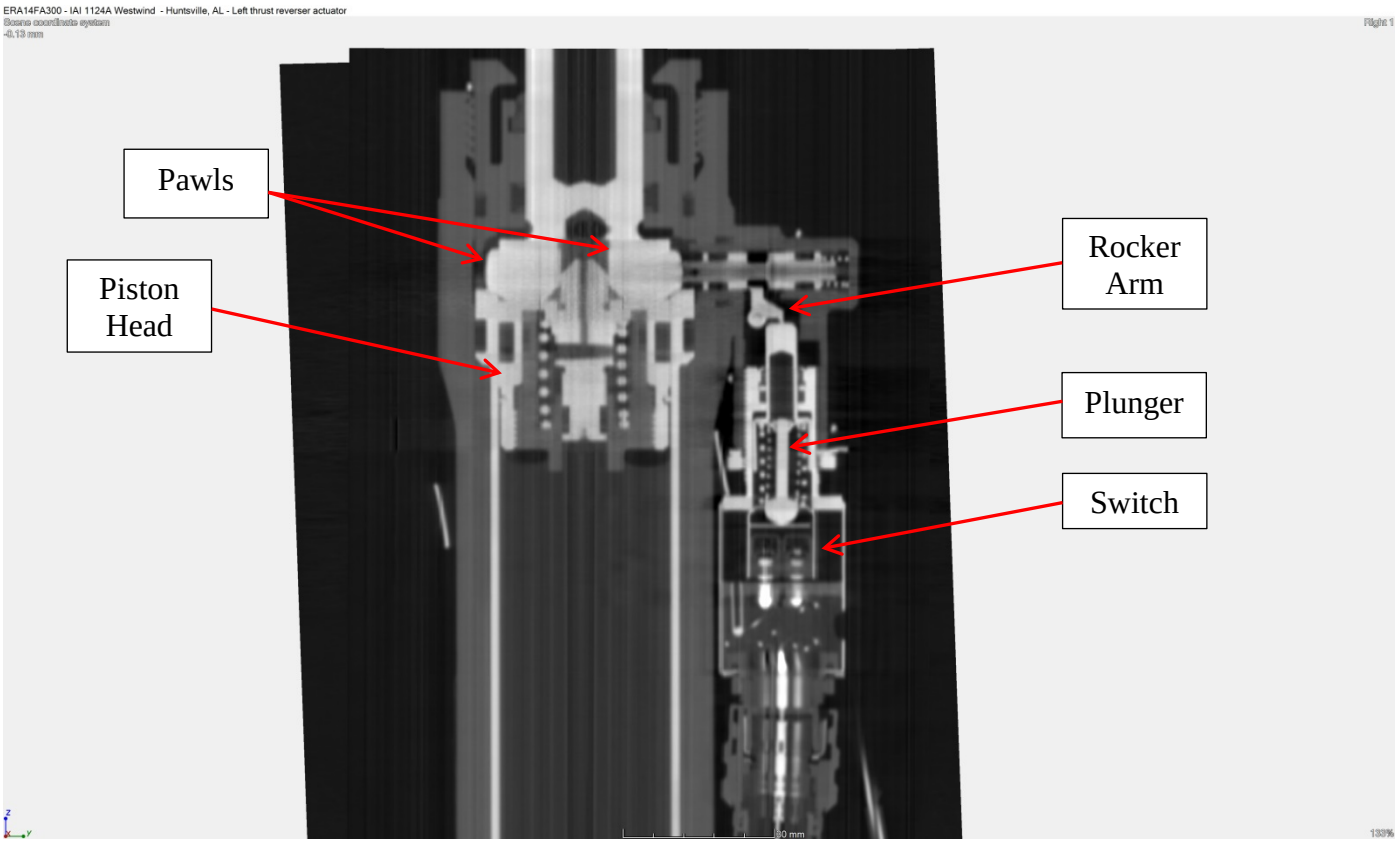

Figure 2
Left thrust reverser actuator – standard focus – cross section through switch plunger

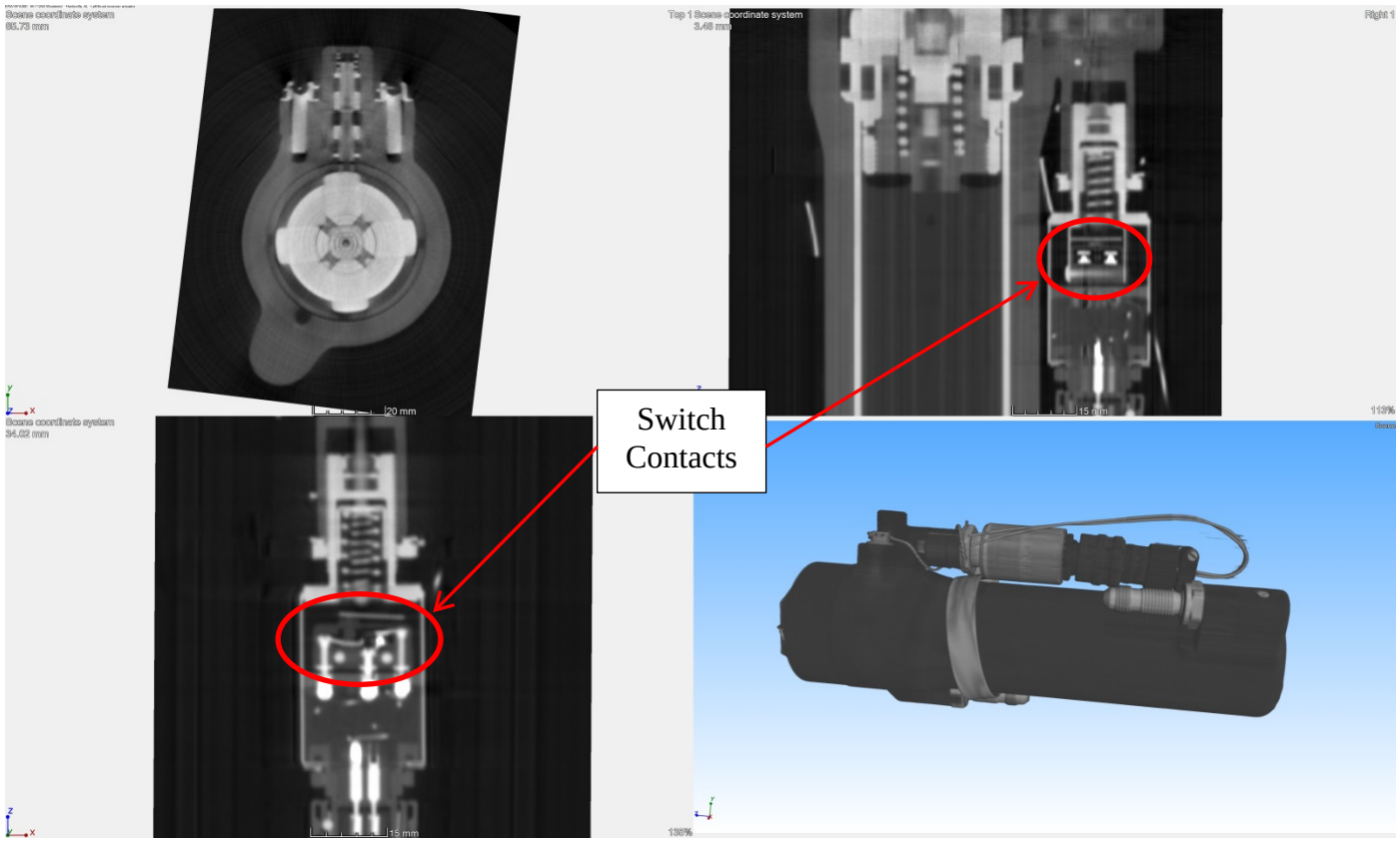

Figure 3
Left thrust reverser actuator – standard focus – switch contacts

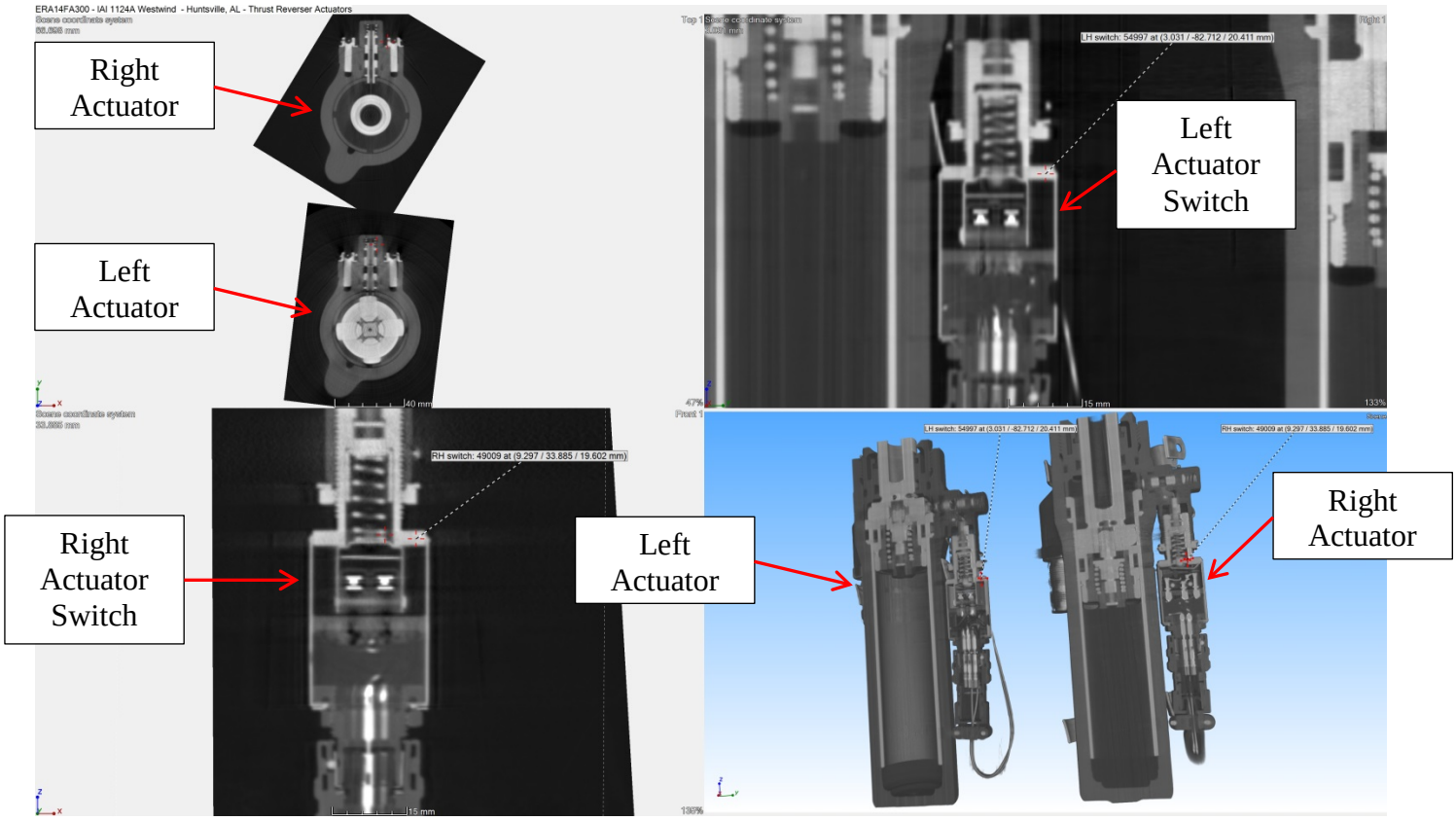

Figure 4
Left and right thrust reverser actuators – standard focus – switch contacts

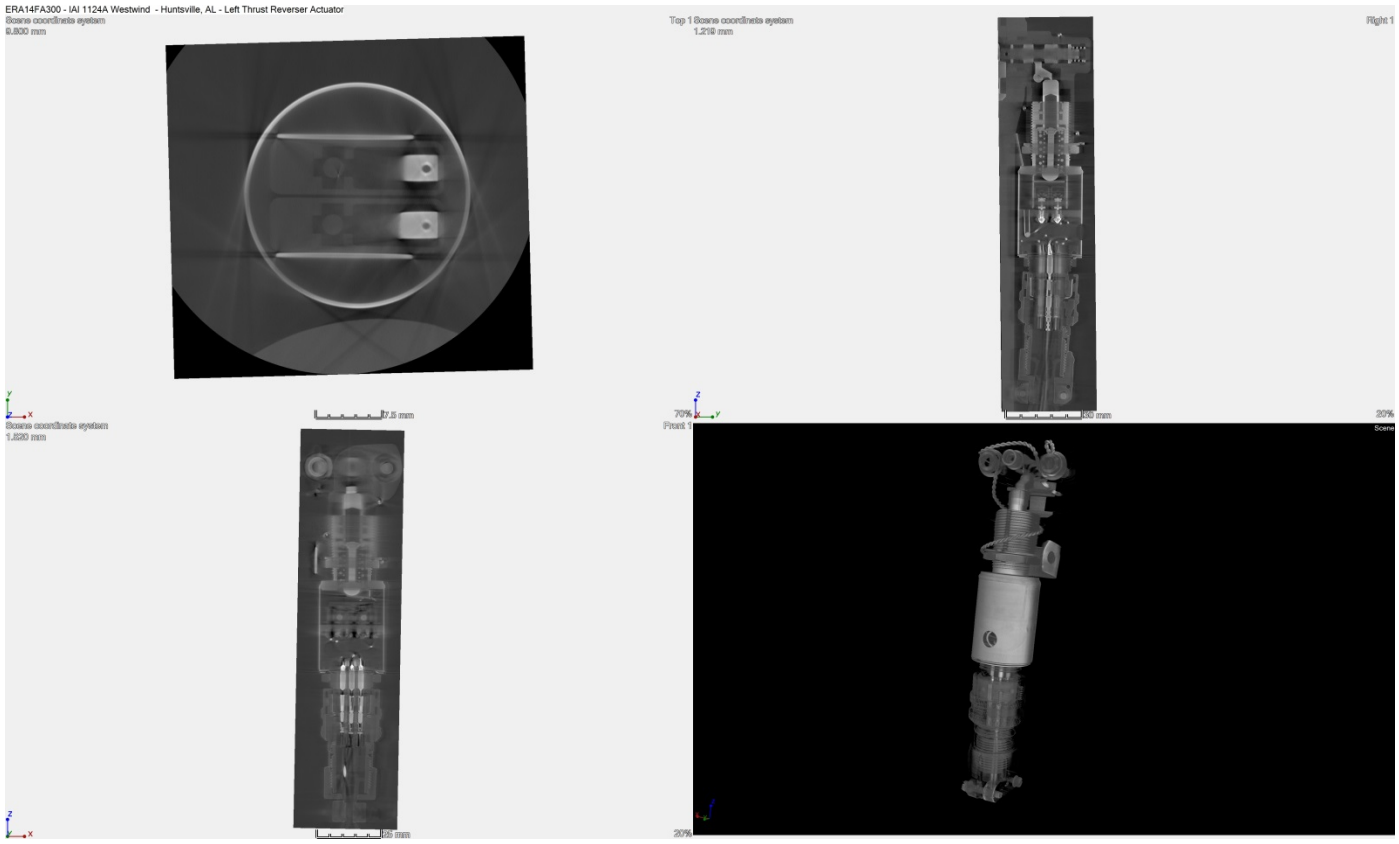

Figure 5
Left thrust reverser actuator – target CT – switch module overall cross section

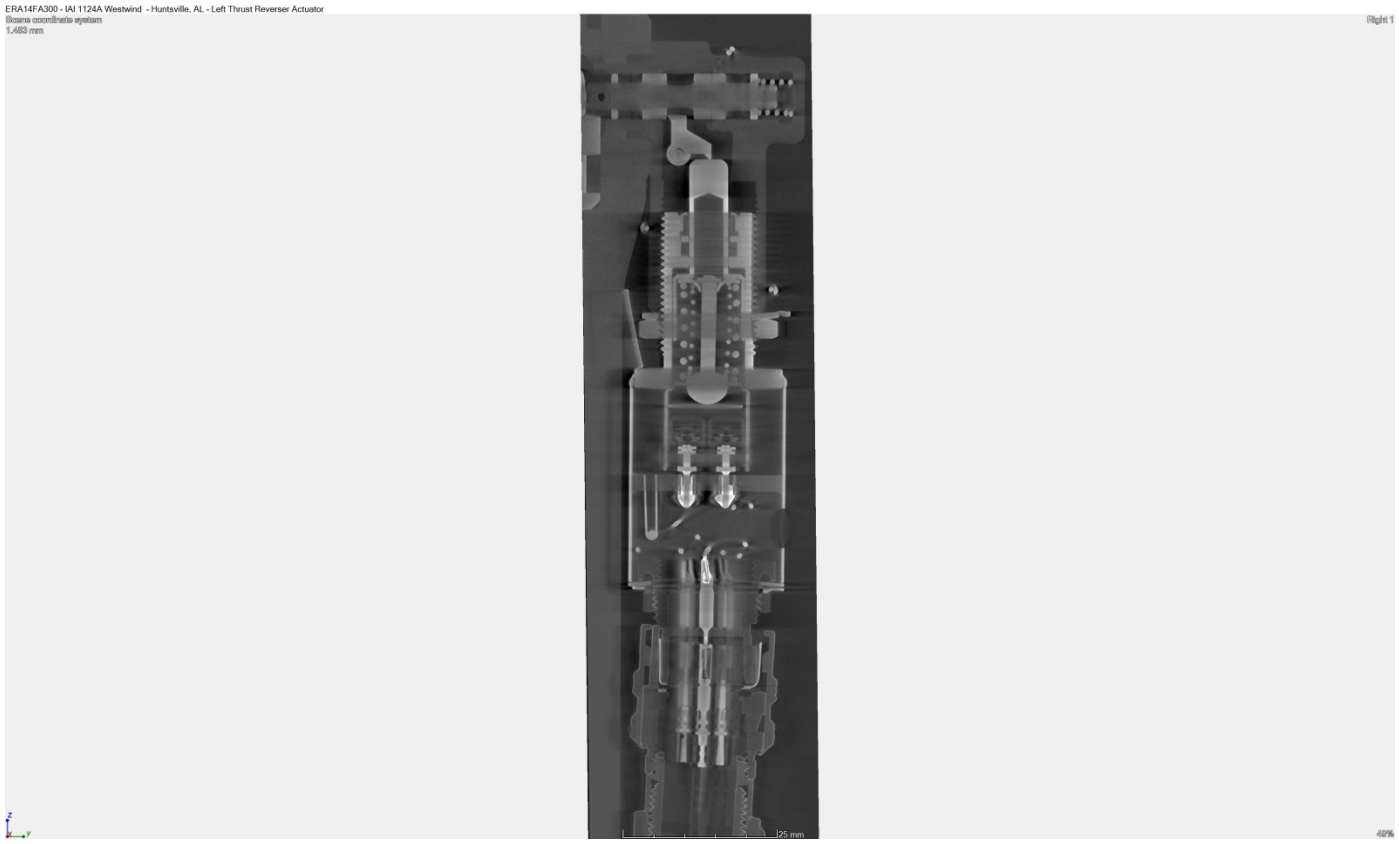

Figure 6
Left thrust reverser actuator – target CT – switch module overall cross section close up

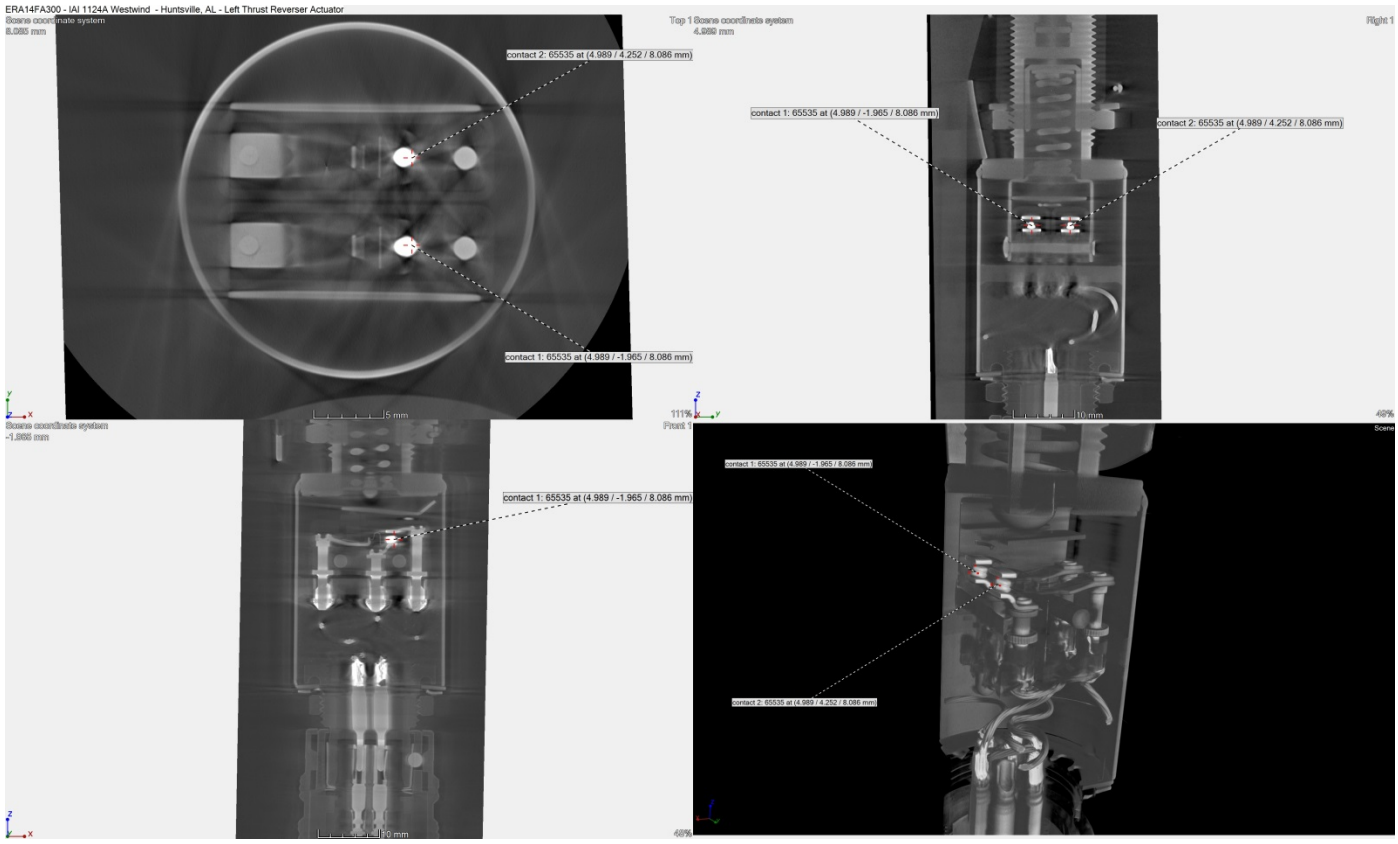

Figure 7
Left thrust reverser actuator – target CT – switch contact 1

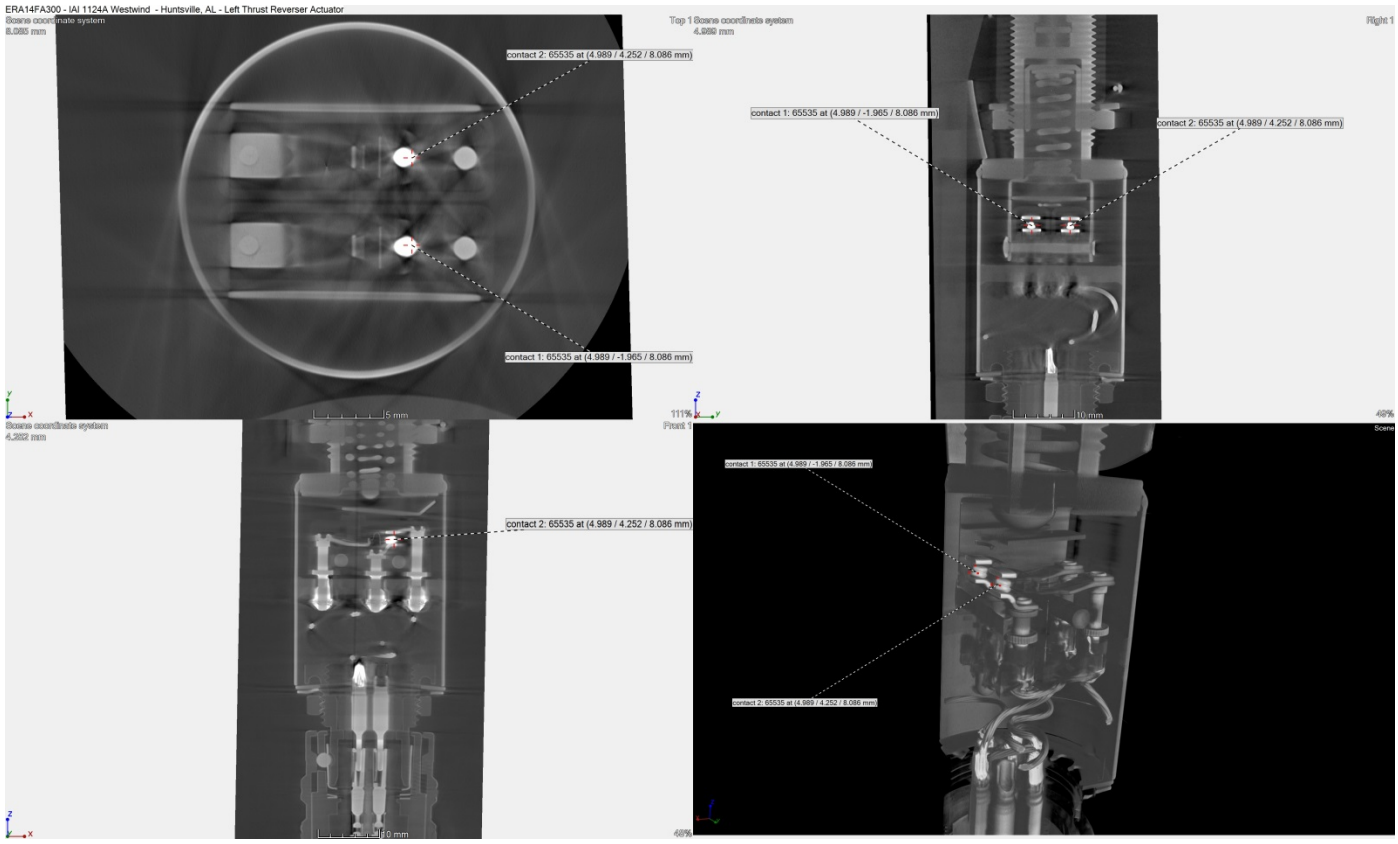

Figure 8
Left thrust reverser actuator – target CT – switch contact 2

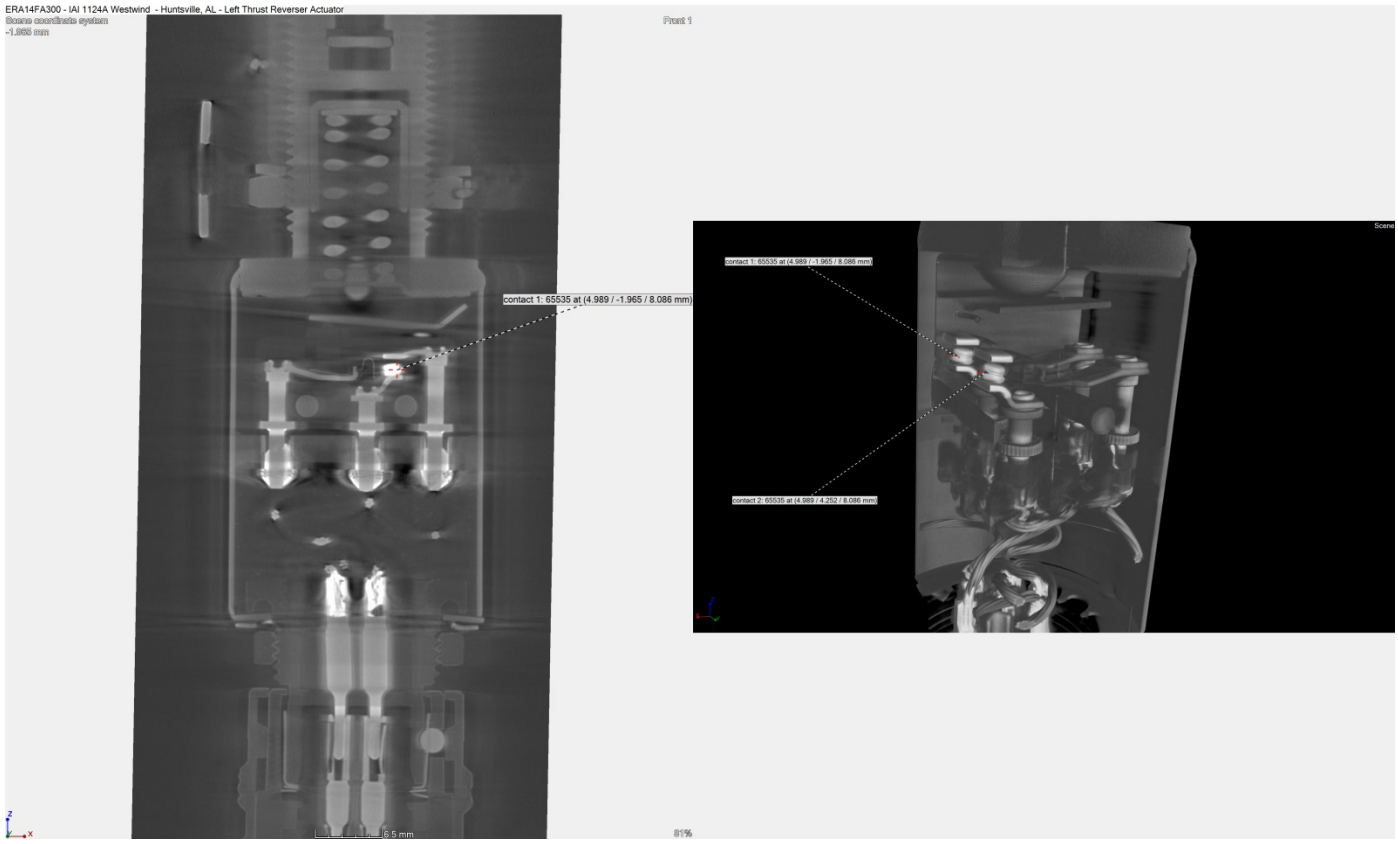

Figure 9
Left thrust reverser actuator – target CT – switch contact 1 close up

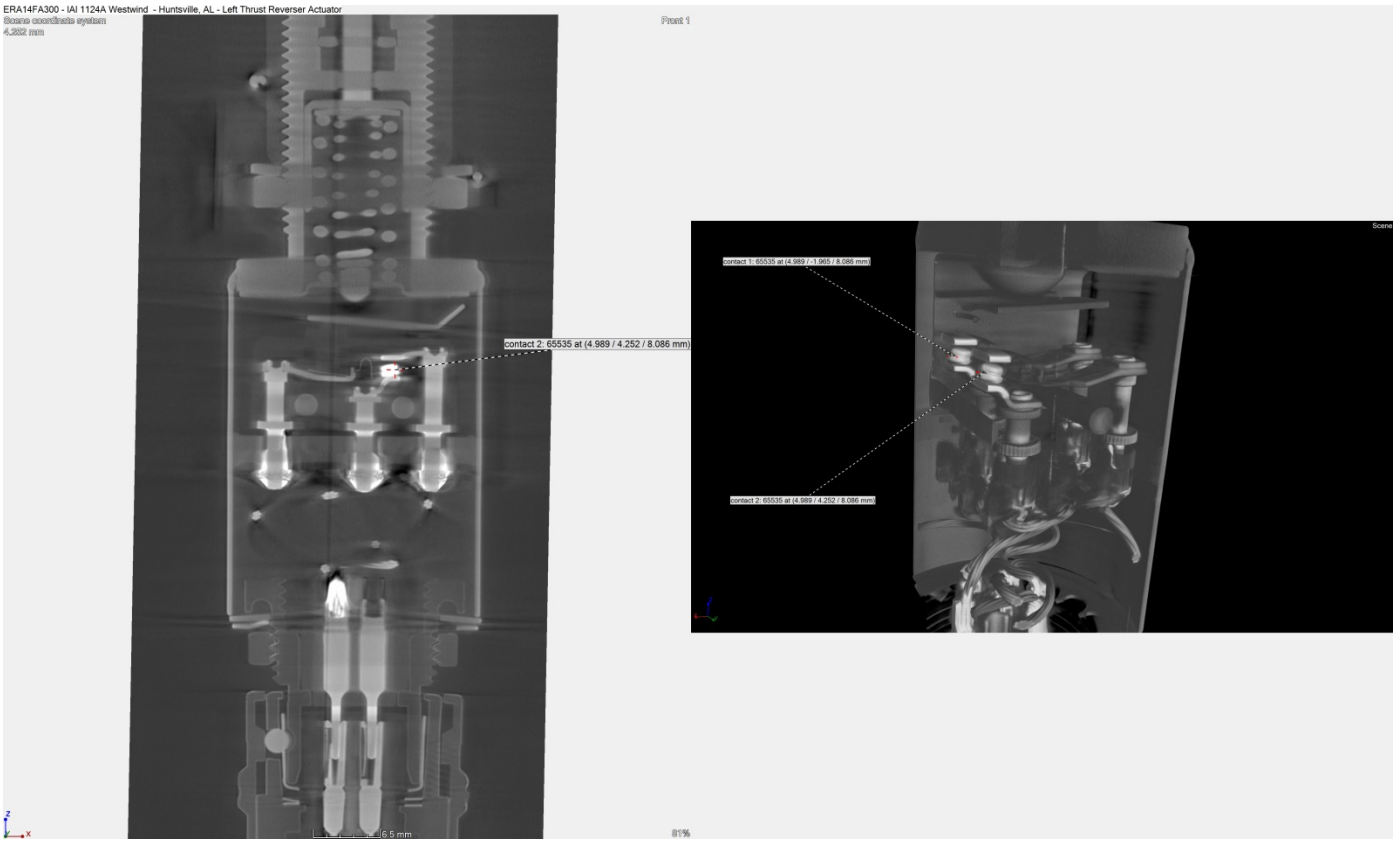

Figure 10
Left thrust reverser actuator – target CT – switch contact 2 close up

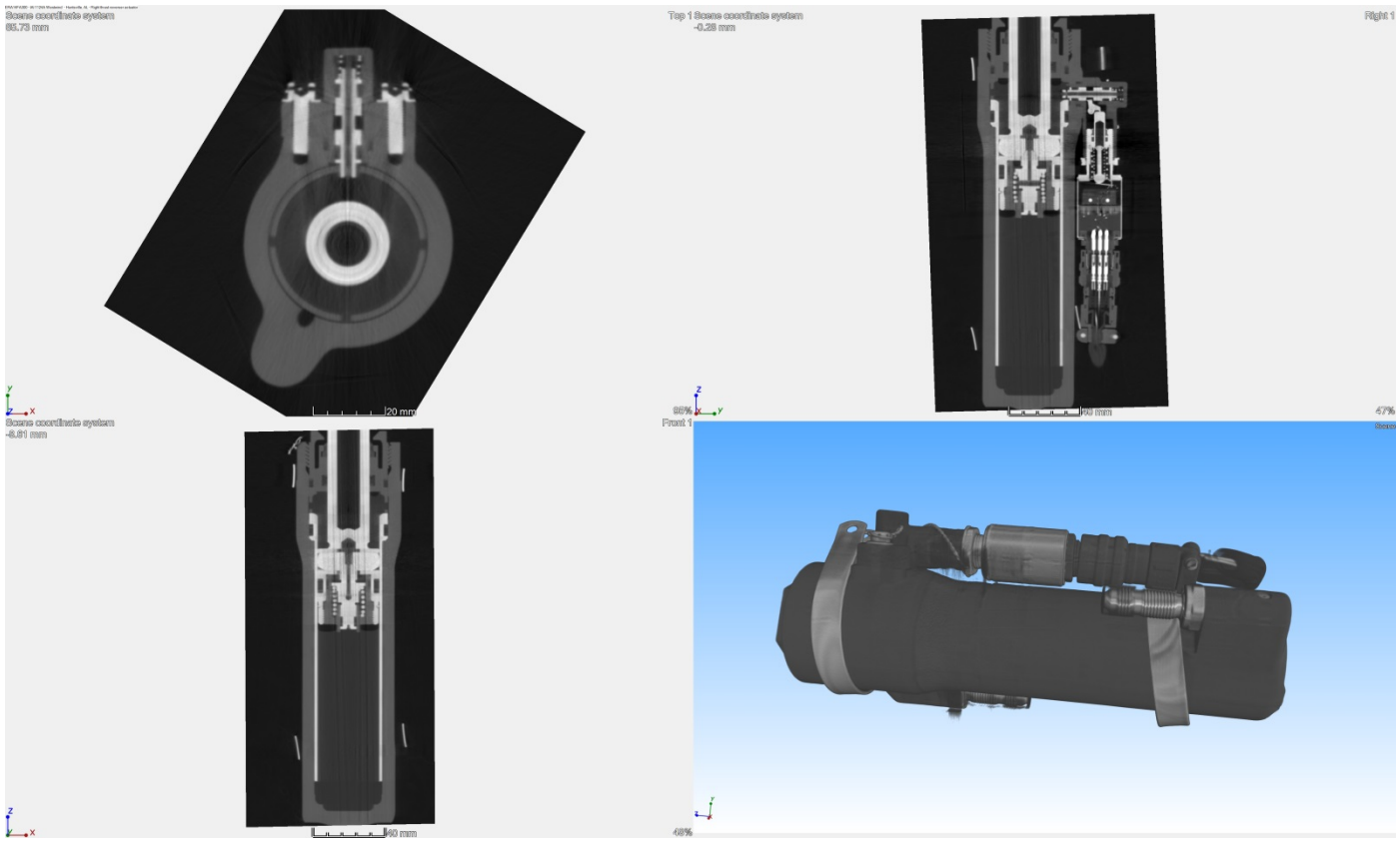

Figure 11
Right thrust reverser actuator – standard focus – overall cross section

Figure 12
Right thrust reverser actuator – standard focus – overall cross section through switch plunger

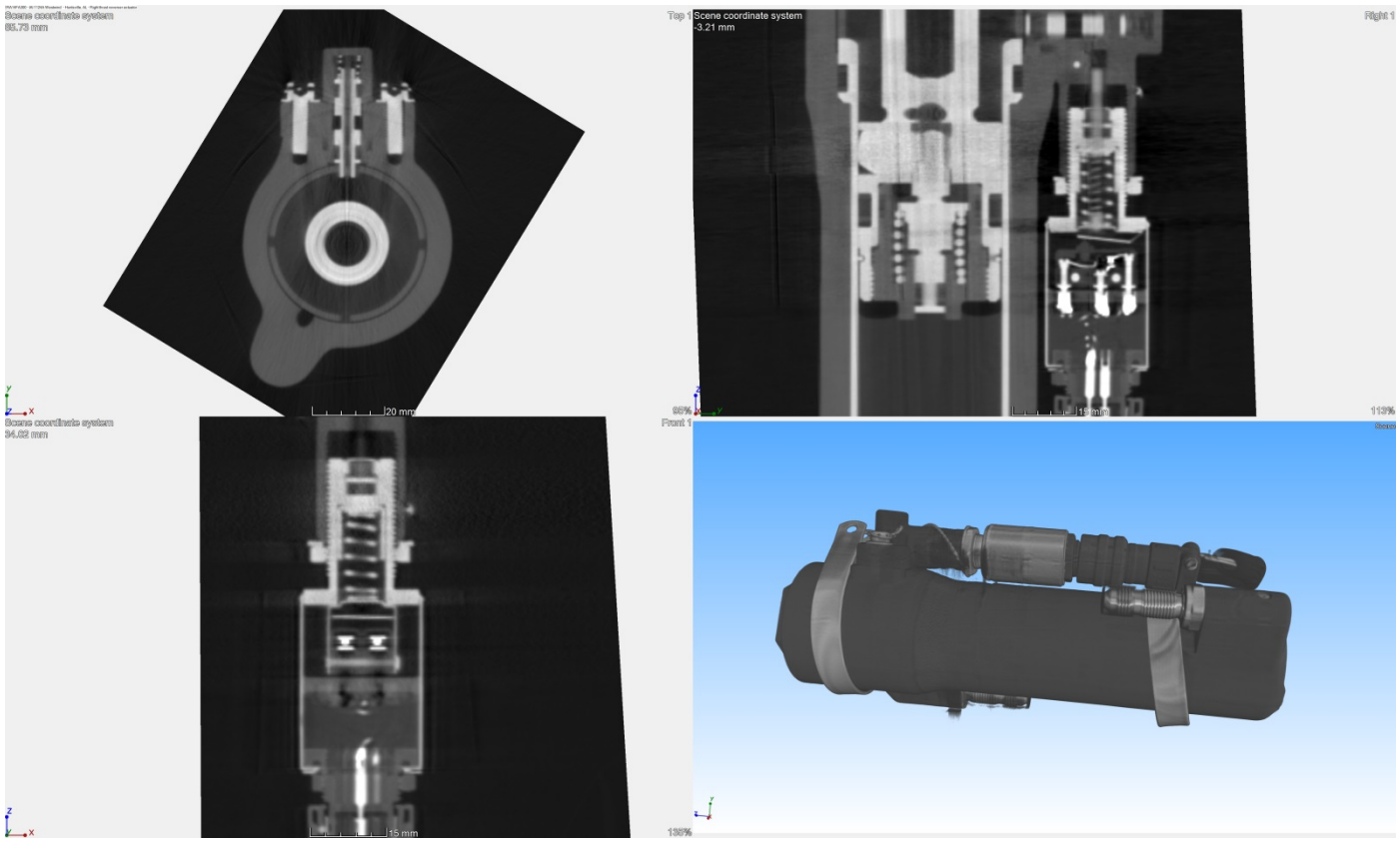

Figure 13
Right thrust reverser actuator – standard focus – switch contacts

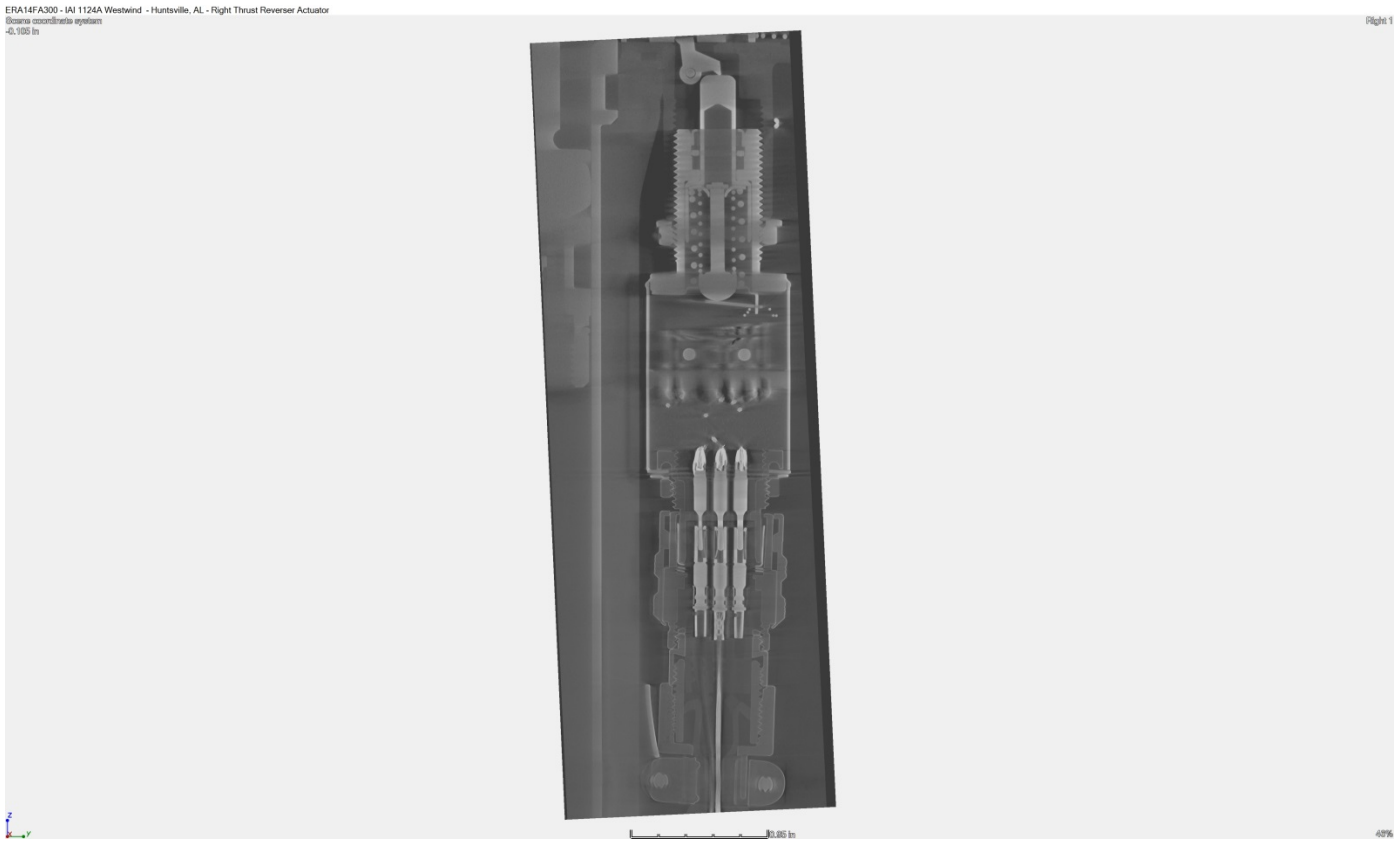

Figure 14
Right thrust reverser actuator – target CT – switch module overall cross section

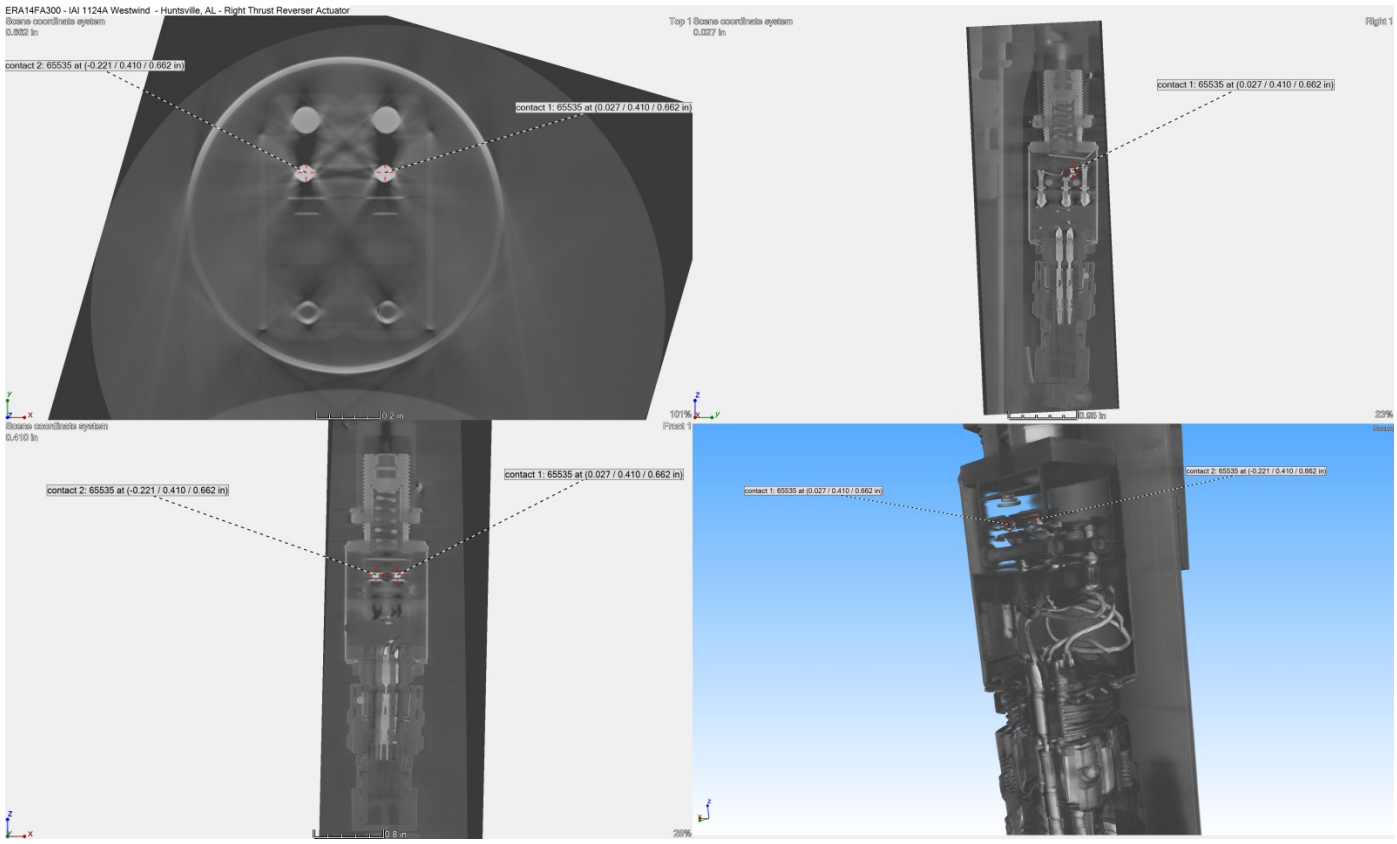

Figure 15
Right thrust reverser actuator – target CT – switch contact 1

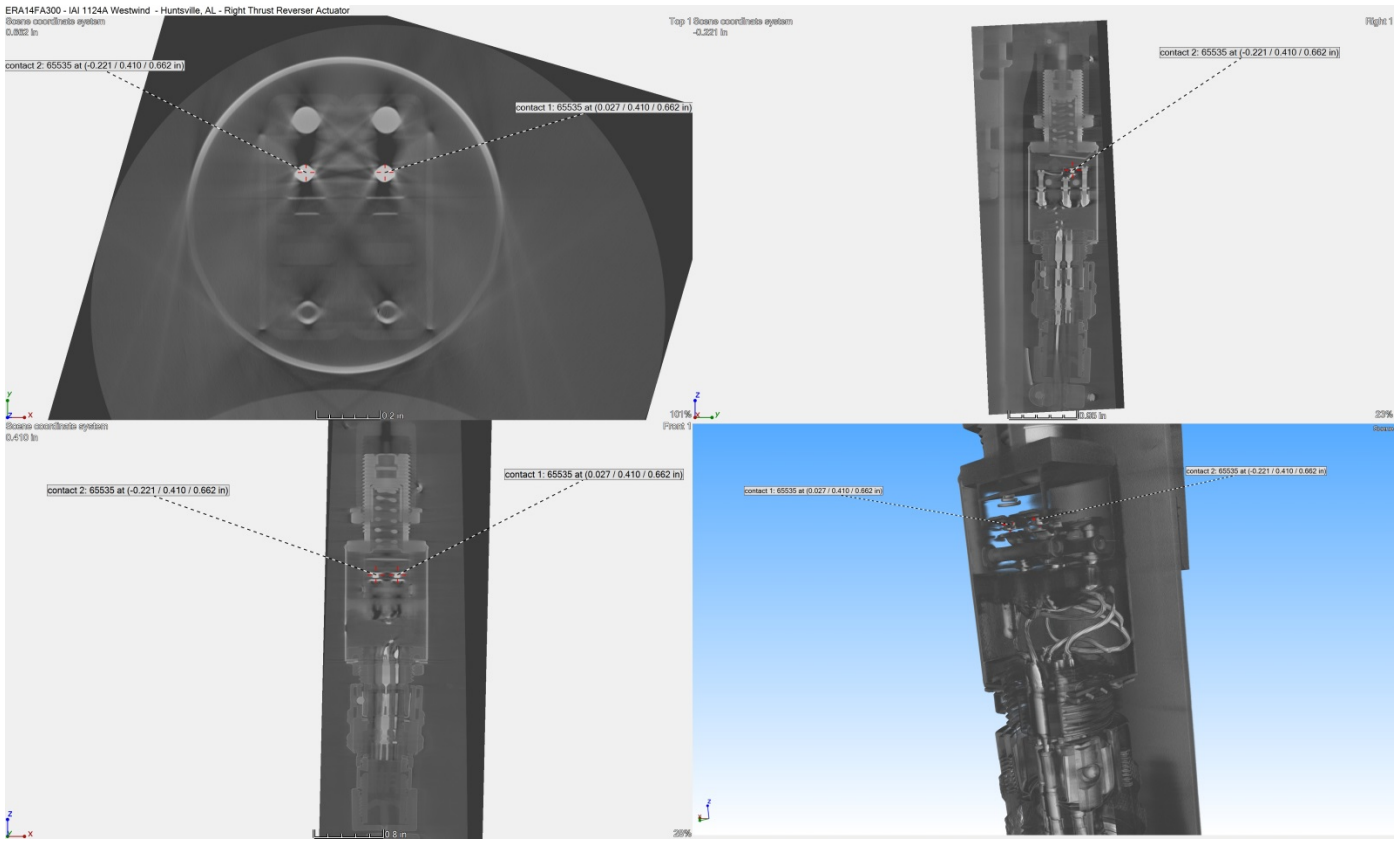

Figure 16
Right thrust reverser actuator – target CT – switch contact 2

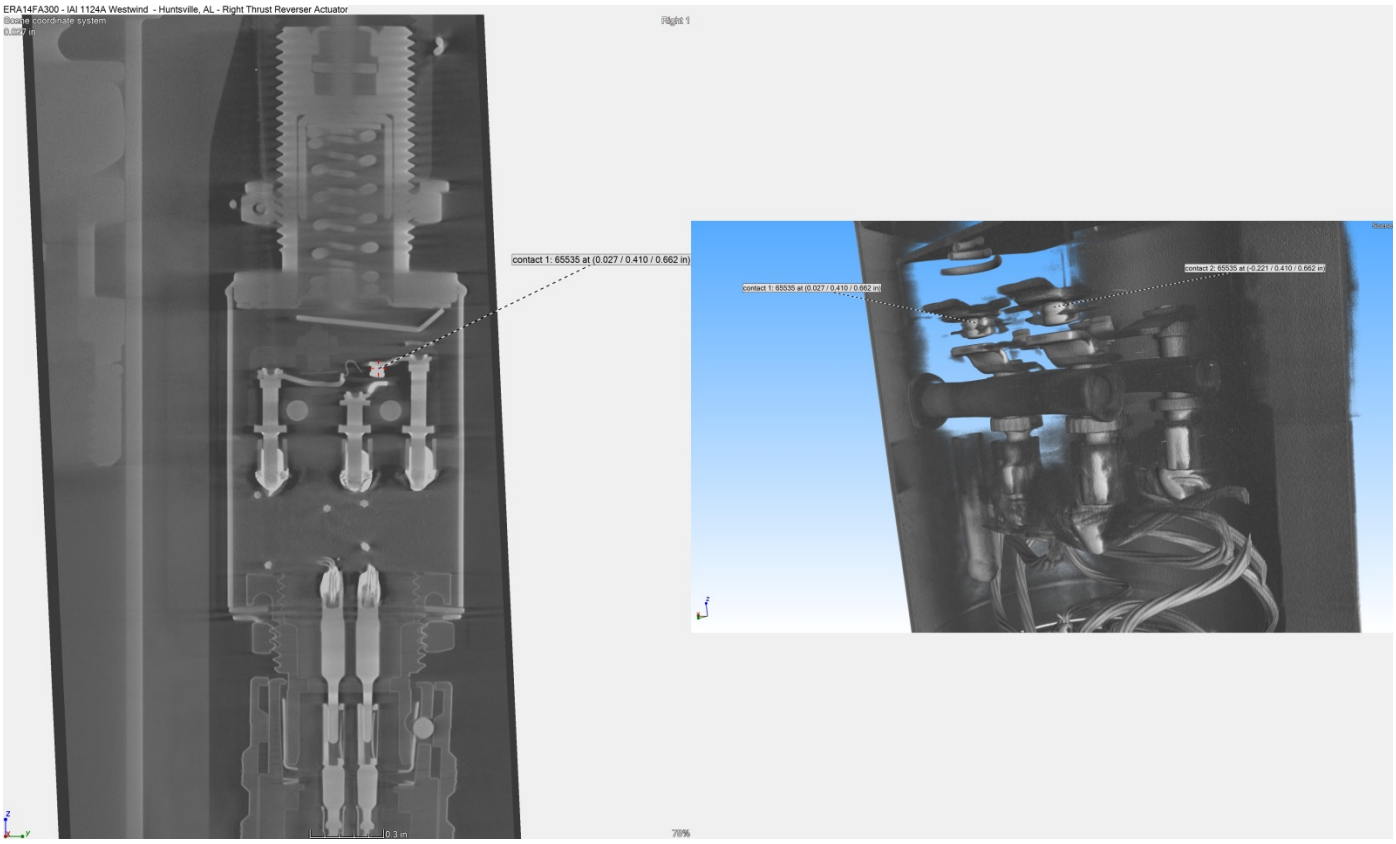

Figure 17
Right thrust reverser actuator – target CT – switch contact 1 close up

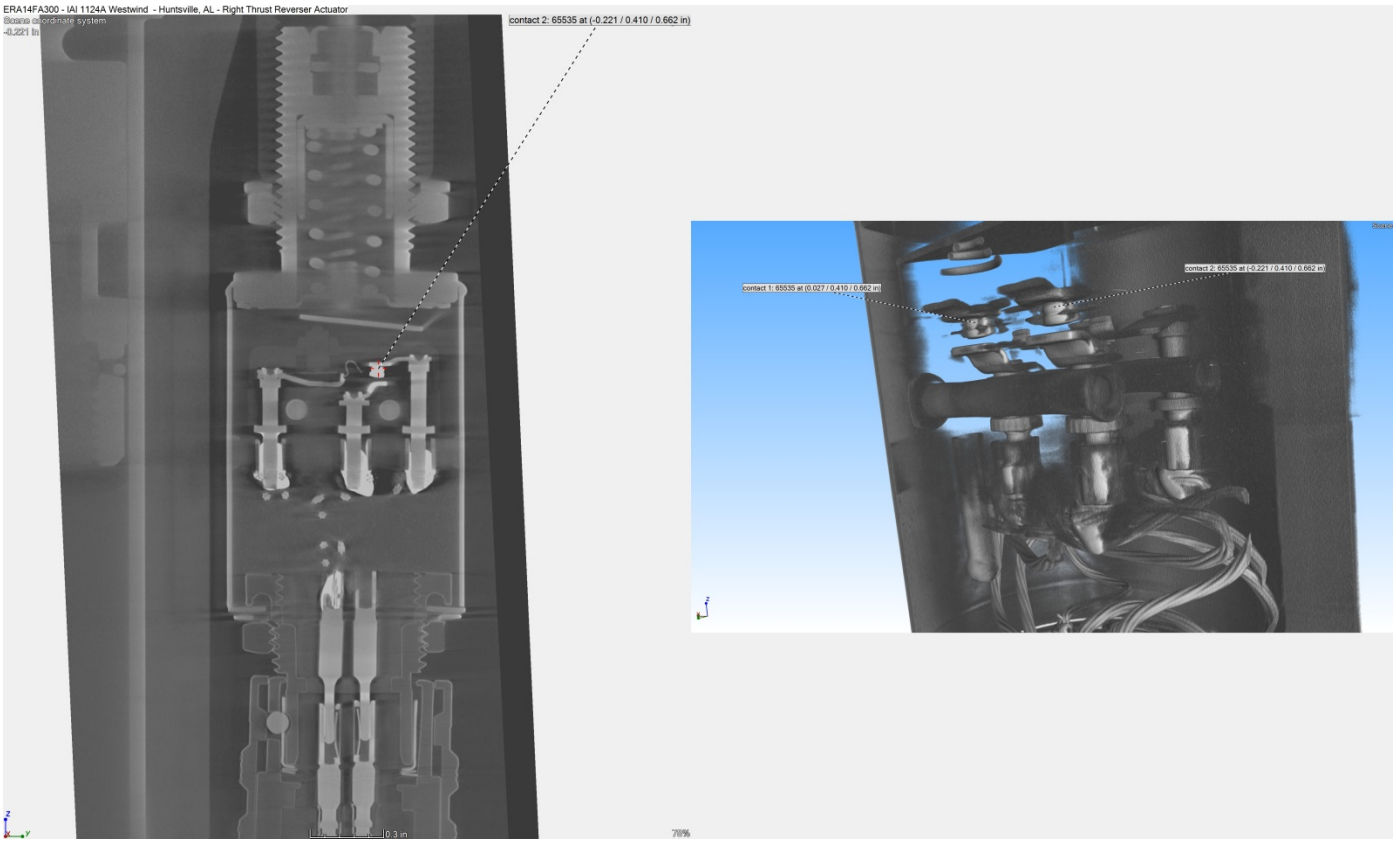

Figure 18
Right thrust reverser actuator – target CT – switch contact 2 close up

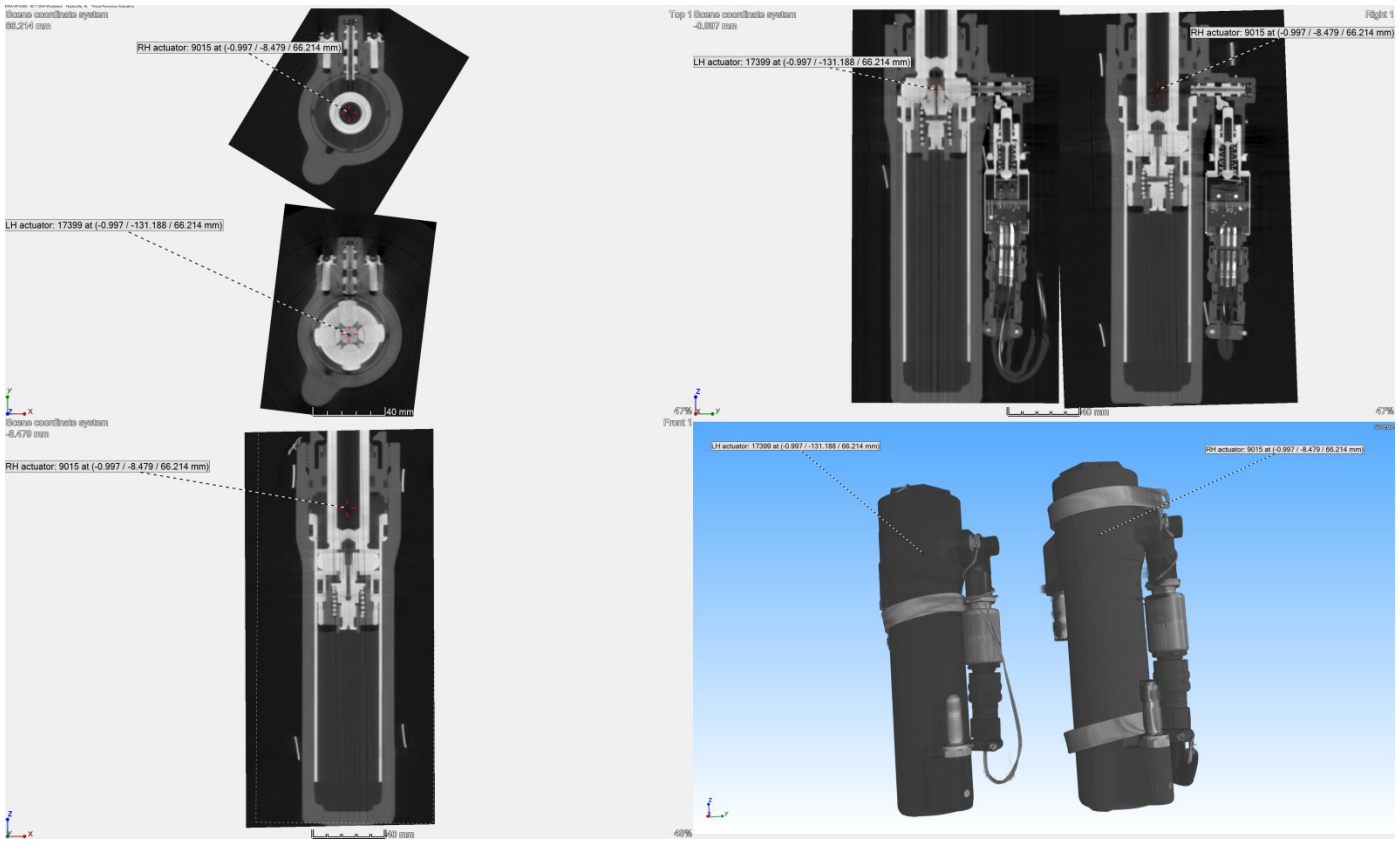

Figure 19
Left and right thrust reverser actuators – standard focus – overall cross section

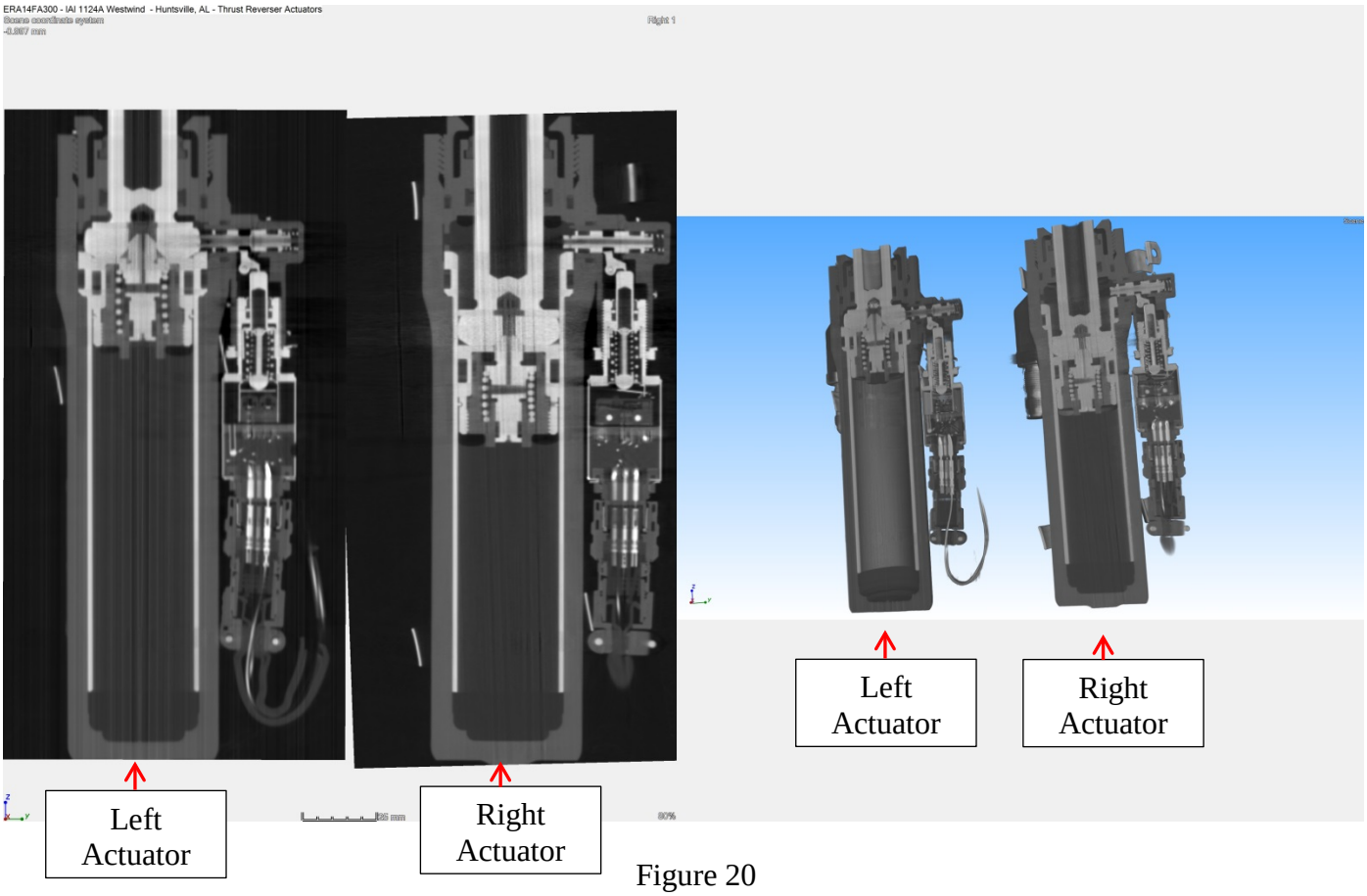

Figure 20

Left and right thrust reverser actuators – standard focus – overall cross section close up view

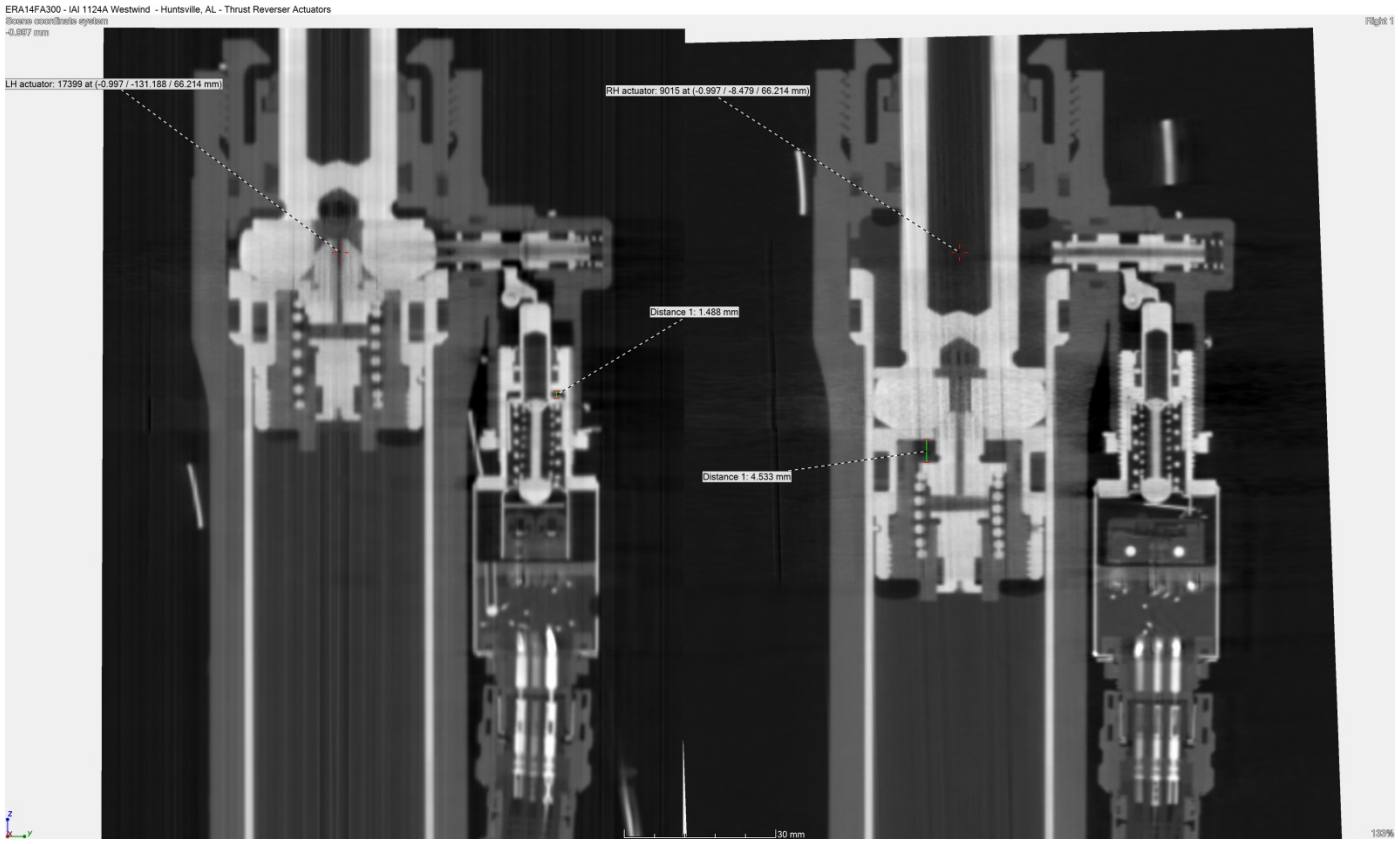

Figure 21
Left and right thrust reverser actuators – standard focus – close up view of piston interior with measurements

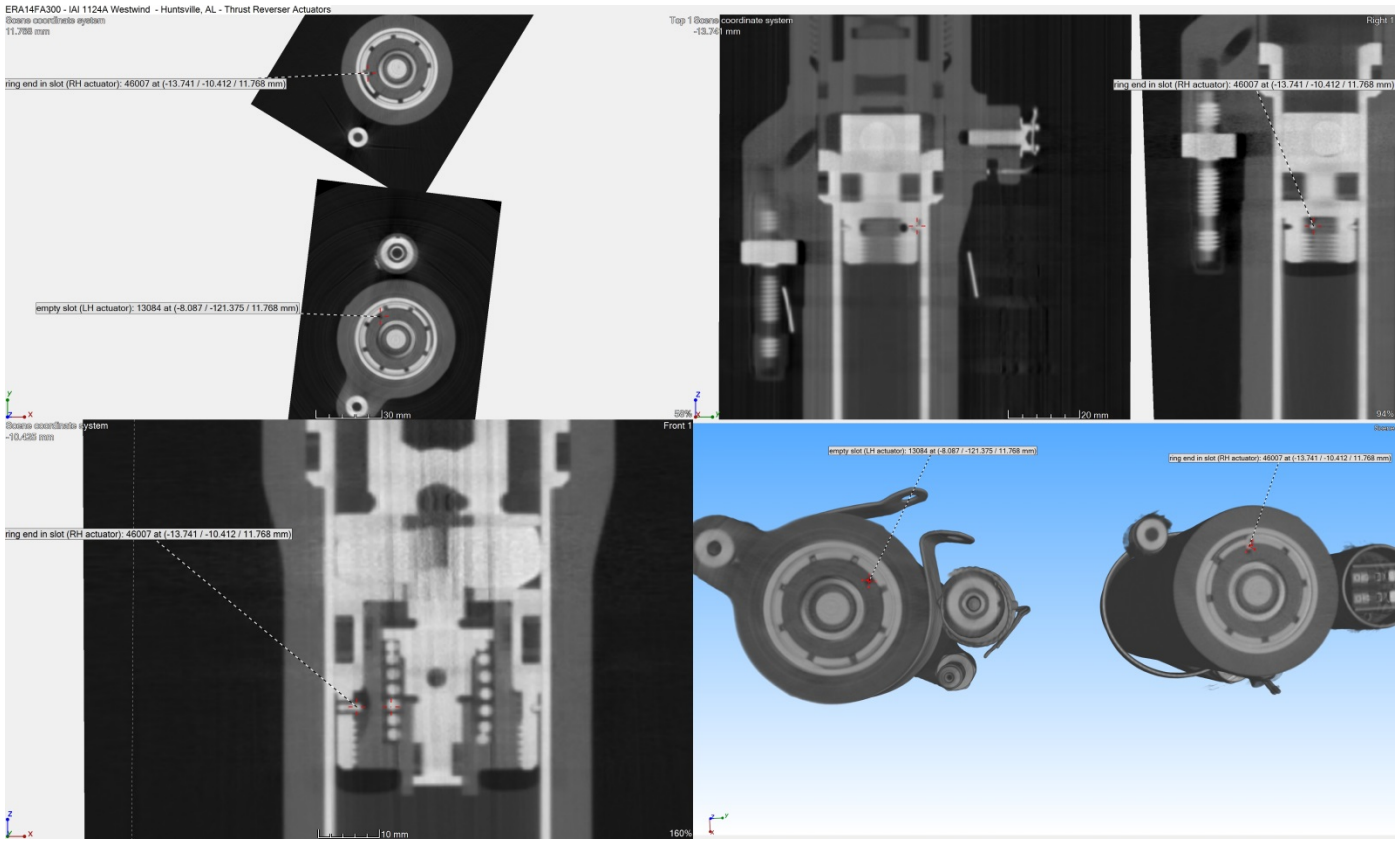

Figure 22
Left and right thrust reverser actuators – standard focus – ring end and slot comparisons

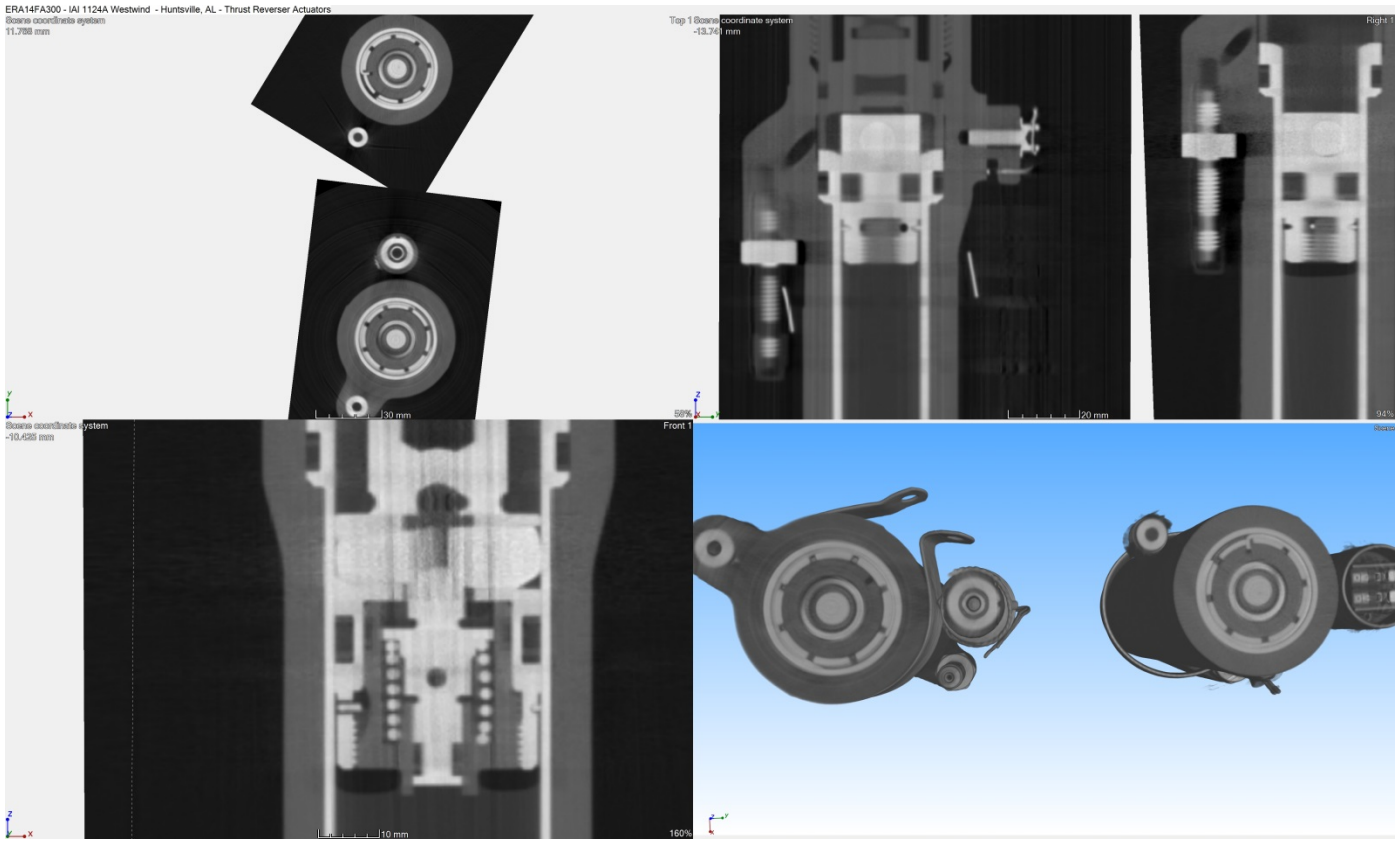

Figure 23

Left and right thrust reverser actuators – standard focus – ring end and slot comparisons – no indicators

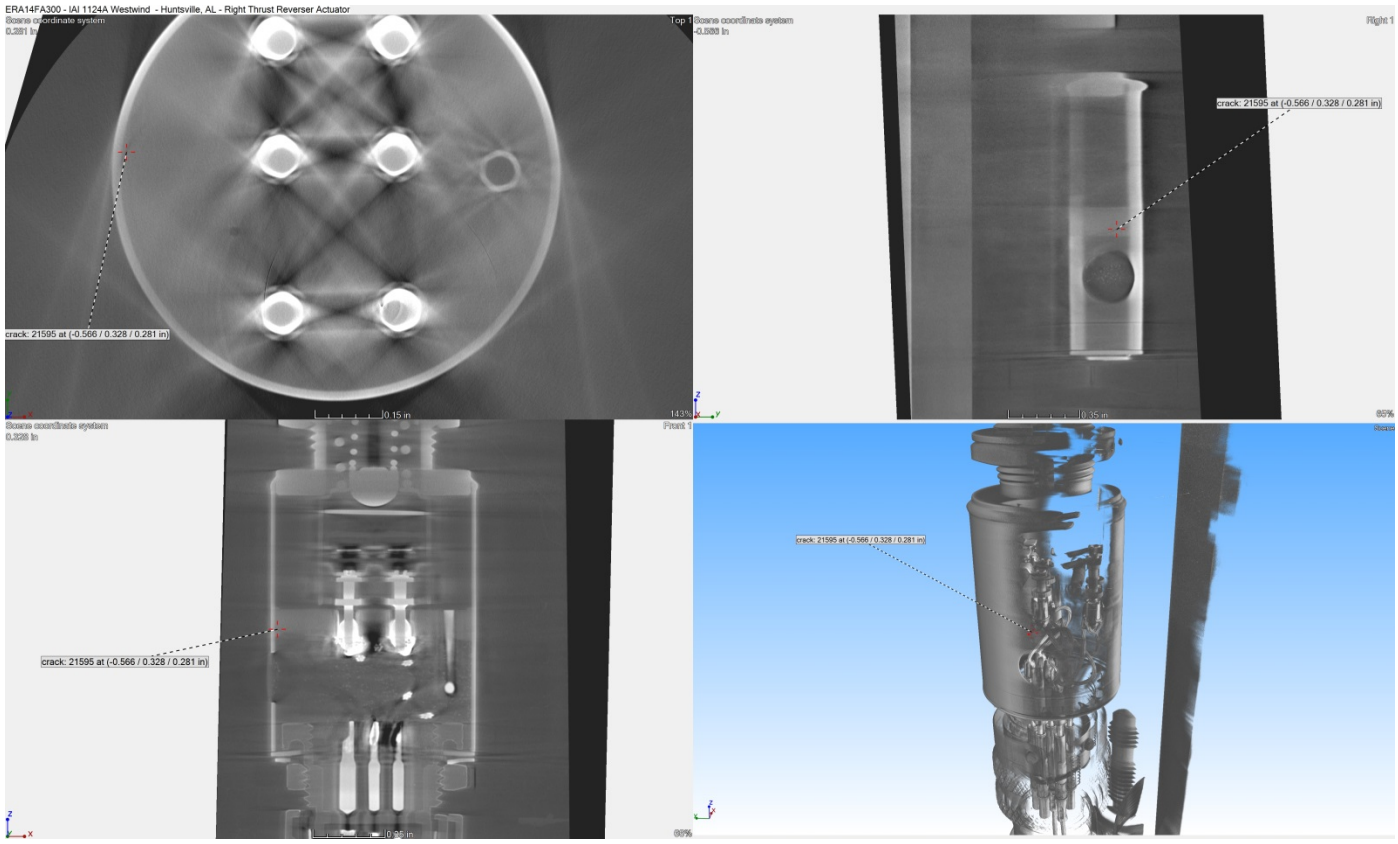

Figure 24
Right thrust reverser actuator – target CT – crack in switch housing

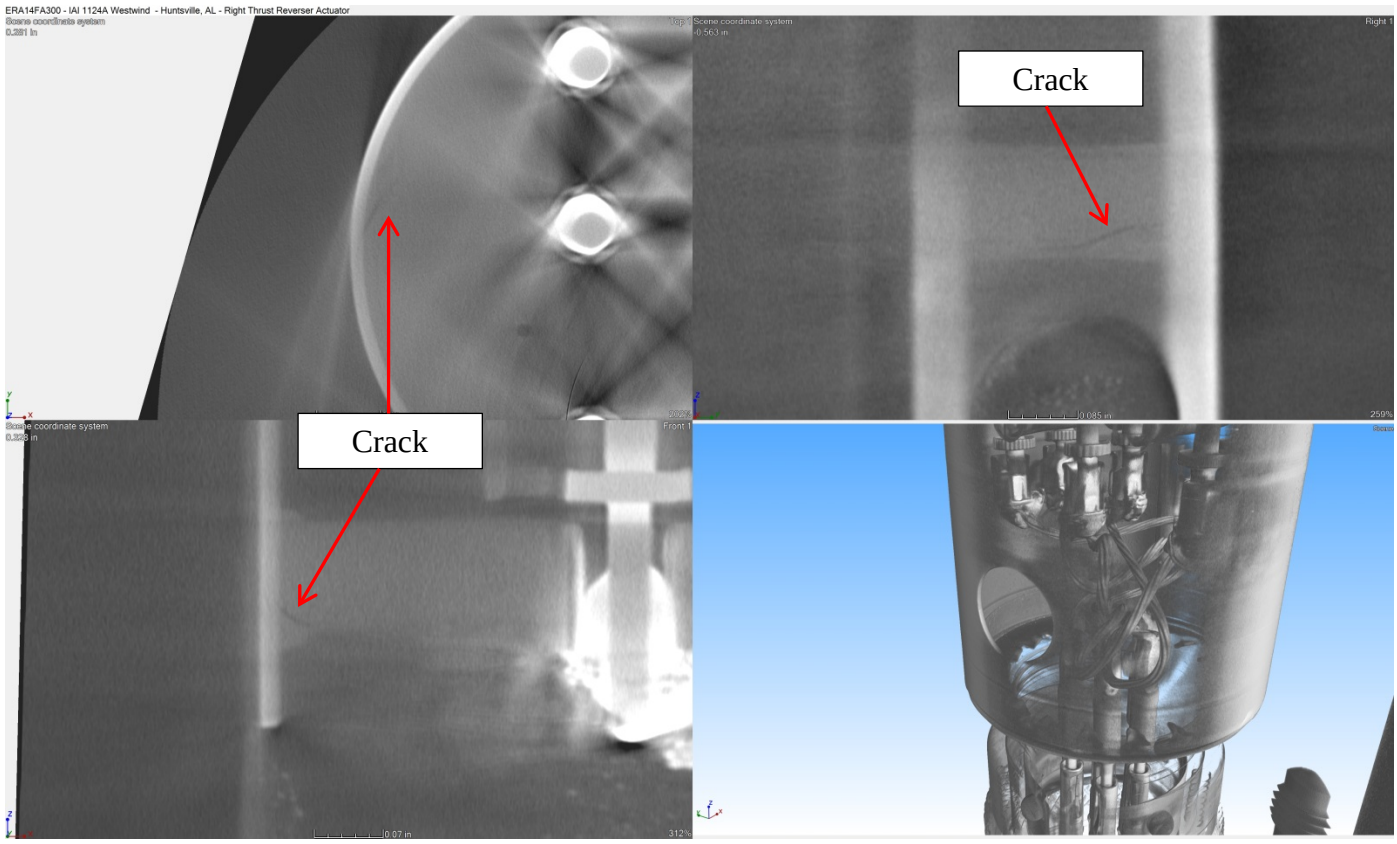

Figure 25
Right thrust reverser actuator – target CT – crack in switch housing close up view

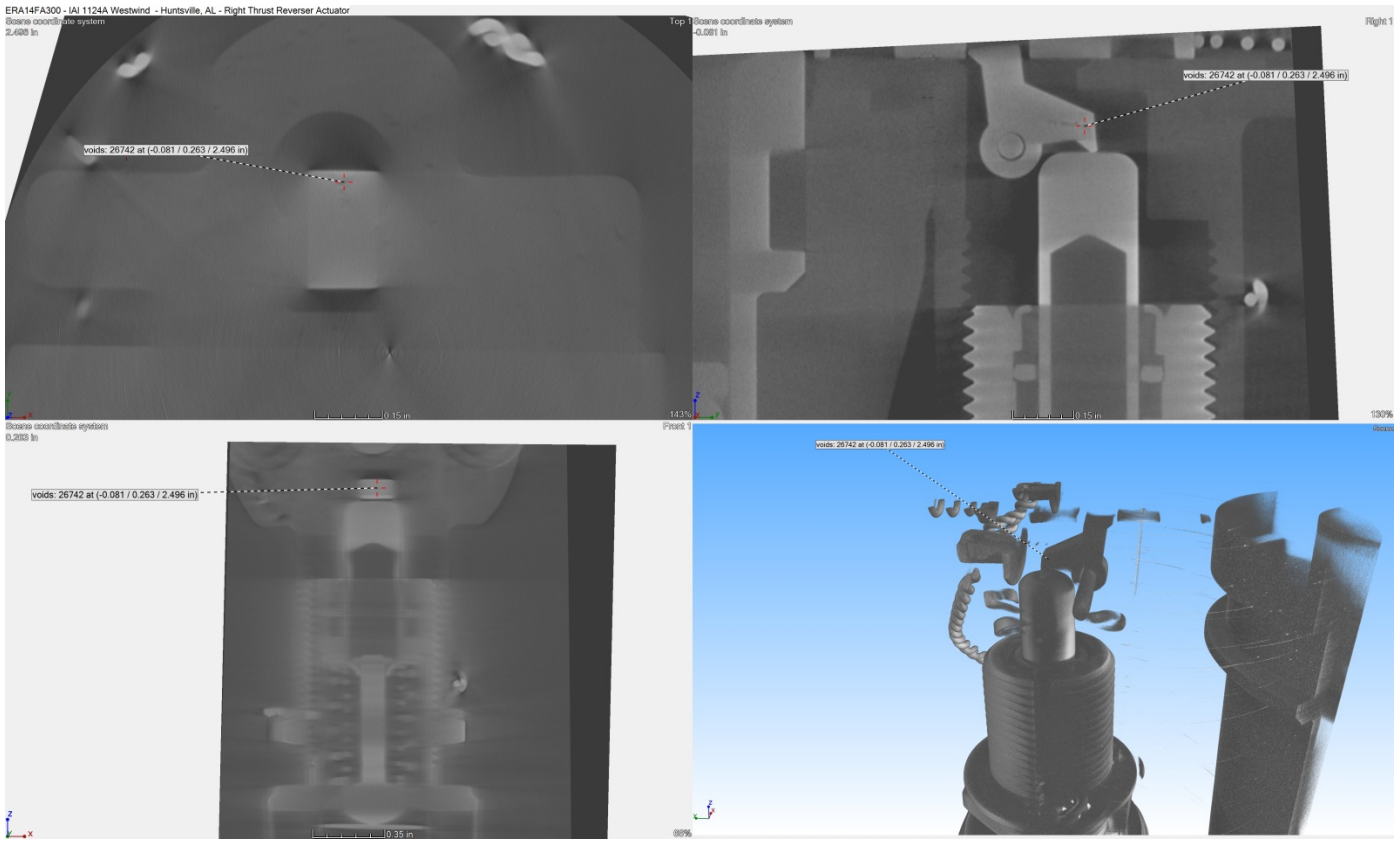

Figure 26
Right thrust reverser actuator – target CT – voids in rocker arm

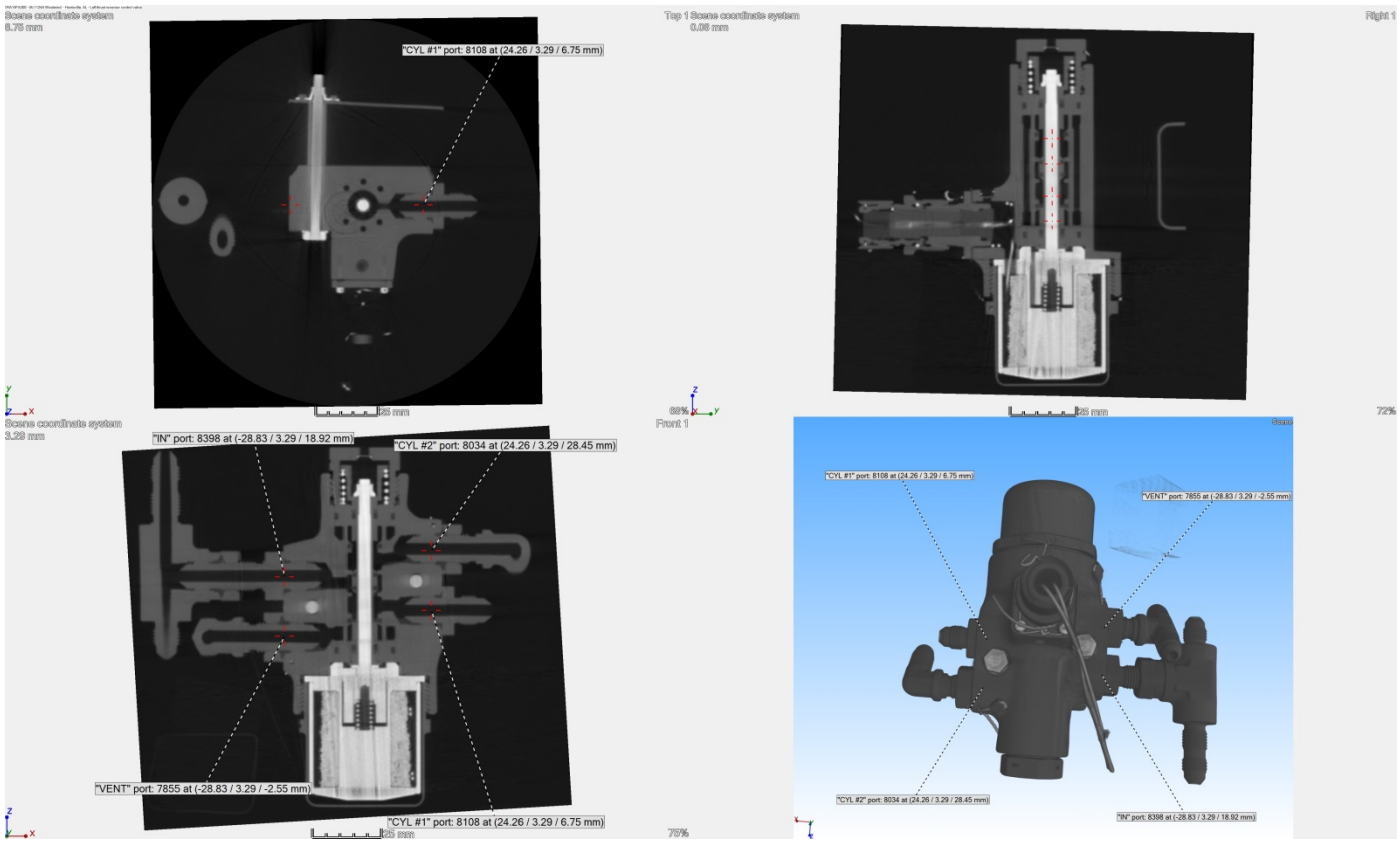

Figure 27
Left thrust reverser control valve – standard focus – overall cross section with ports identified

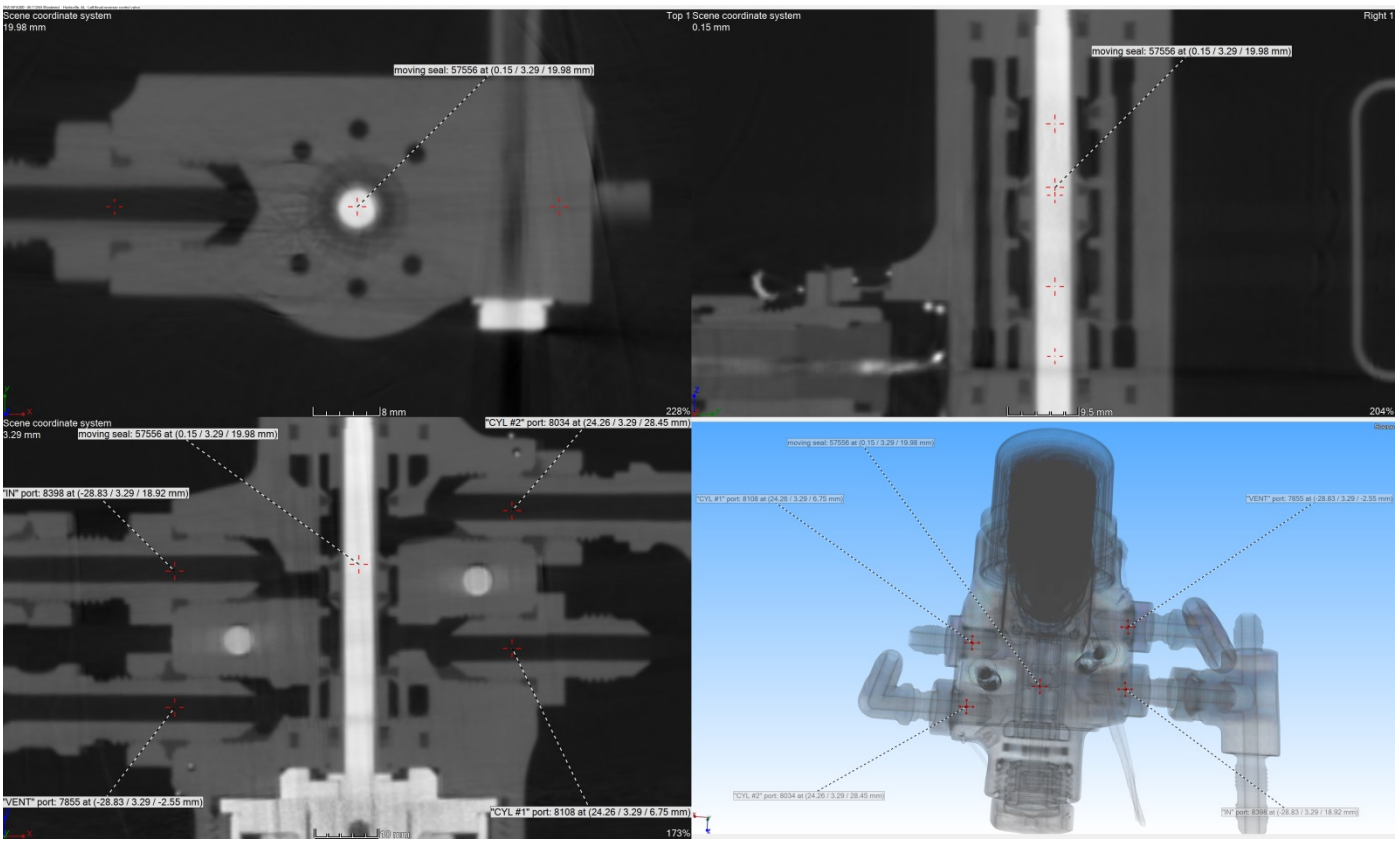

Figure 28
Left thrust reverser control valve – standard focus – moving seal

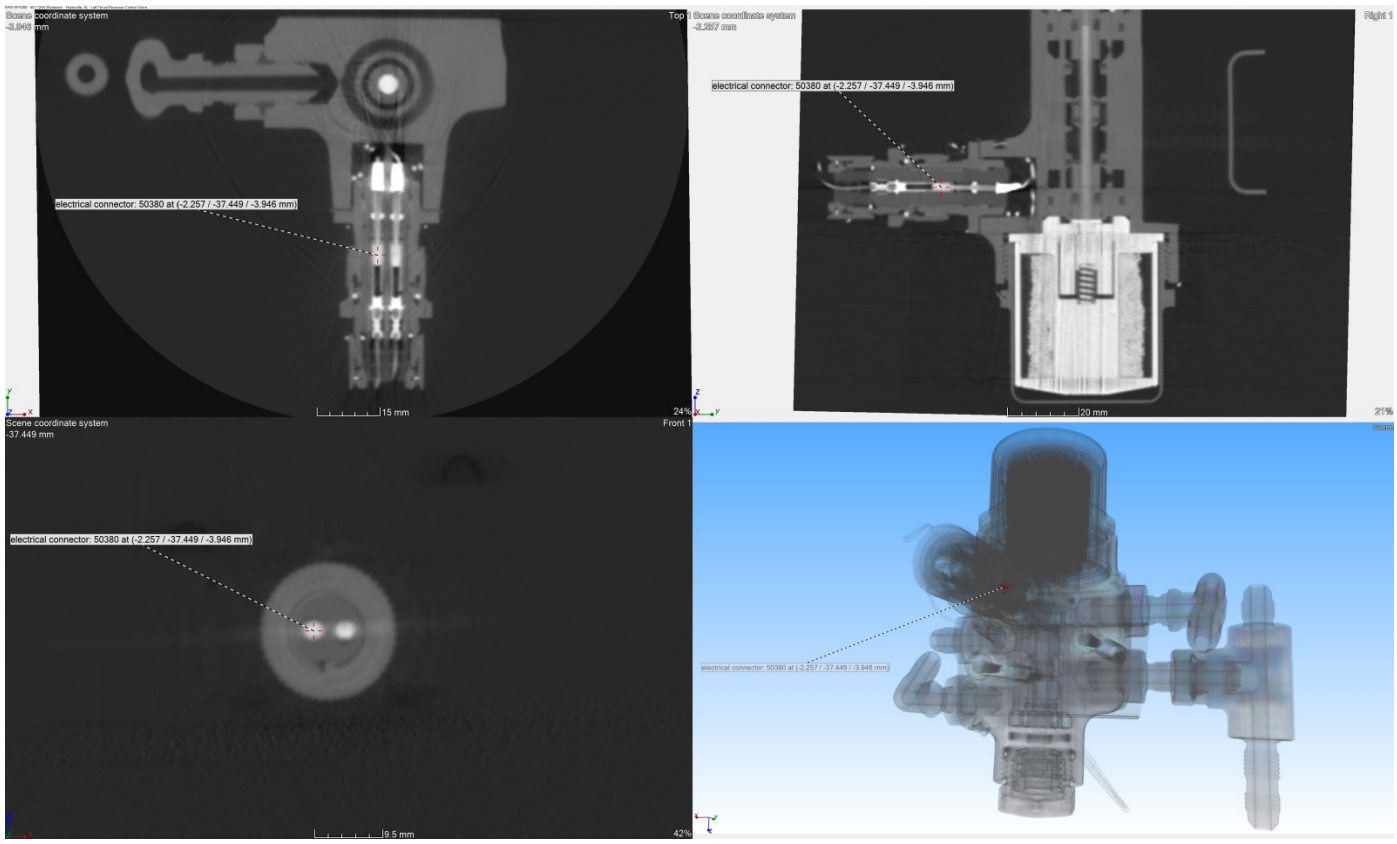

Figure 29
Left thrust reverser control valve – standard focus – electrical connector

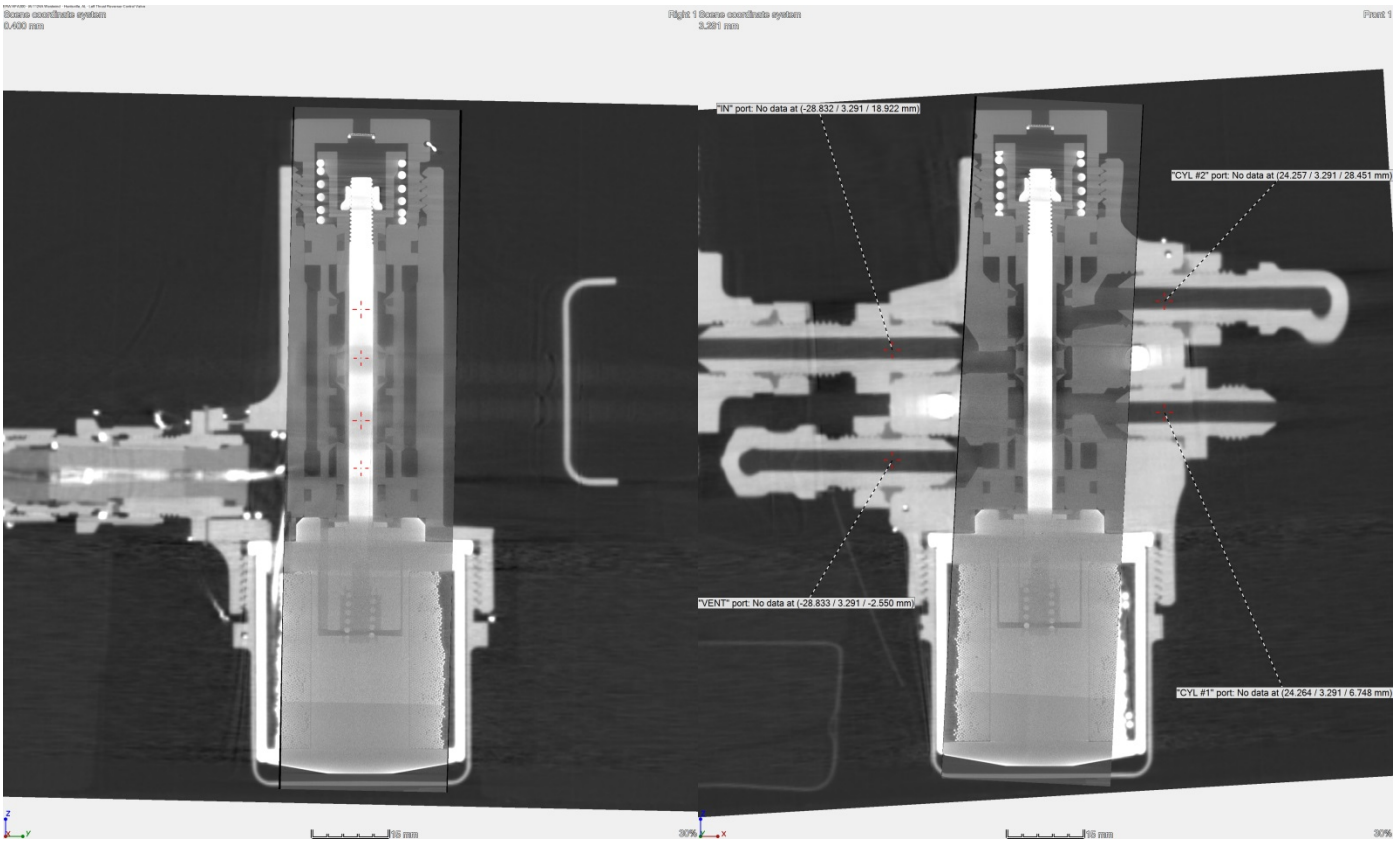

Figure 30
Left thrust reverser control valve – standard focus with target CT overlaid – overall cross section with ports identified

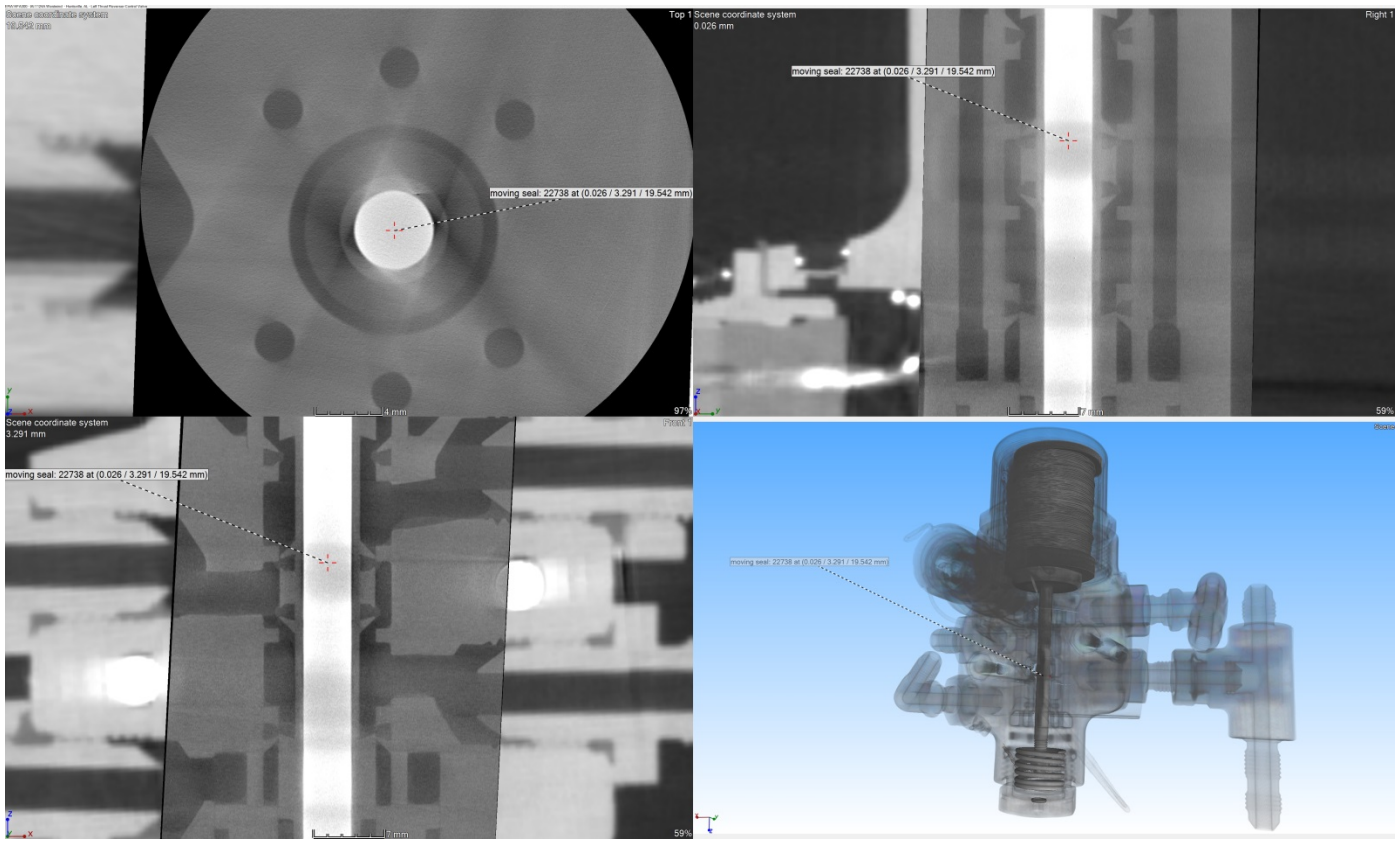

Figure 31
Left thrust reverser control valve – standard focus with target CT overlaid – moving seal

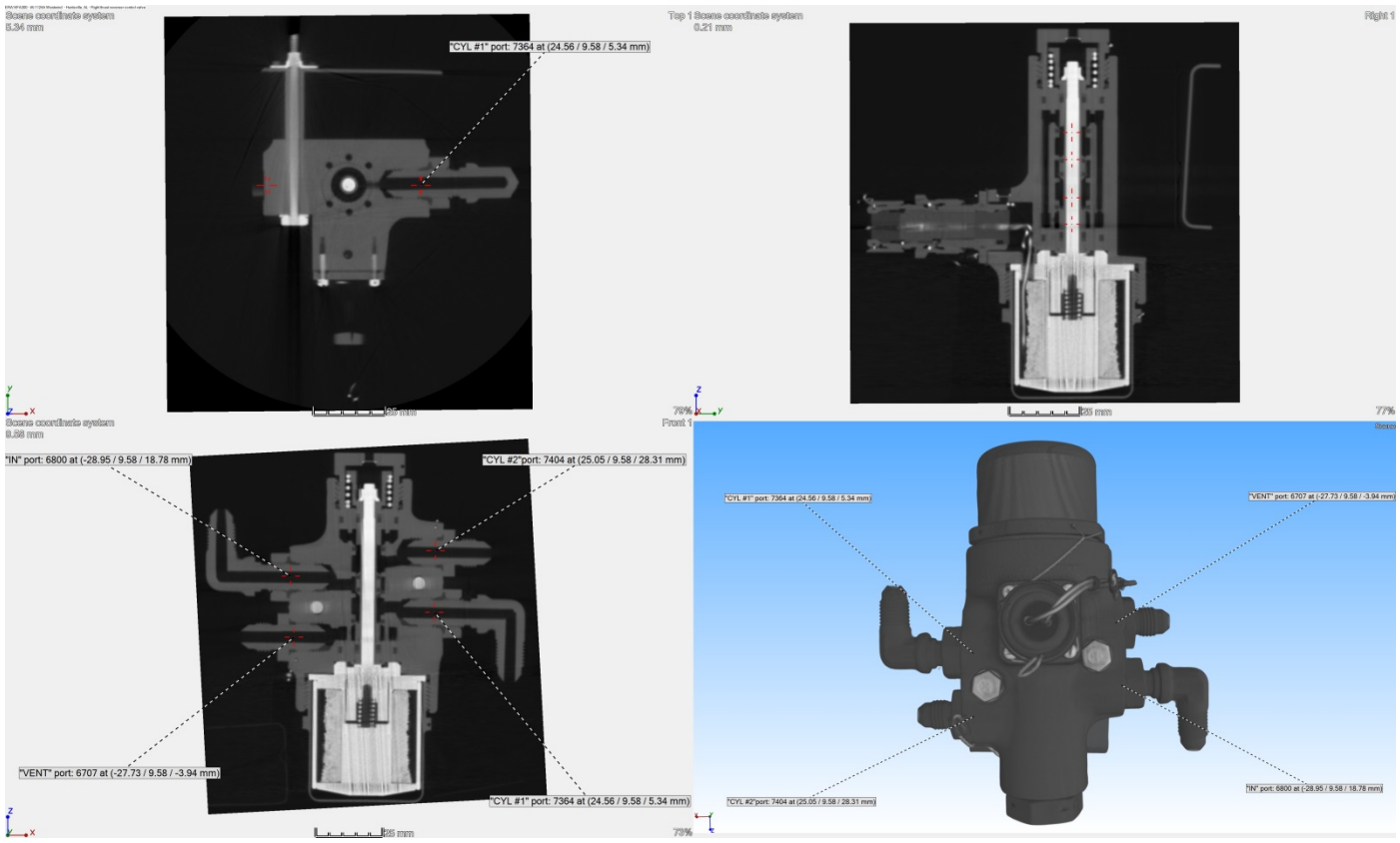

Figure 32
Right thrust reverser control valve – standard focus – overall cross section with ports identified

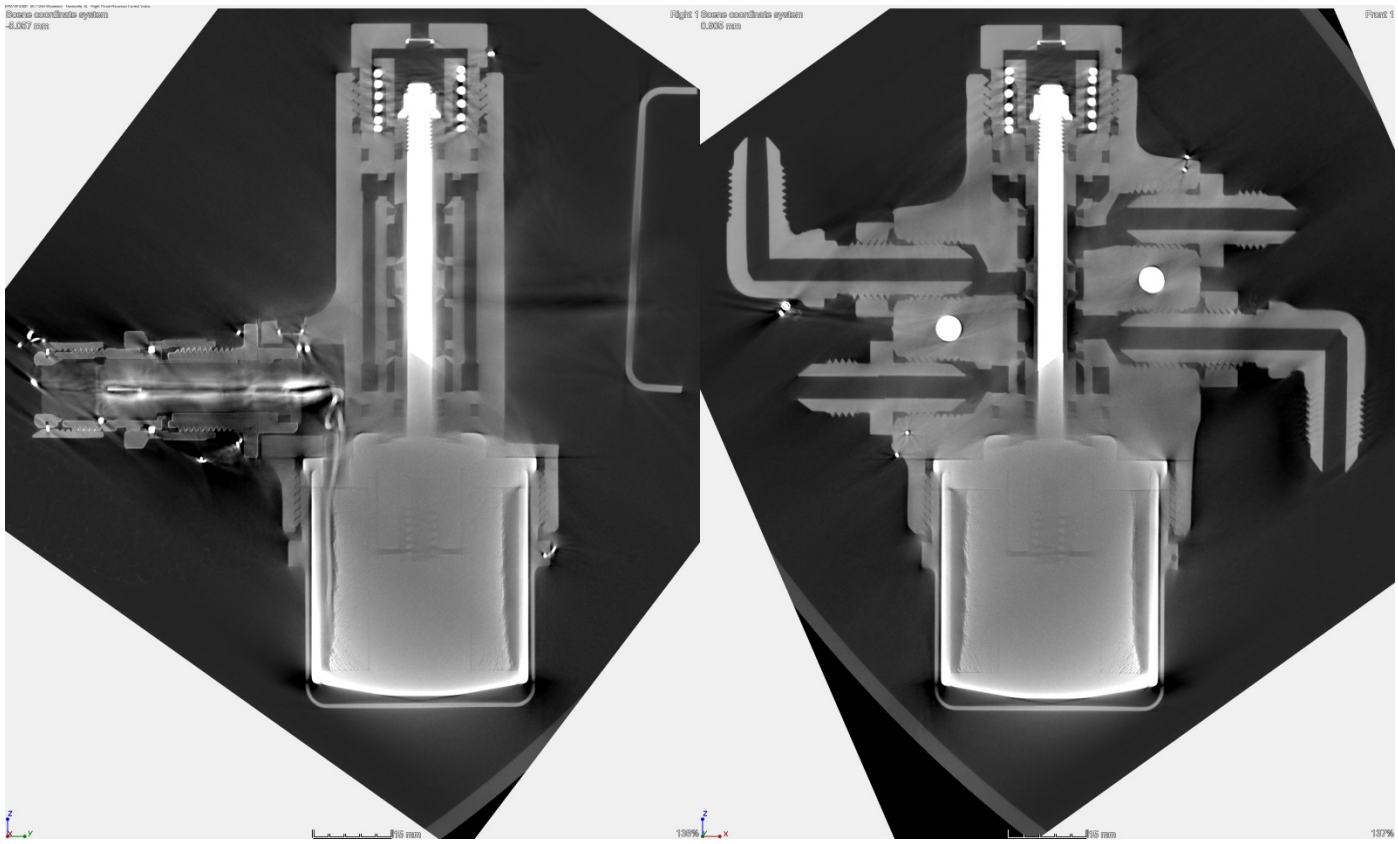

Figure 33
Right thrust reverser control valve – microfocus – overall cross section

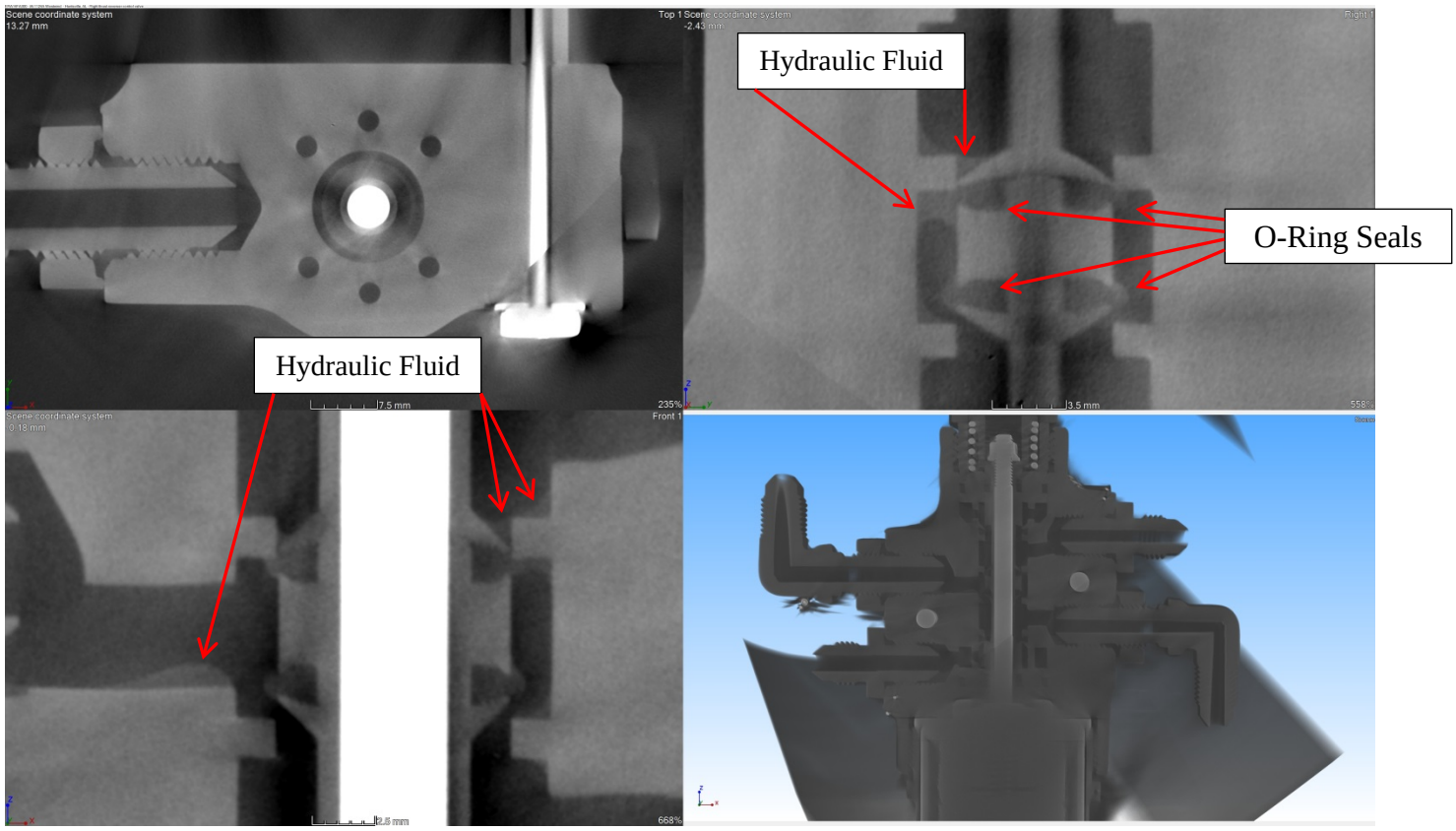

Figure 34
Right thrust reverser control valve – microfocus – moving seal

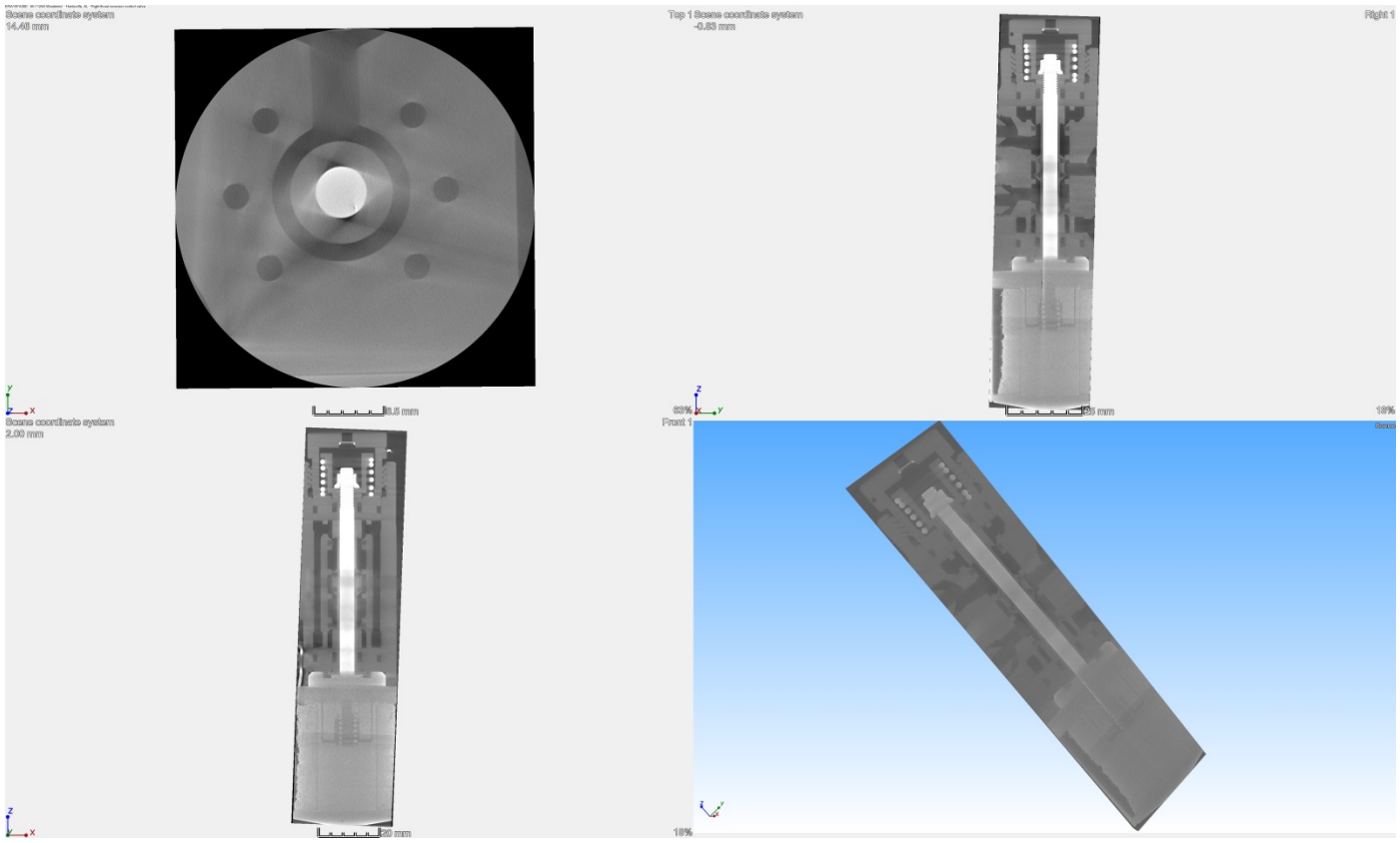

Figure 35
Right thrust reverser control valve – target CT – overall cross section

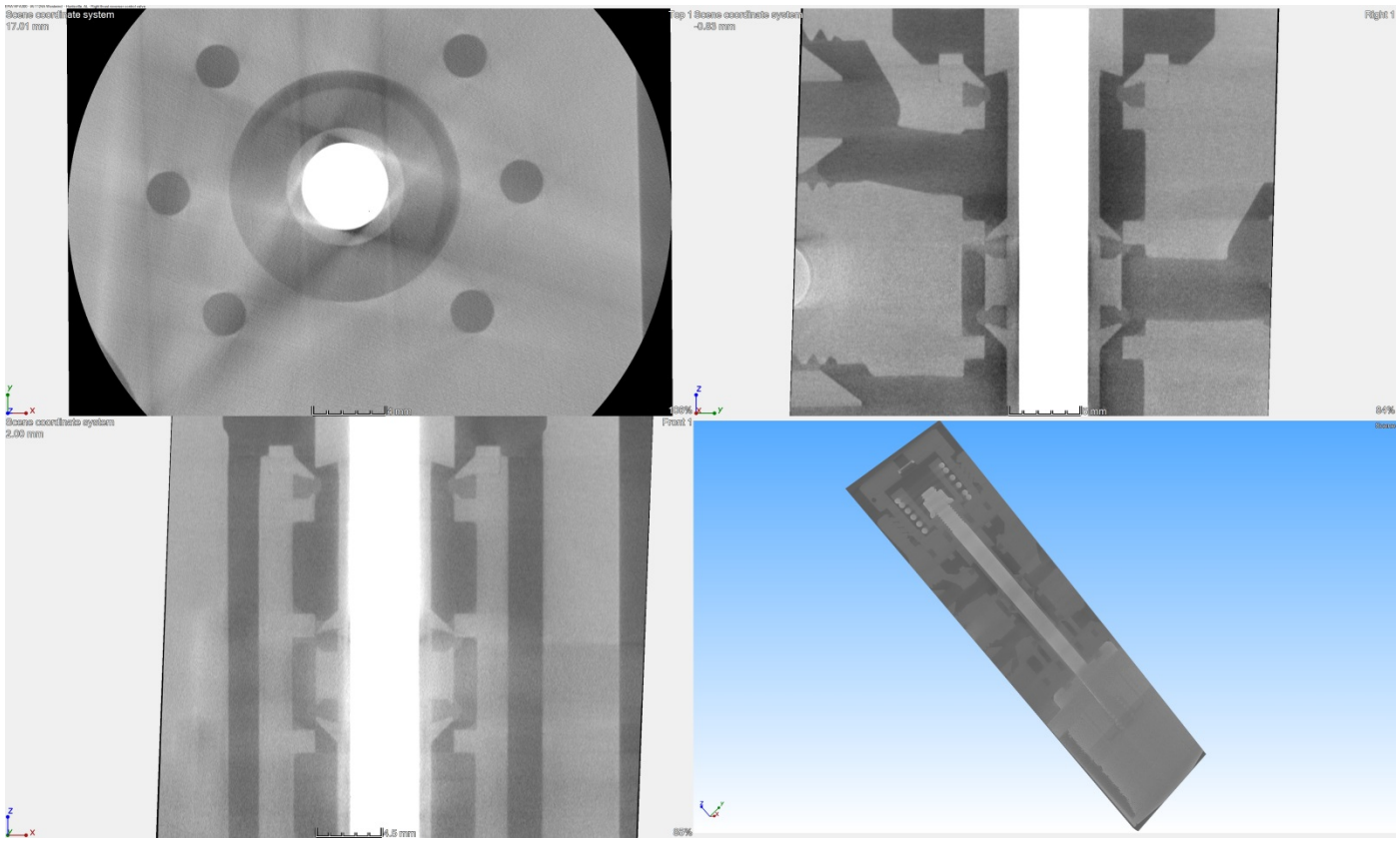

Figure 36
Right thrust reverser control valve – target CT – moving seal

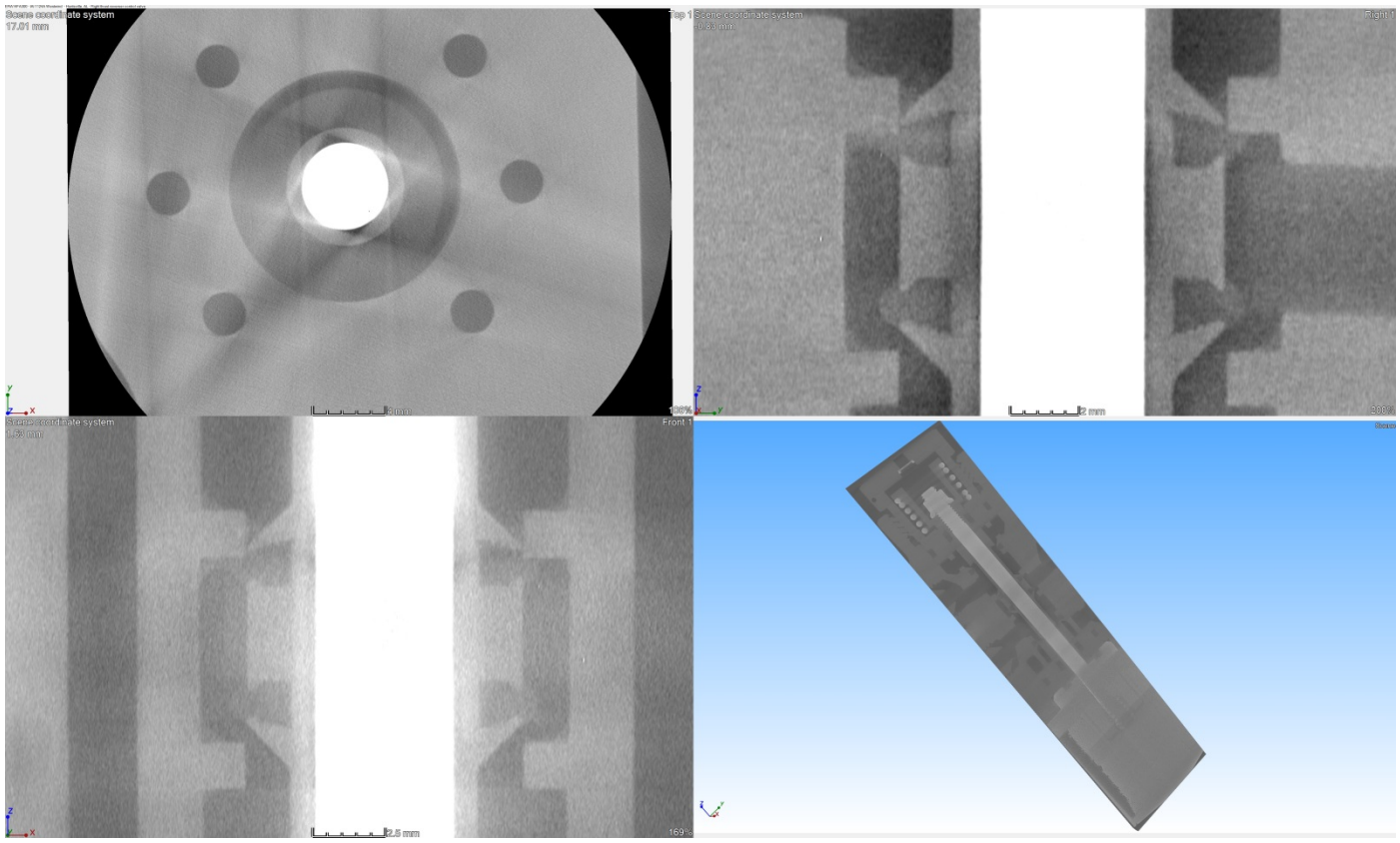

Figure 37
Right thrust reverser control valve – target CT – moving seal close up view

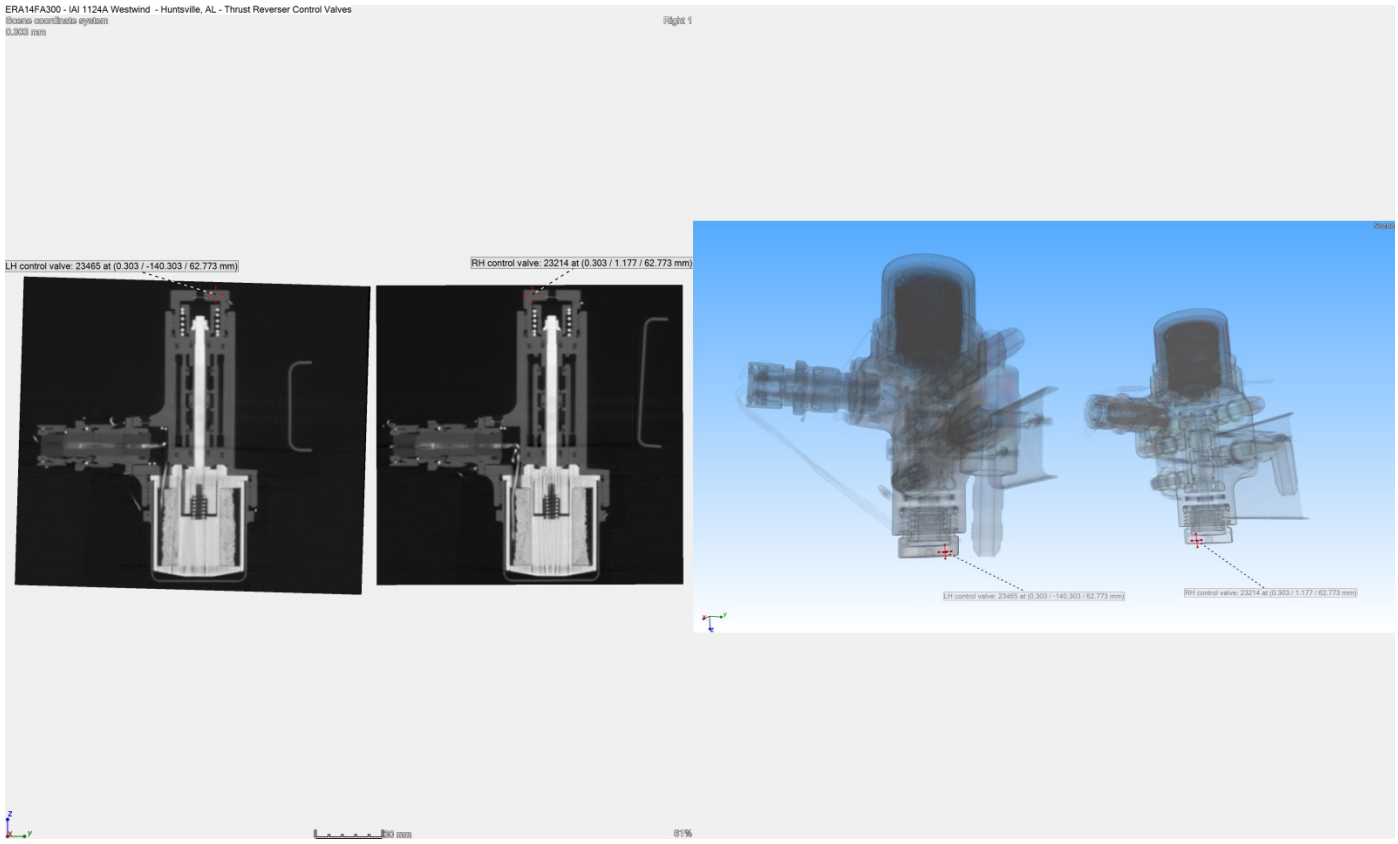

Figure 38

Left and right thrust reverser control valves – standard focus – overall cross sections

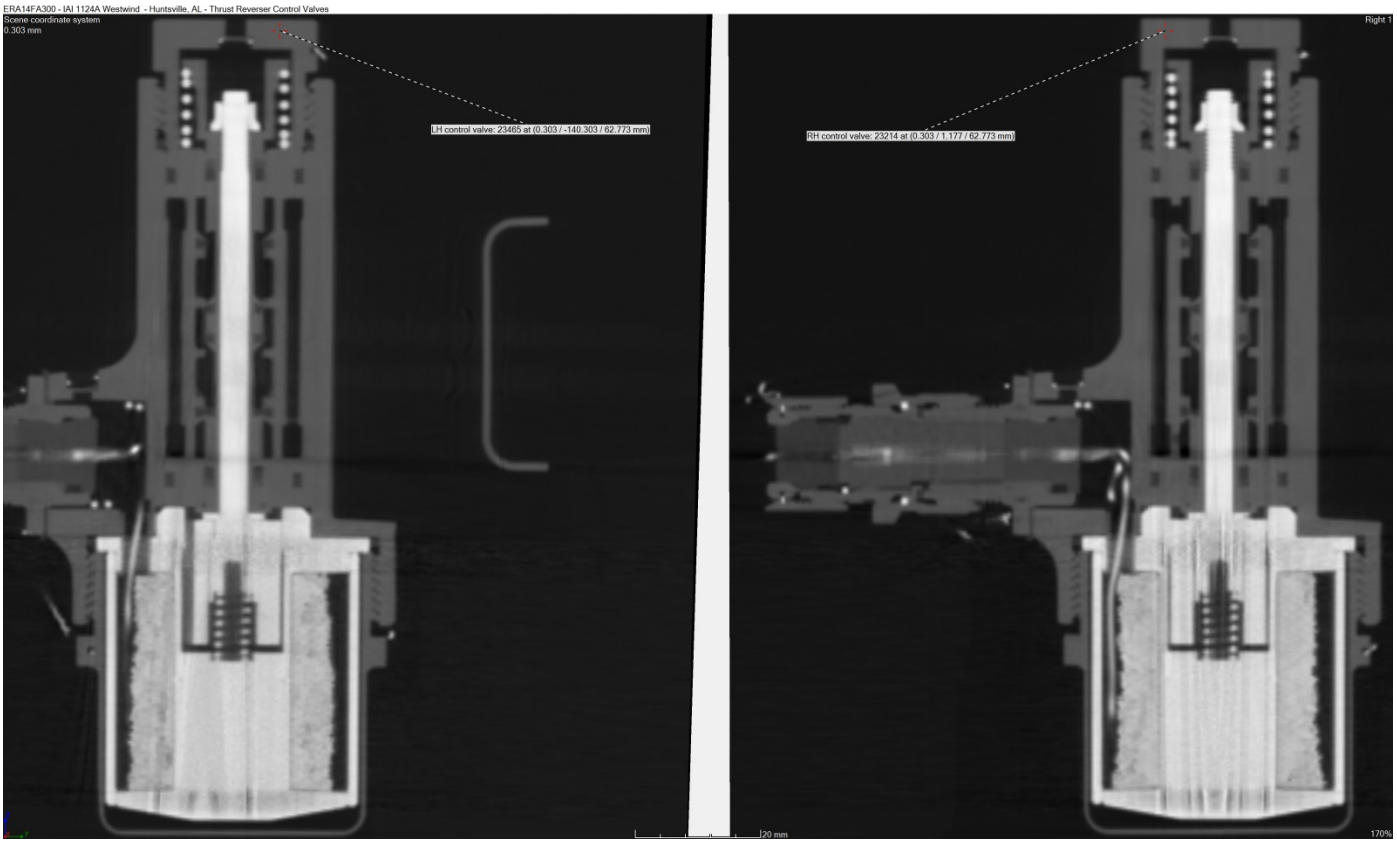

Figure 39
Left and right thrust reverser control valves – standard focus – overall cross sections close up view

Scott Warren
Lead Aerospace Engineer - Aircraft Systems
(Computed Tomography Specialist)