

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

April 15, 2021

Computed Tomography Specialist's Factual Report

ERA20FA074

A. ACCIDENT

Location: Mechanicsburg, Pennsylvania
Date: January 9, 2020
Time: 2029 eastern standard time
Airplane: Robinson R66 helicopter, N450MC

B. GROUP

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

C. SUMMARY

On January 9, 2020, about 2029 eastern standard time, a Robinson R66, N450MC, experienced an in-flight break-up near Mechanicsburg, Pennsylvania. The private pilot and one passenger were fatally injured, and the helicopter was destroyed. The helicopter was operated under the provisions of title 14 *Code of Federal Regulations Part 91* personal flight. Night visual meteorological conditions prevailed at the time and no flight plan was filed for the flight. The flight originated about 1958 from Martin State Airport (MTN), Baltimore, Maryland, and was destined for Buffalo Niagara International Airport (BUF), Buffalo, New York.

The internal configuration of the sprag clutch from the accident helicopter was documented using radiographic images that were collected from February 1-4, 2021 in Chicago, Illinois. A total of 581 computed tomography (CT) slice images were examined, processed, and analyzed by the NTSB to evaluate the components.

Review of the images determined that, when the scans were conducted, there was one location where there were indications of low clearance distances between two adjacent sprag teeth. There were no other indications of missing or damaged parts, contamination, or any other anomalies.

D. DETAILS OF THE INVESTIGATION

1.0 General

The sprag clutch from the accident helicopter was subjected to x-ray radiograph and computed tomography (CT) scanning to document its internal condition. The scanning was conducted from February 1-4, 2021 by Varex, Inc under the direction of the NTSB using the Actis 1000 1 megavolt (MV) 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.

A technique known as 2-times oversampling was used for the 1 MV scanning to improve spatial resolution. It involved acquiring one slice in a full 360-degree rotation then shifting the detector array 0.5 mm and acquiring a second slice at the same position. The two scans were algorithmically combined during reconstruction. The technique algorithmically doubled the size of the detector to oversample the data in the x, y plane.

For a selected area within the component, in this case an area of the sprag teeth, target CT techniques were used. The target CT techniques used geometric magnification¹ to provide for enhanced resolution within a component. The field of view during these scans is reduced, but the resolution within that field of view is much better than in the overall component scans. In this case, the resulting images contained too many imaging artifacts to provide useful information.

The cylindrical sprag tooth structure was “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 component was scanned using a total of 581 slices, and the total size of the combined data sets was approximately 2.36 GB. The complete scan protocols are given in table 1. The digital radiograph and CT axial slice images were provided

¹ Geometric magnification is a scanning technique where the component is moved closer to the x-ray source. The x-ray beam passes through a smaller region within the component, and that smaller region’s image information is spread across the x-ray detector. The resulting image is created at a higher resolution.

by Varex to the NTSB where they were examined, processed, and analyzed to evaluate the components.

Table 1
Scan Protocols

Component	Sprag clutch - 1 MV Overall scan	Microfocus scan of sprag area
Number of slices	208	373
Voxel ² Size - X Direction (millimeters(mm))	0.27	0.037
Voxel Size - Y Direction (mm)	0.27	0.037
Voxel Size - Z Direction (mm)	0.40	0.039
Image Projections per Revolution	5040	3600
Exposure time (milliseconds (ms))	10	285.6
Frames to Avg (frames per projection)	1	2
X-ray Source Voltage (kilovolts)	1000	223
X-ray beam flux or current (milliamps (mA)) ³	2.5 ms period, 4 pulses/view	0.580
Source Filter Thickness (mm)	3.3	1
Source Filter Material	Steel	Brass
Image Matrix Size (pixels)	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 component were digitally removed or rendered transparent to allow closer observation of interior parts. In the images, the higher density areas were shown as brighter shades of

² A voxel is a three-dimensional picture element (pixel).

³ X-ray flux is shown for MV scans while current is shown for the microfocus scans. Both of these characteristics indicate the photon flux used to create the scan images.

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 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 Computed Tomography Results

The computed tomography (CT) results for the components are shown in figures 1 through 11. Review of the images determined that, when the scans were conducted, there was one location where there were indications of low clearance distances between two adjacent sprag teeth. There were no other indications of missing or damaged parts, contamination, or any other anomalies.

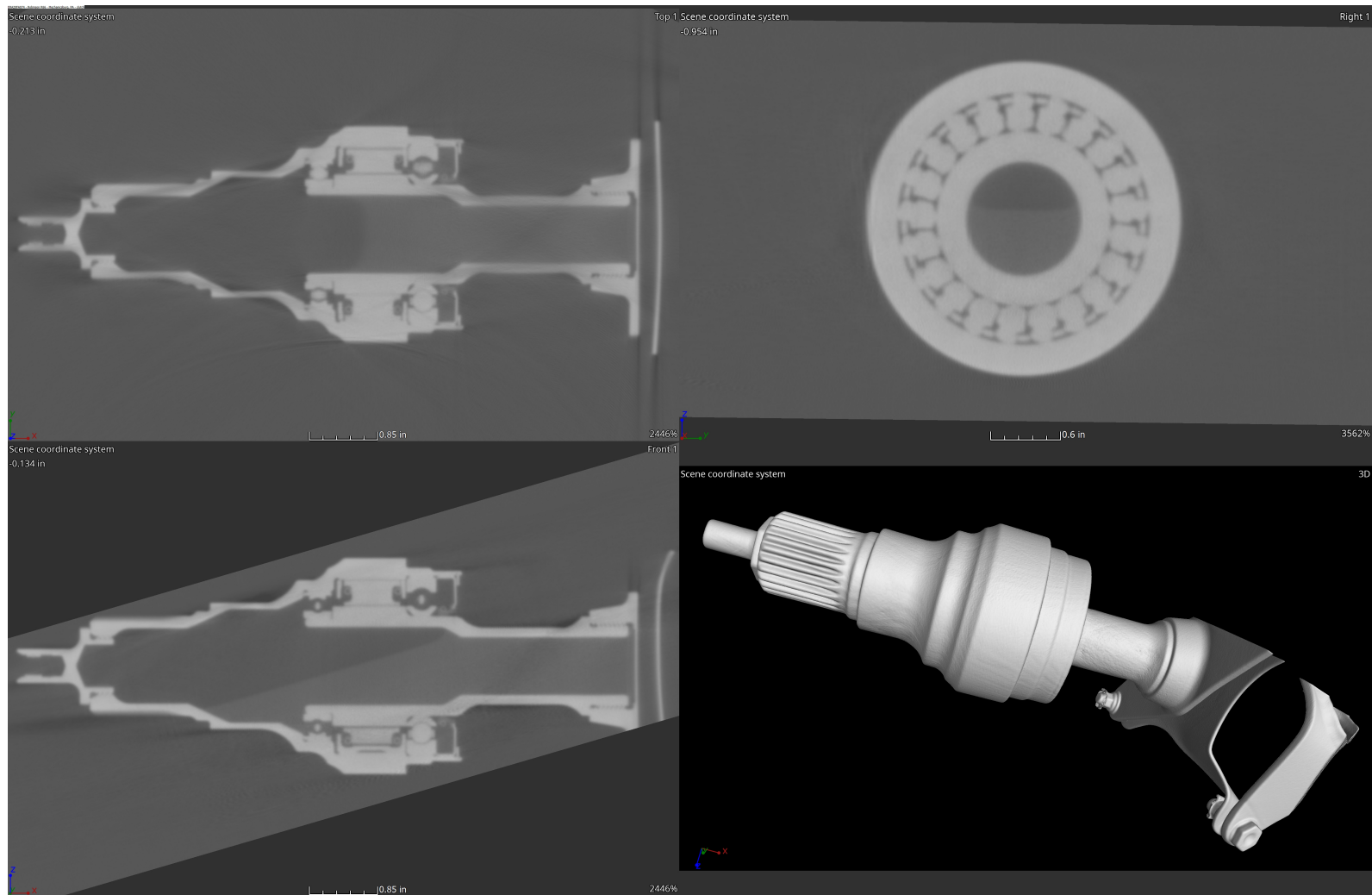


Figure 1
Sprag clutch - overview

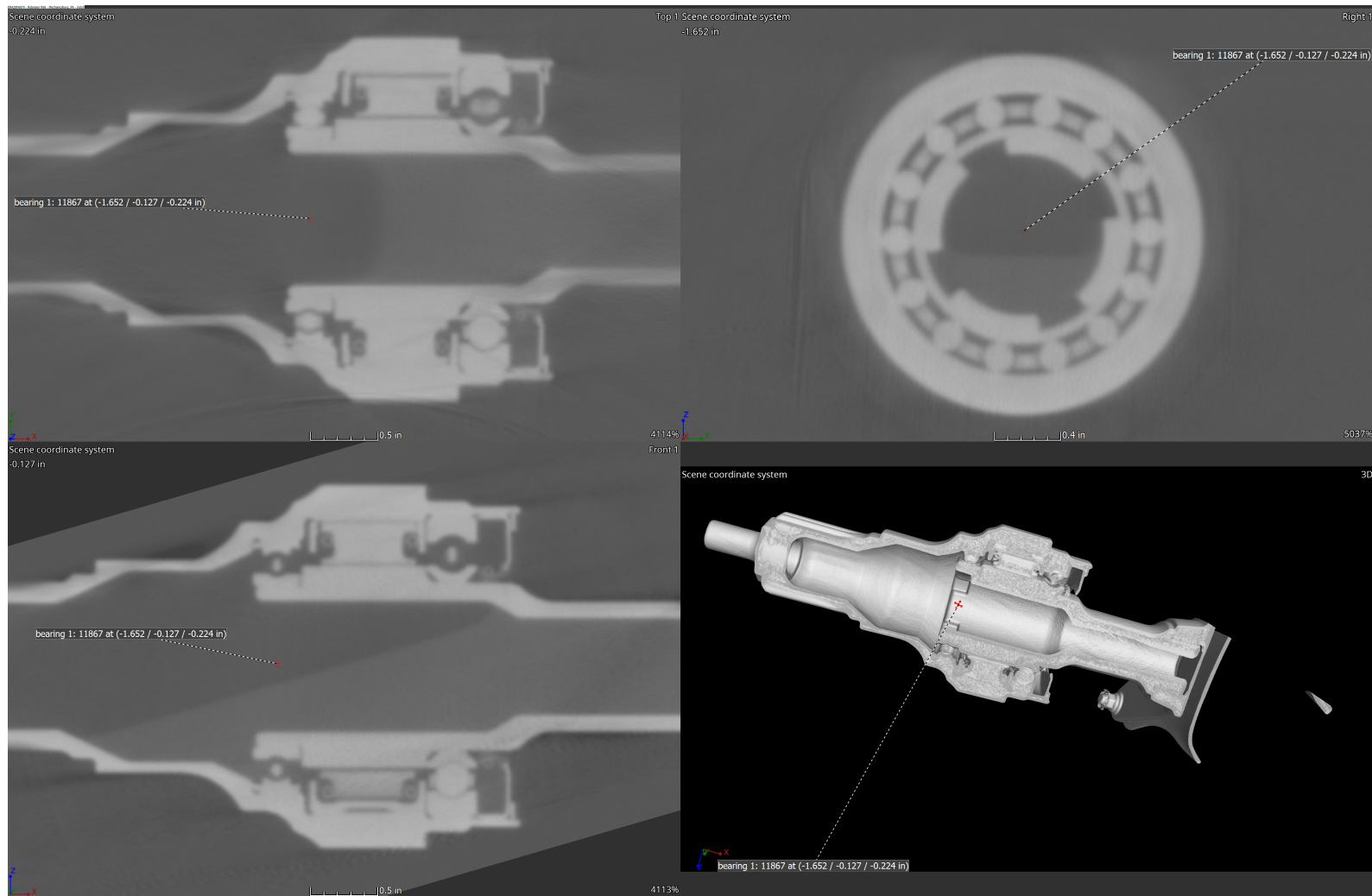


Figure 2
Sprag clutch – bearing 1

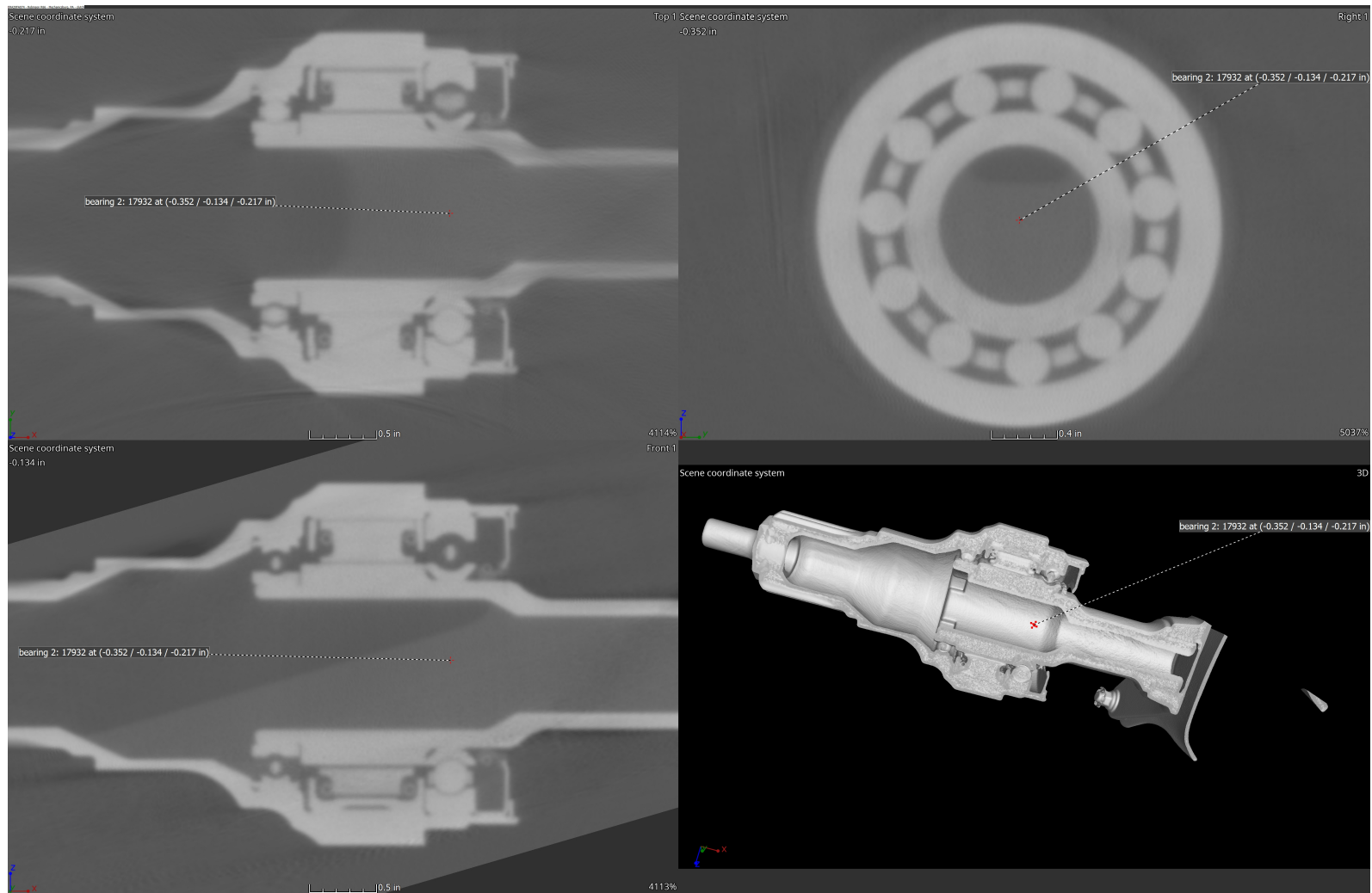


Figure 3
Sprag clutch – bearing 2

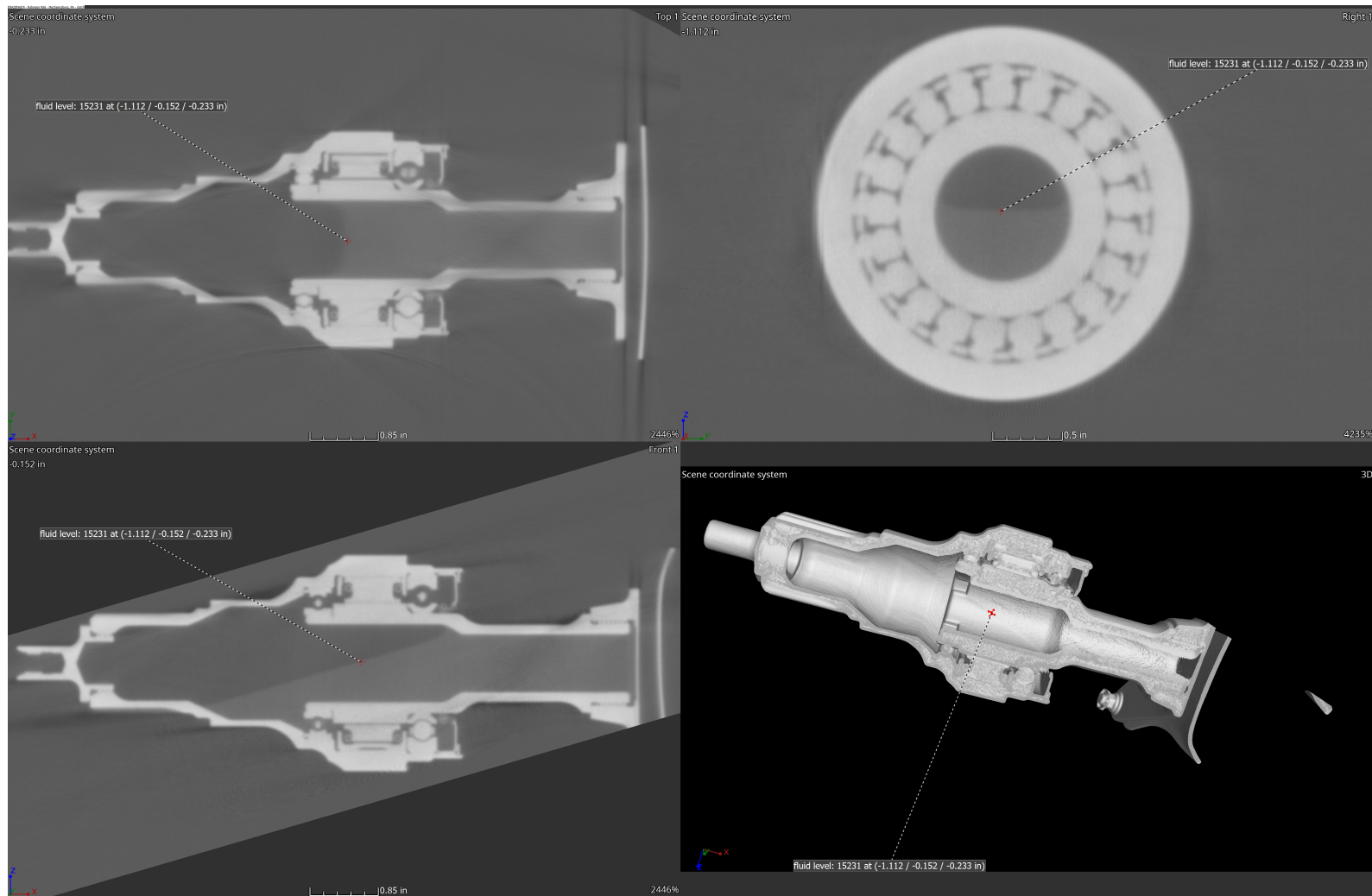


Figure 4
Sprag clutch – fluid level

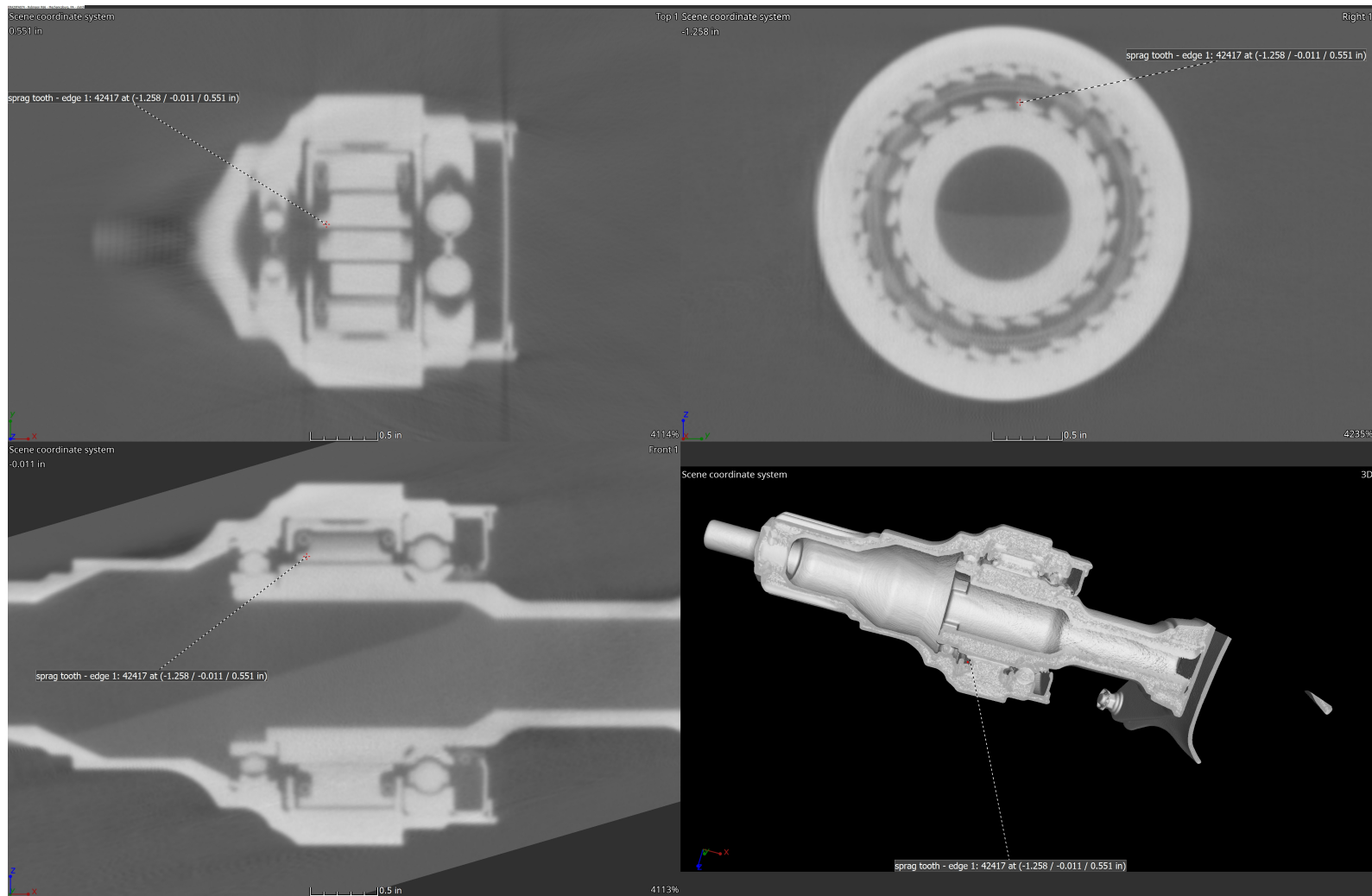


Figure 5
Sprag clutch – sprag teeth – edge 1

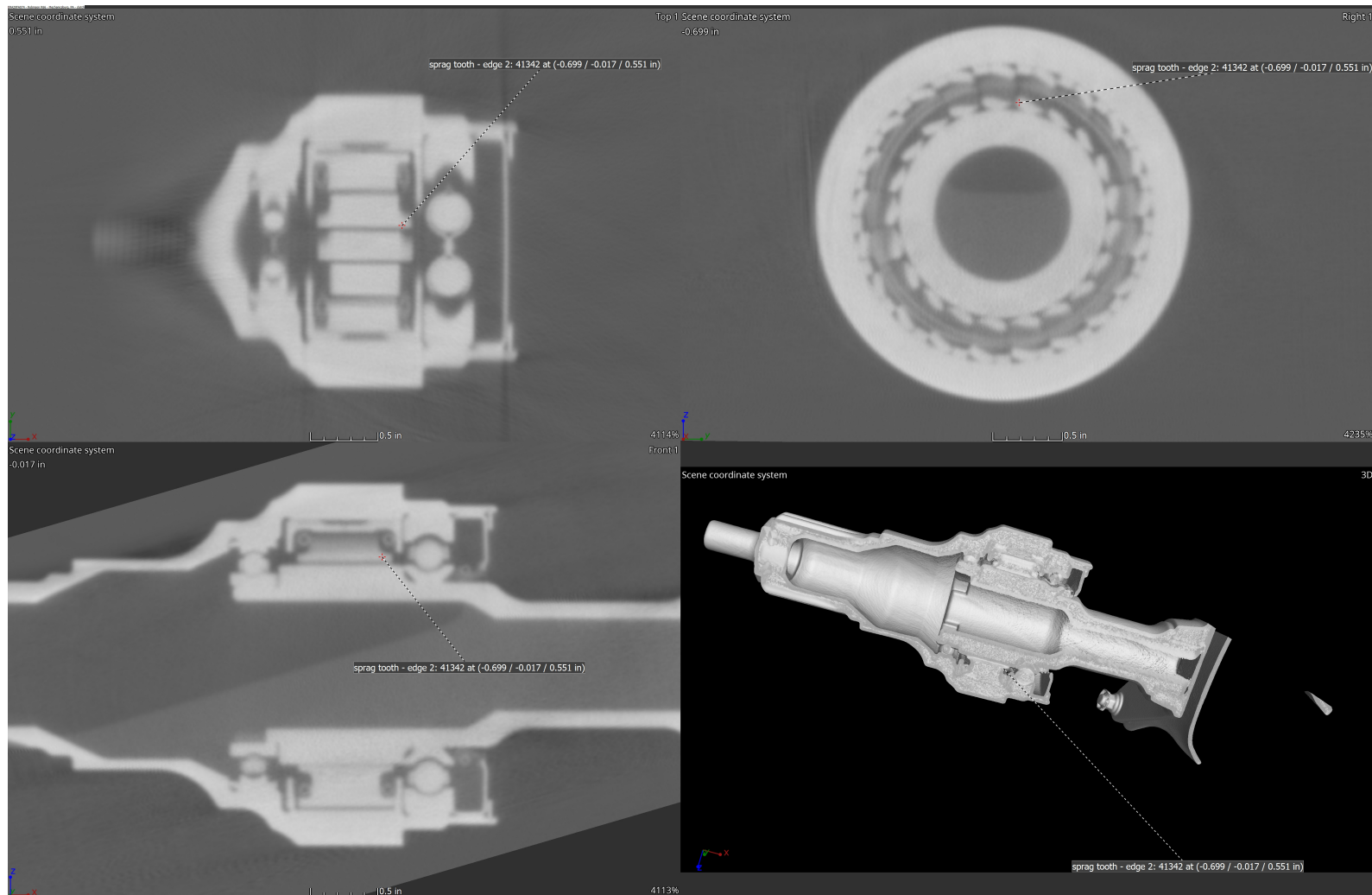


Figure 6
Sprag clutch – sprag teeth – edge 2

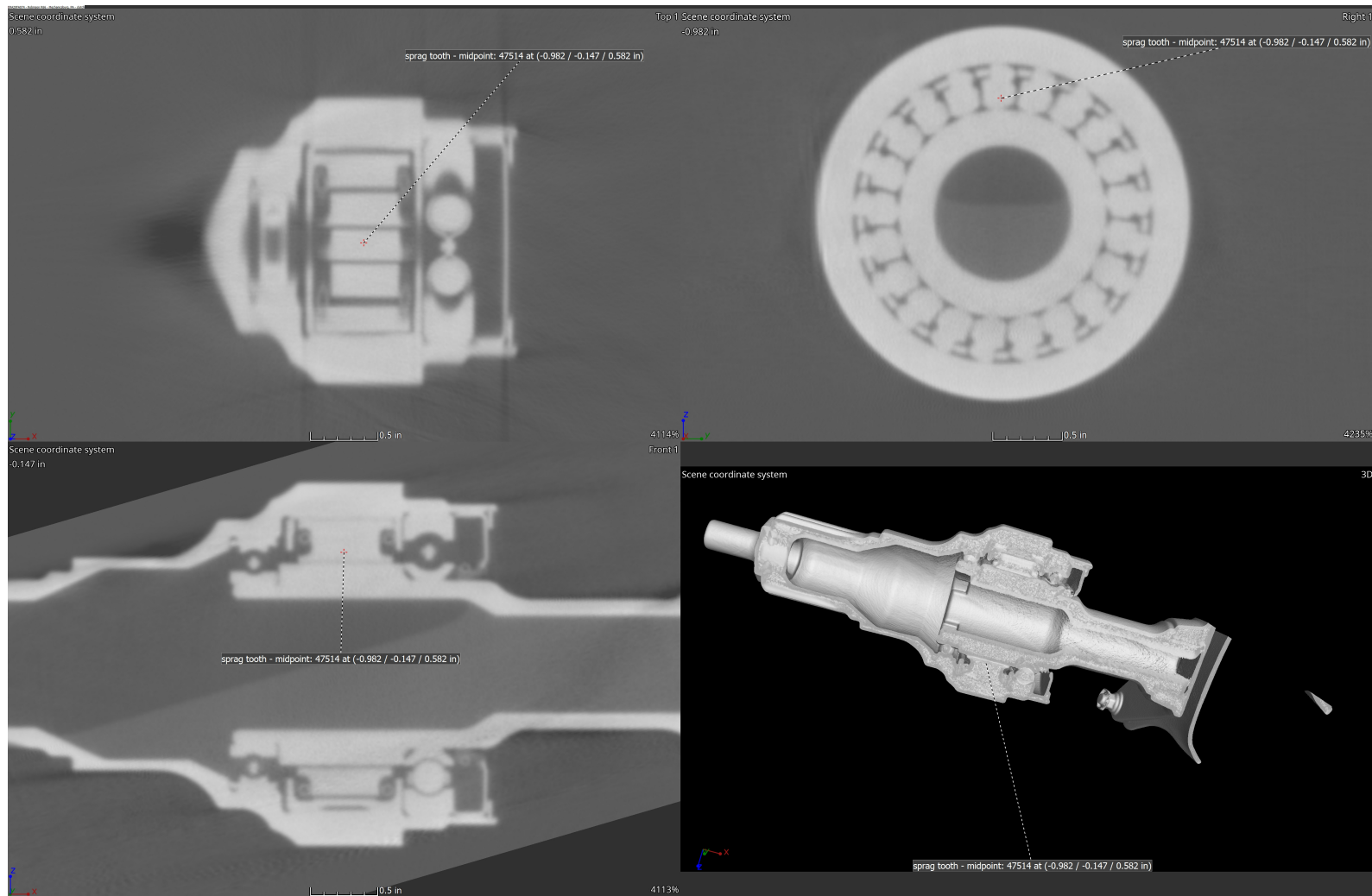


Figure 7
Sprag clutch – sprag teeth – midpoint

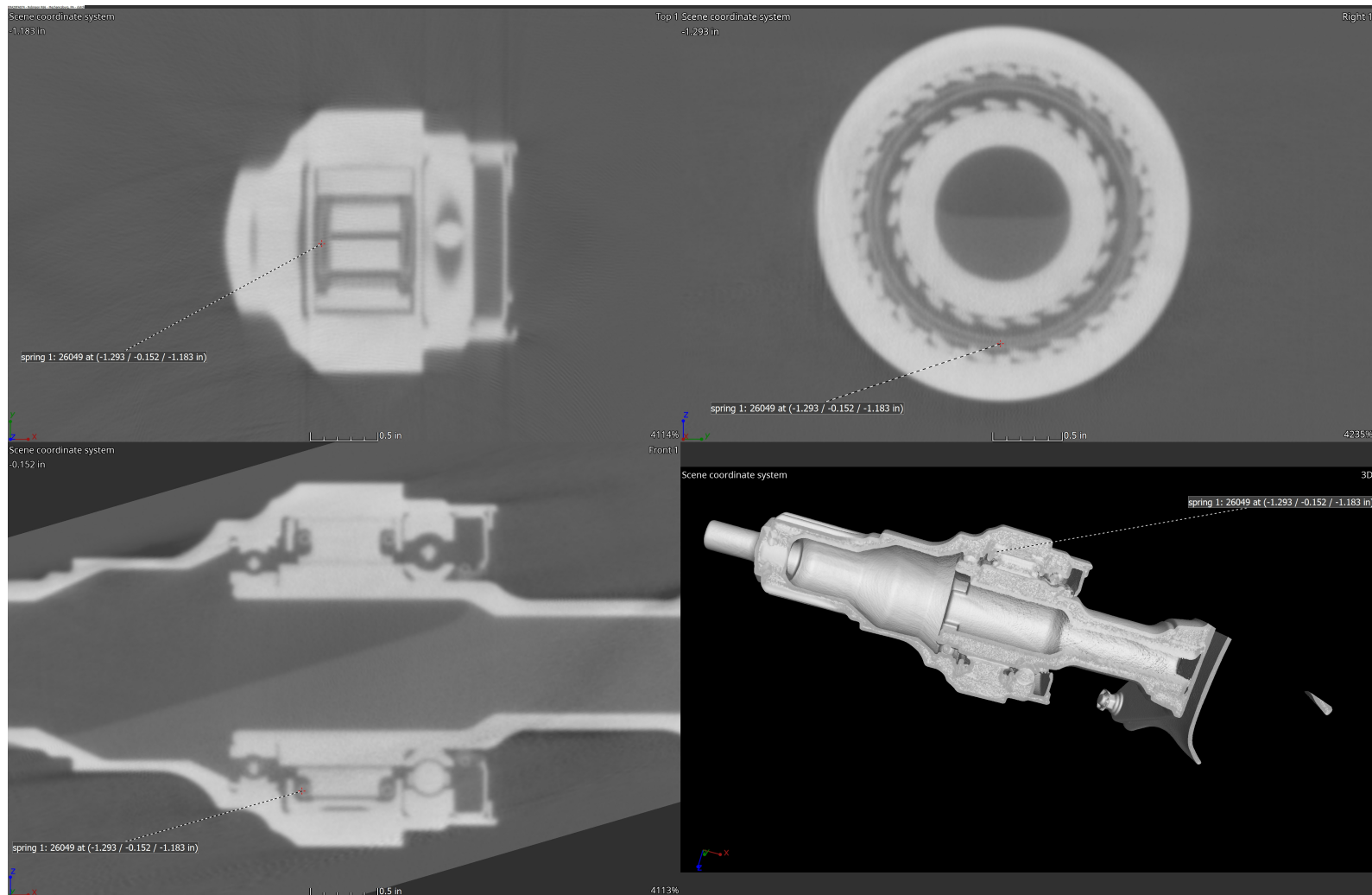


Figure 8
Sprag clutch – spring 1

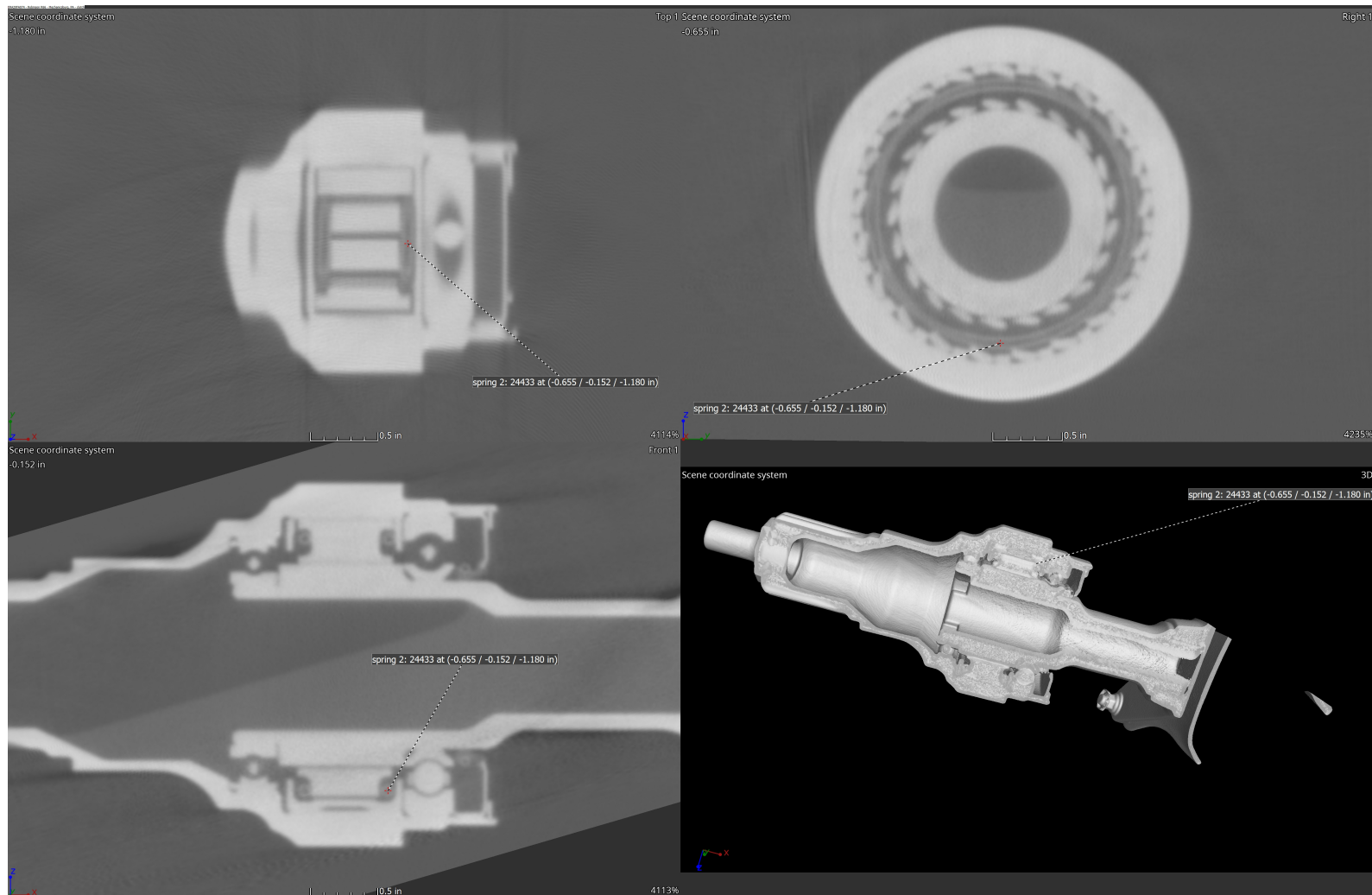


Figure 9
Sprag clutch – spring 2

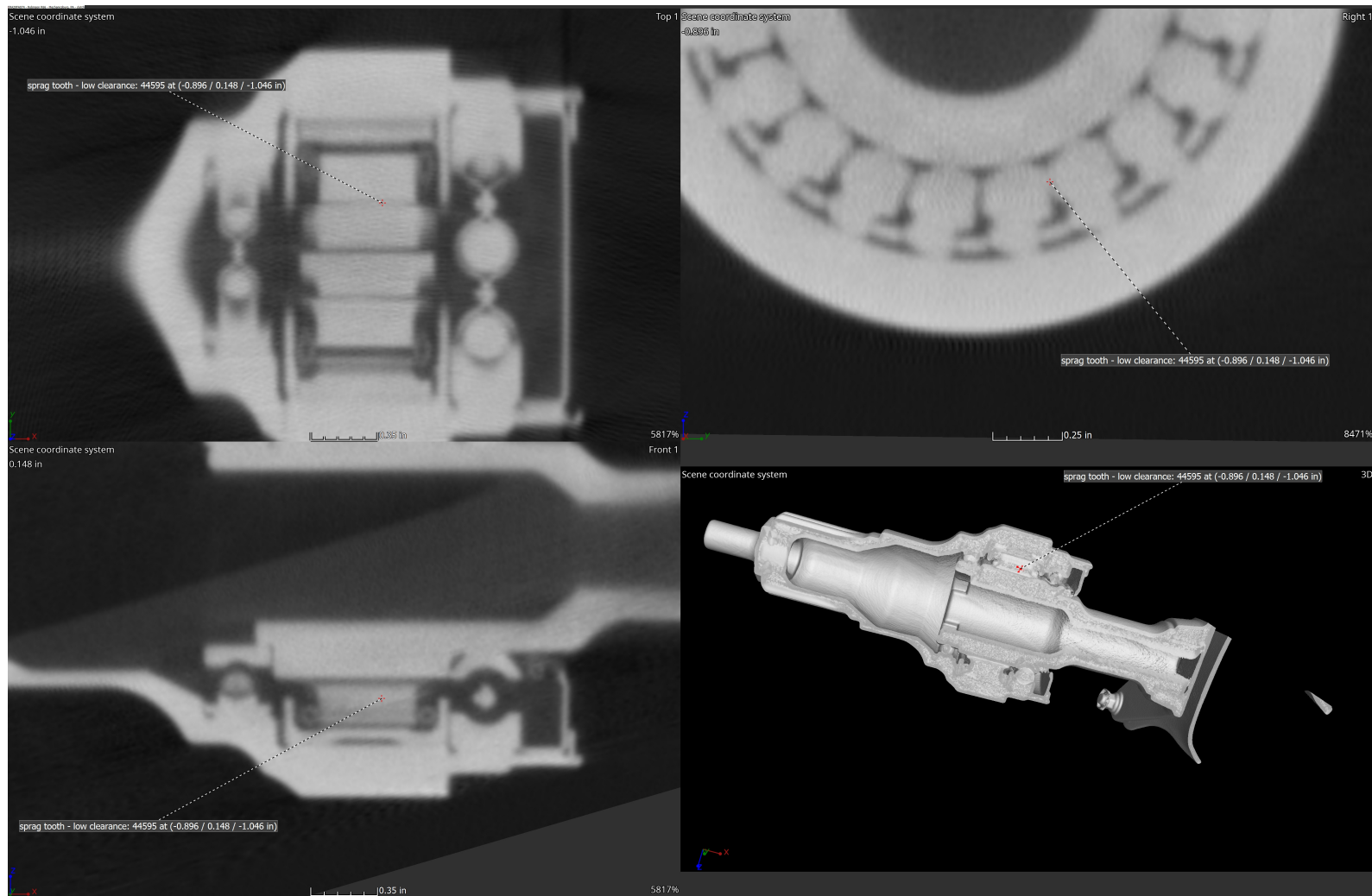


Figure 10
Sprag clutch – sprag tooth low clearance point

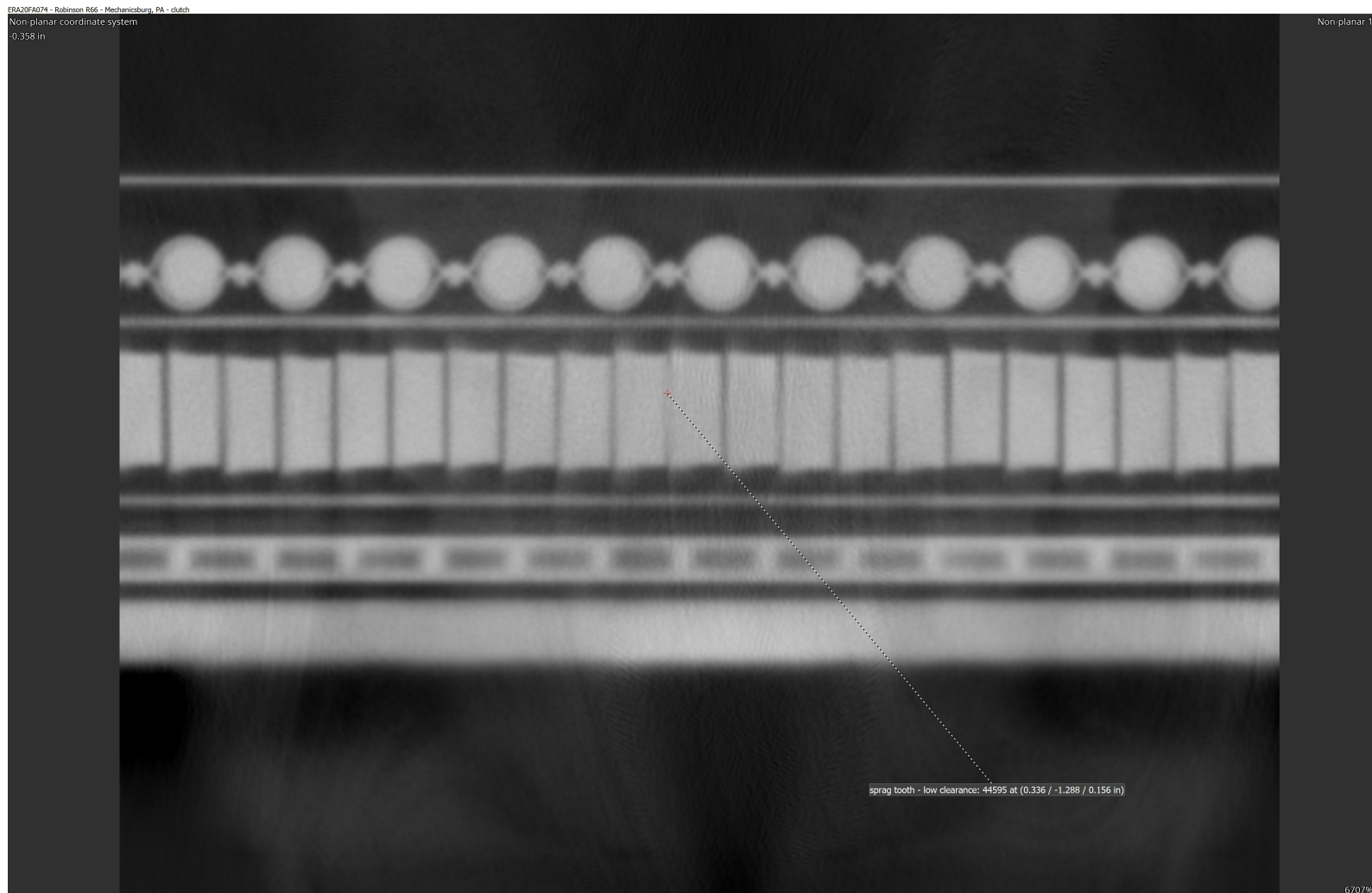


Figure 11
Sprag clutch – sprag tooth low clearance point - unrolled

Scott Warren
Lead Aerospace Engineer
(Computed Tomography Specialist)