



GE Aerospace

2025 A4A Nondestructive Testing Forum

— CFM LEAP - High Pressure Turbine Module Level PAUT Inspection of LLPs

— Stetson Watkins

Background

Challenge:

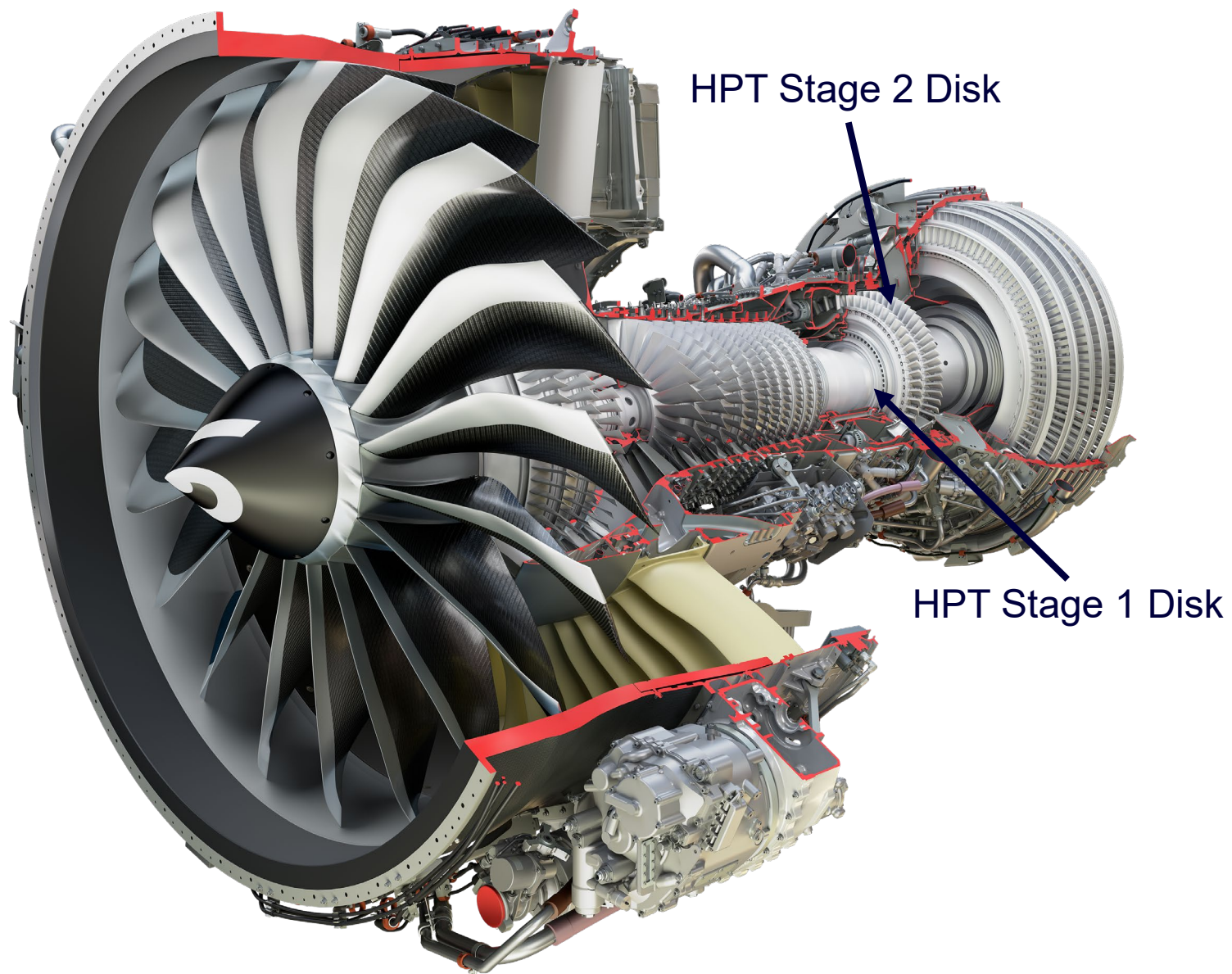
- The LEAP program has a goal of keeping HPT rotors installed at a module level until end of life, as is the case for currently fielded CFM56 HPT rotors.
- Because of the criticality of life-limited rotating hardware, we were asked to consider in-service inspection options for stage 1 and stage 2 HPT disks at module level.

Solution:

- Perform volumetric ultrasonic inspections of the high-stressed regions of the LEAP HPT stage 1 and stage 2 disks while the hardware is in a module configuration.



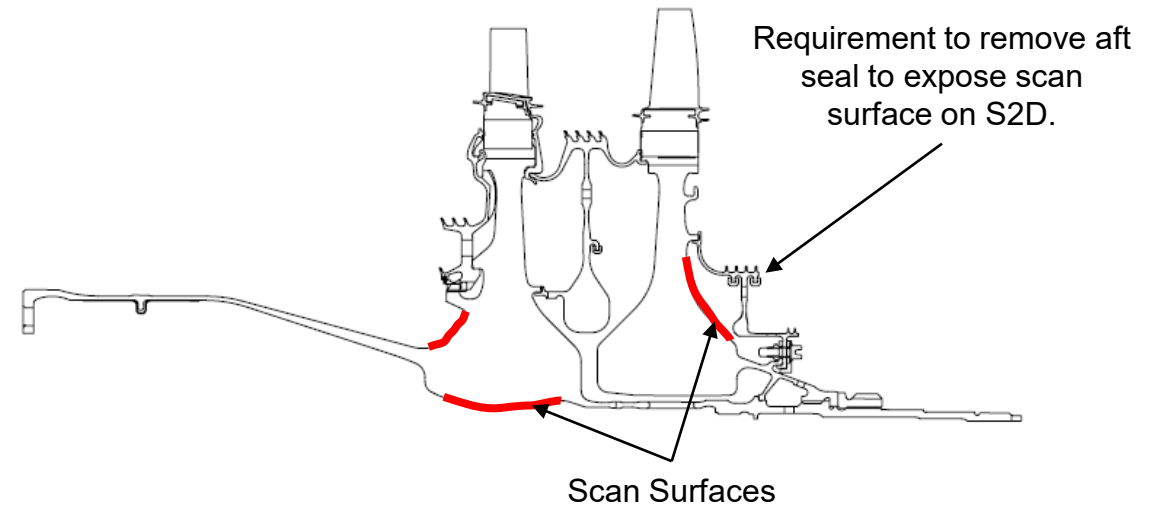
Engine Architecture



Inspection Overview

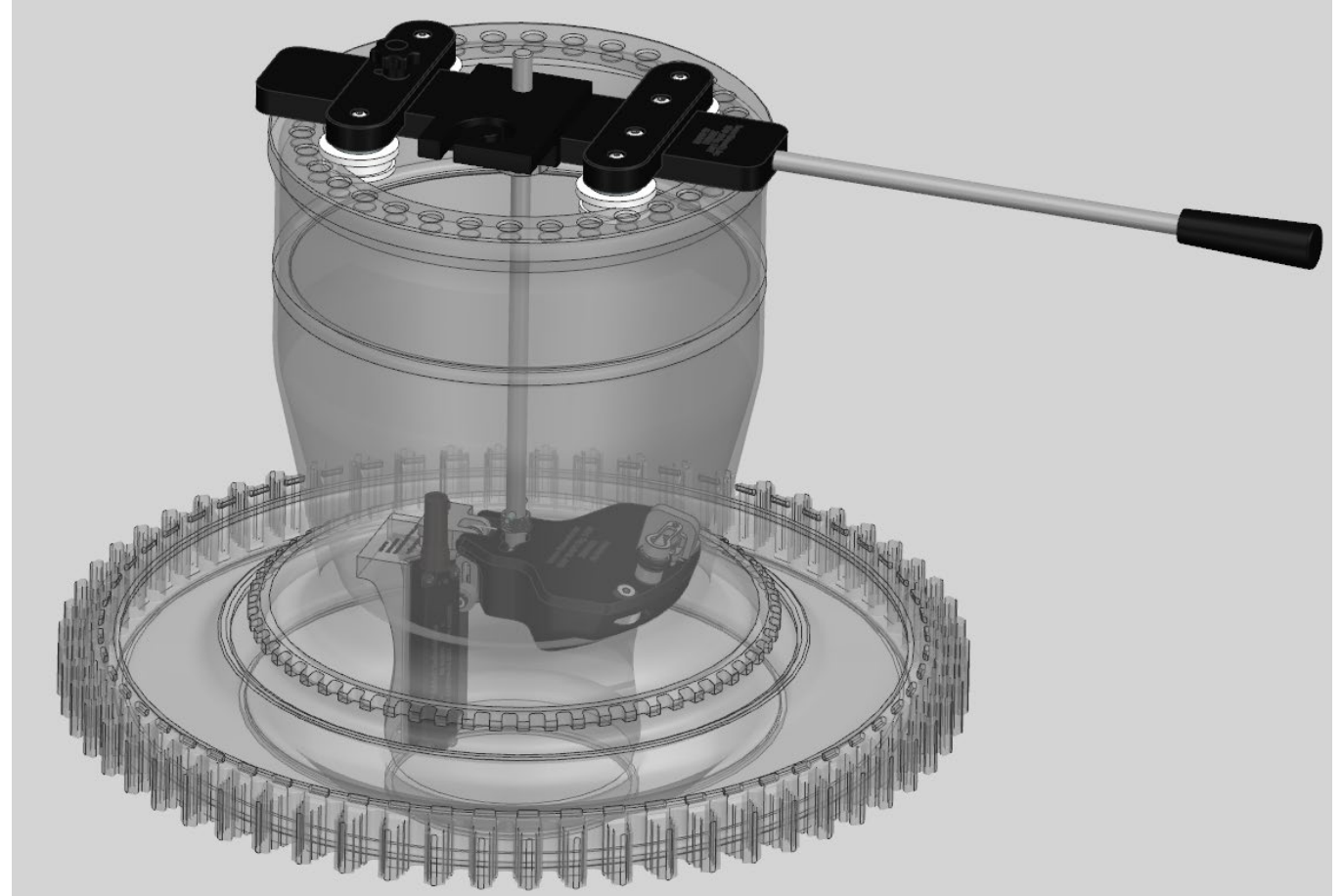


- **S1D:** 45S / 65S circumferential from bore and 45S circumferential from forward transition surface.
- **S2D:** 20L / 45S / 65S circumferential from aft slant face.



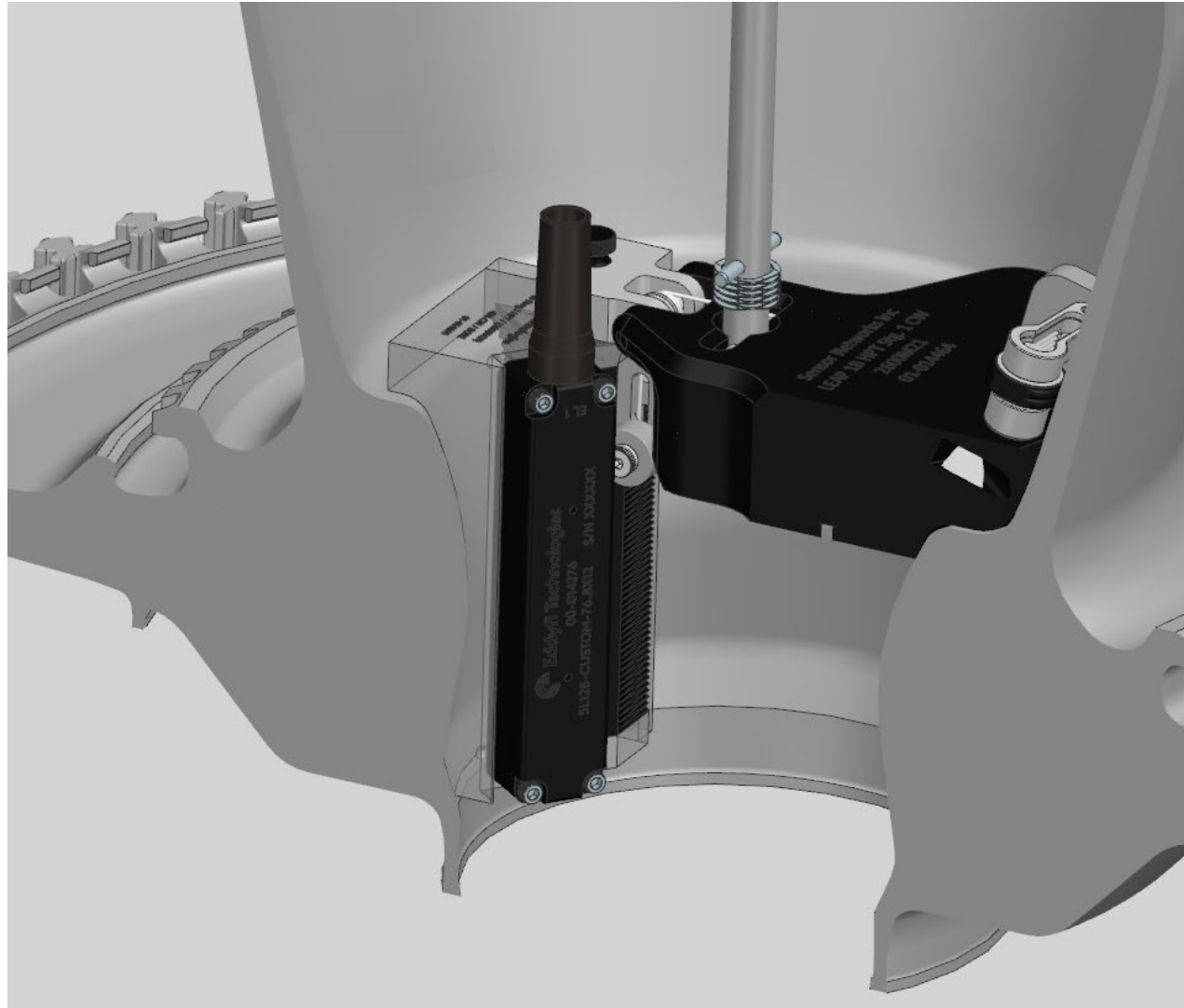
Equipment Overview – S1D Bore

- S1D bore:
 - 5 MHz 128 element linear array.
 - 45S* circumferential CW/CCW
 - 65S* circumferential CW/CCW
 - Custom wedge which contours to the geometry of the S1D bore.
 - Rotation fixture that rides along the flange of the forward shaft of the S1D.
 - Gravity-fed water supply system.

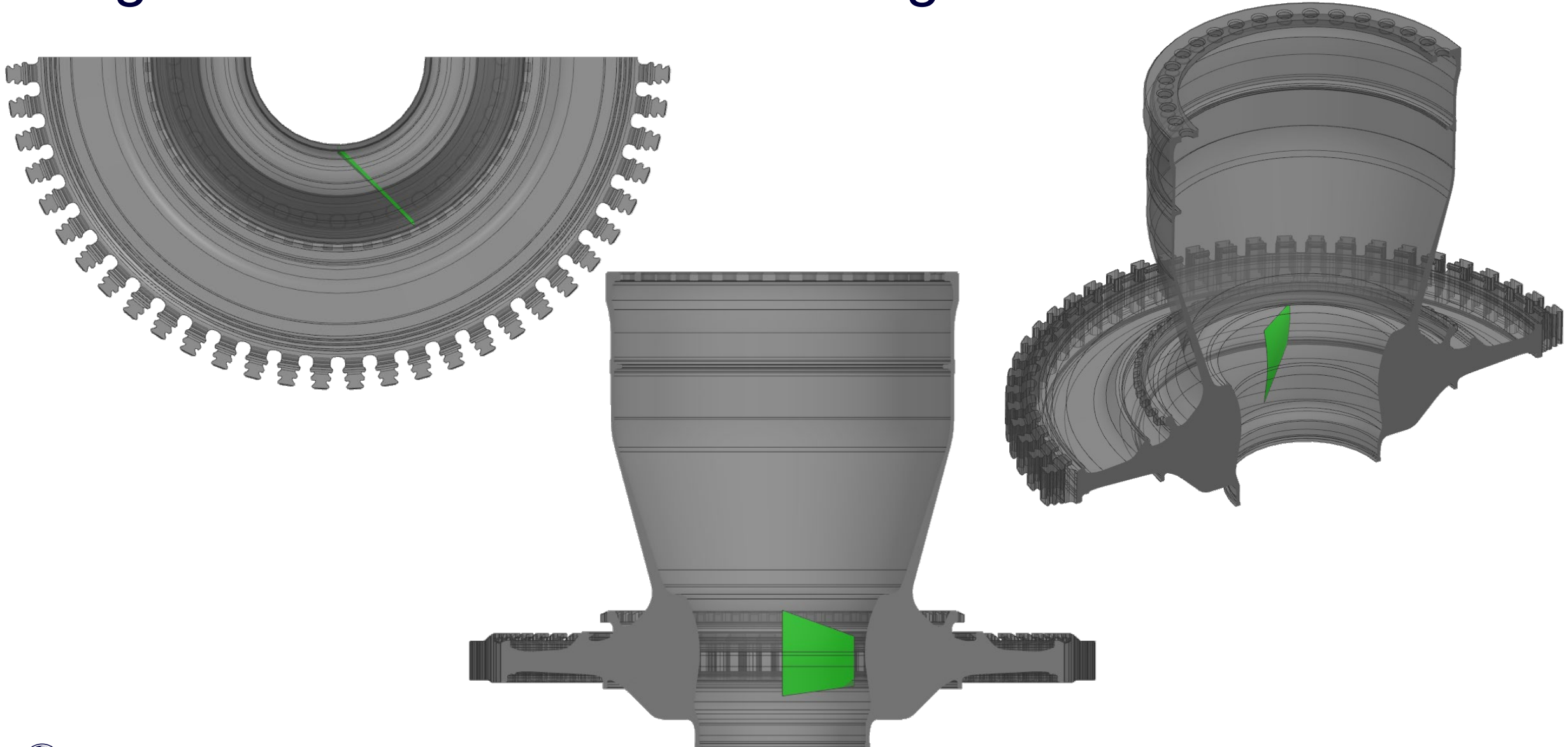


* All angled beams are achieved by refraction.

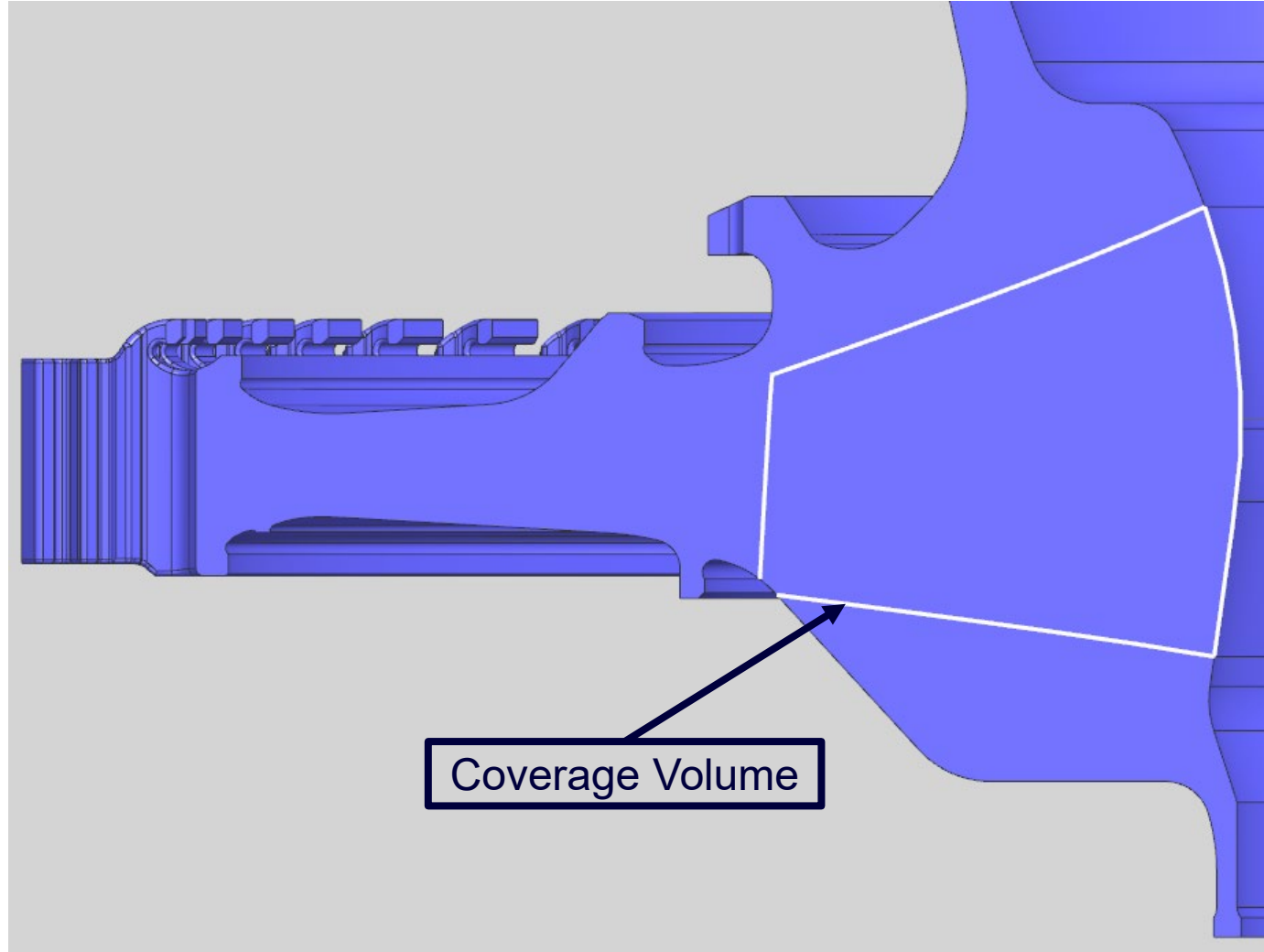
Equipment Overview – S1D Bore



Stage 1 Disk – 45S Bore Coverage

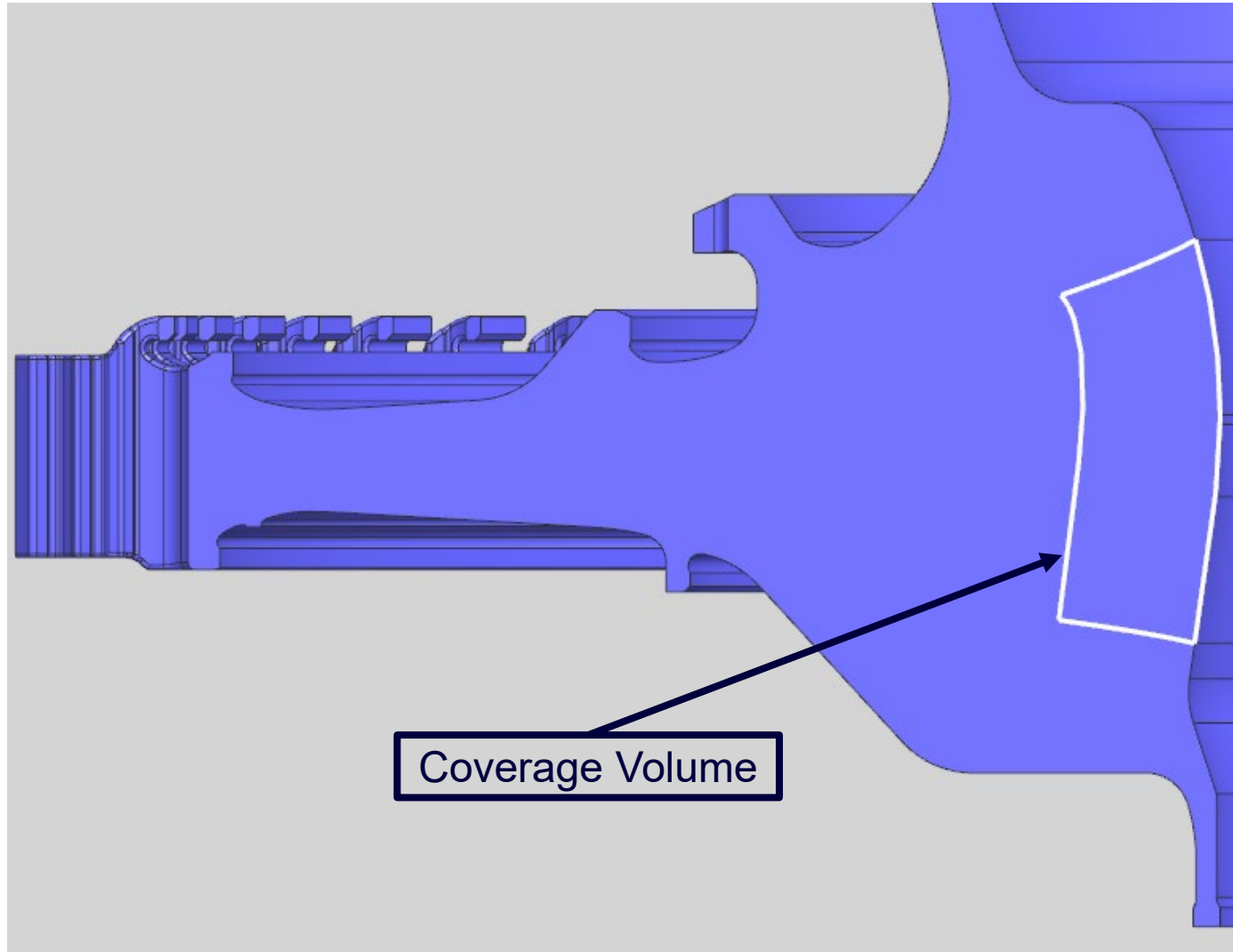


Stage 1 Disk – 45S Bore Coverage



LEAP-1B shown, LEAP-1A similar.

Stage 1 Disk – 65S Bore Coverage

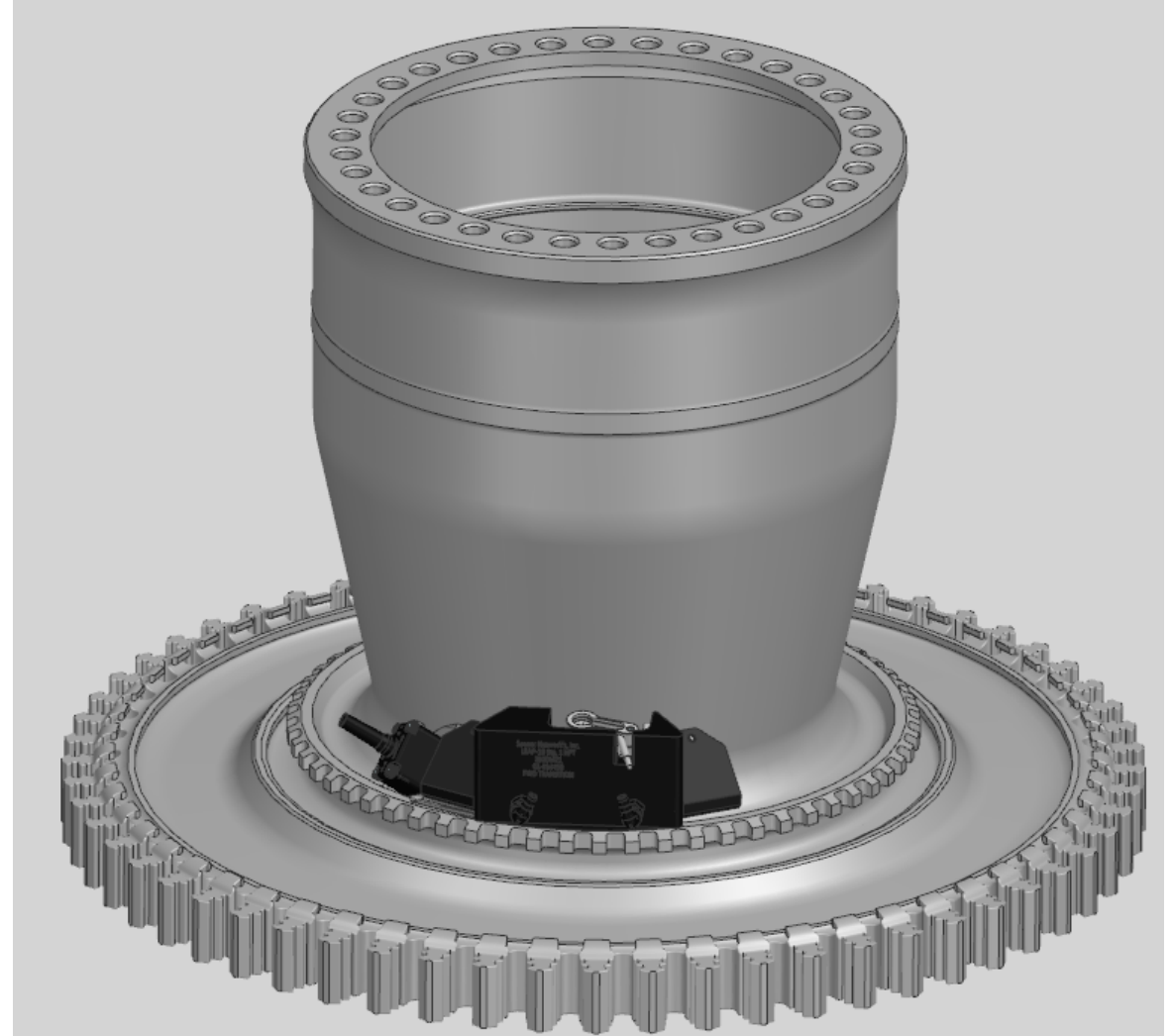


LEAP-1B shown, LEAP-1A similar.

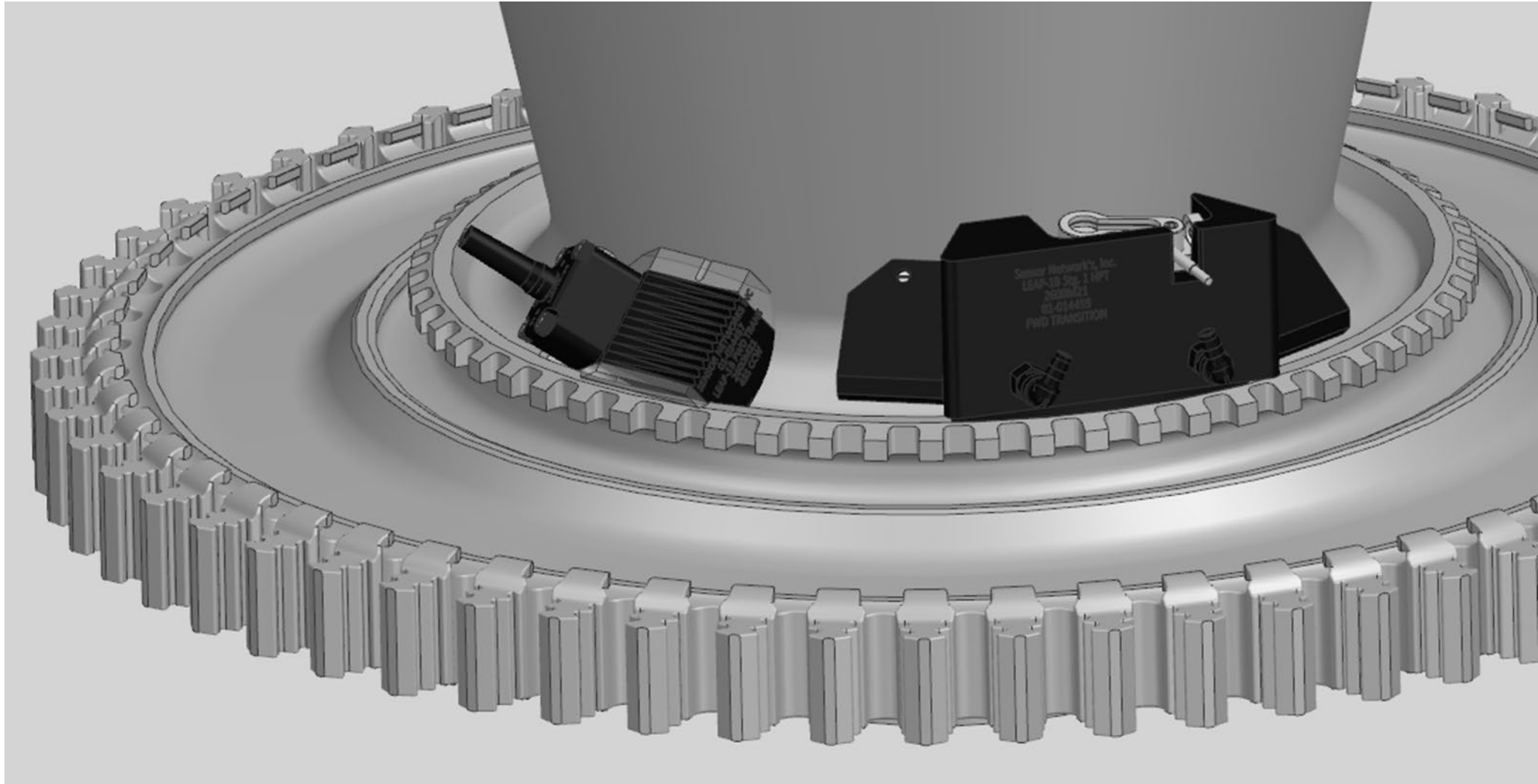
Equipment Overview – S1D Transition

- S1D transition:
 - 5 MHz 16 element linear array.
 - 45S* CW/CCW
 - Custom wedge which contours to the geometry of the S1D forward transition surface.
 - Rotation fixture that rides along the forward transition pocket.
 - Gravity-fed water supply system.

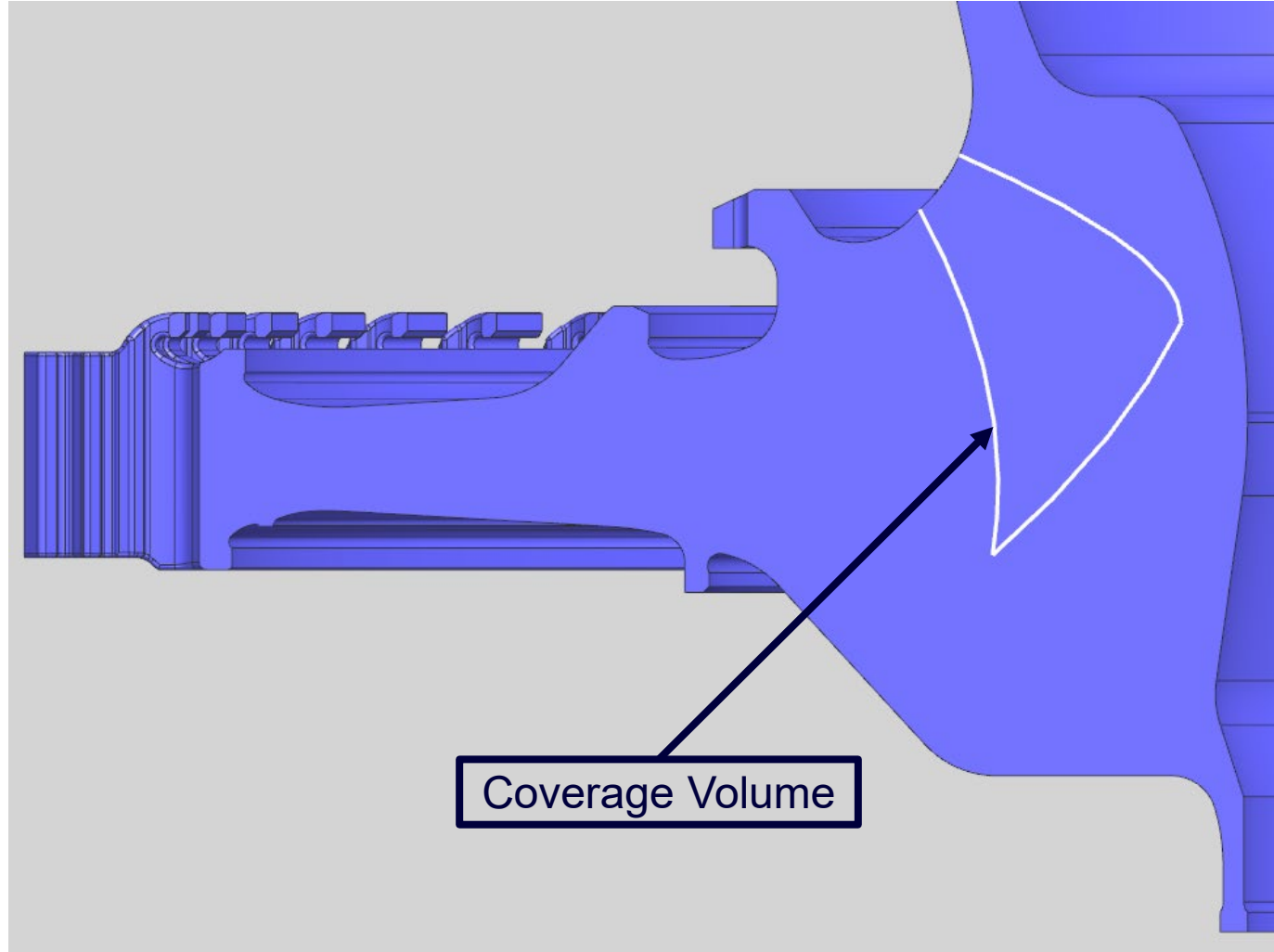
* Angled beams are achieved by refraction.



Equipment Overview – S1D Transition



Stage 1 Disk – 45S Transition Coverage

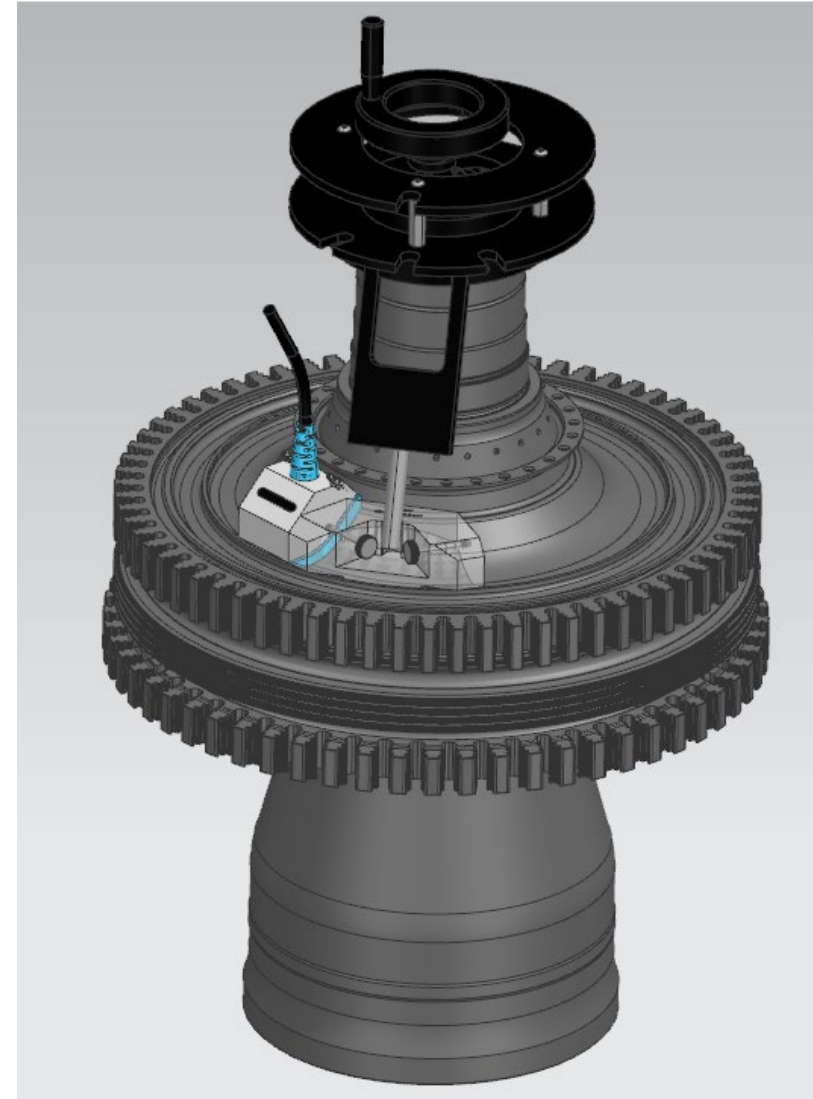


LEAP-1B shown, LEAP-1A similar.

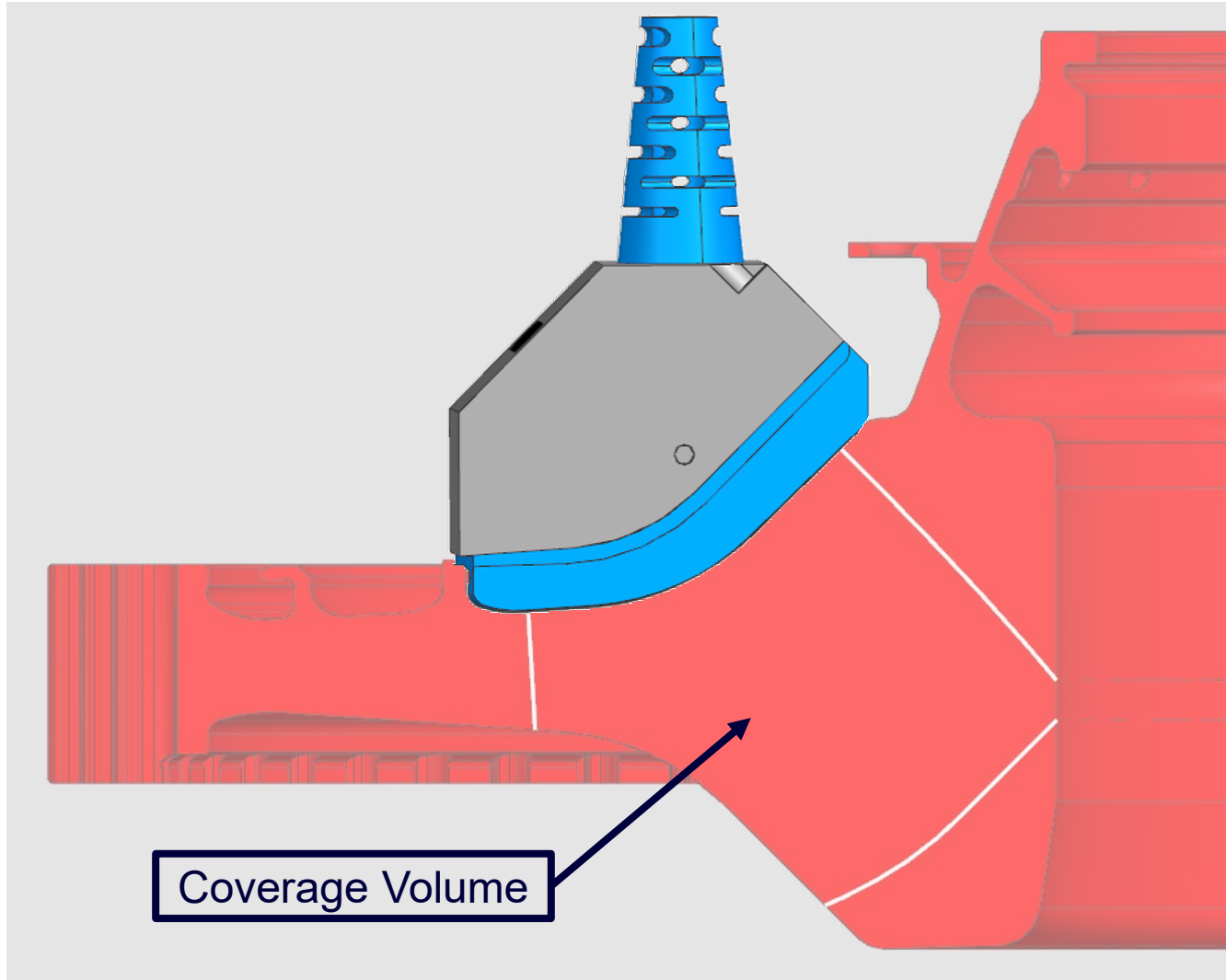
Equipment Overview – S2D Aft Face

- S2D:
 - 5 MHz custom arrays
 - 20L* circumferential CW/CCW
 - 45S* circumferential CW/CCW
 - 65S* circumferential CW/CCW
 - Rotation fixture which mounts to the aft shaft of the S1D.
 - Gravity-fed water supply system.

* All angled beams are achieved by refraction.

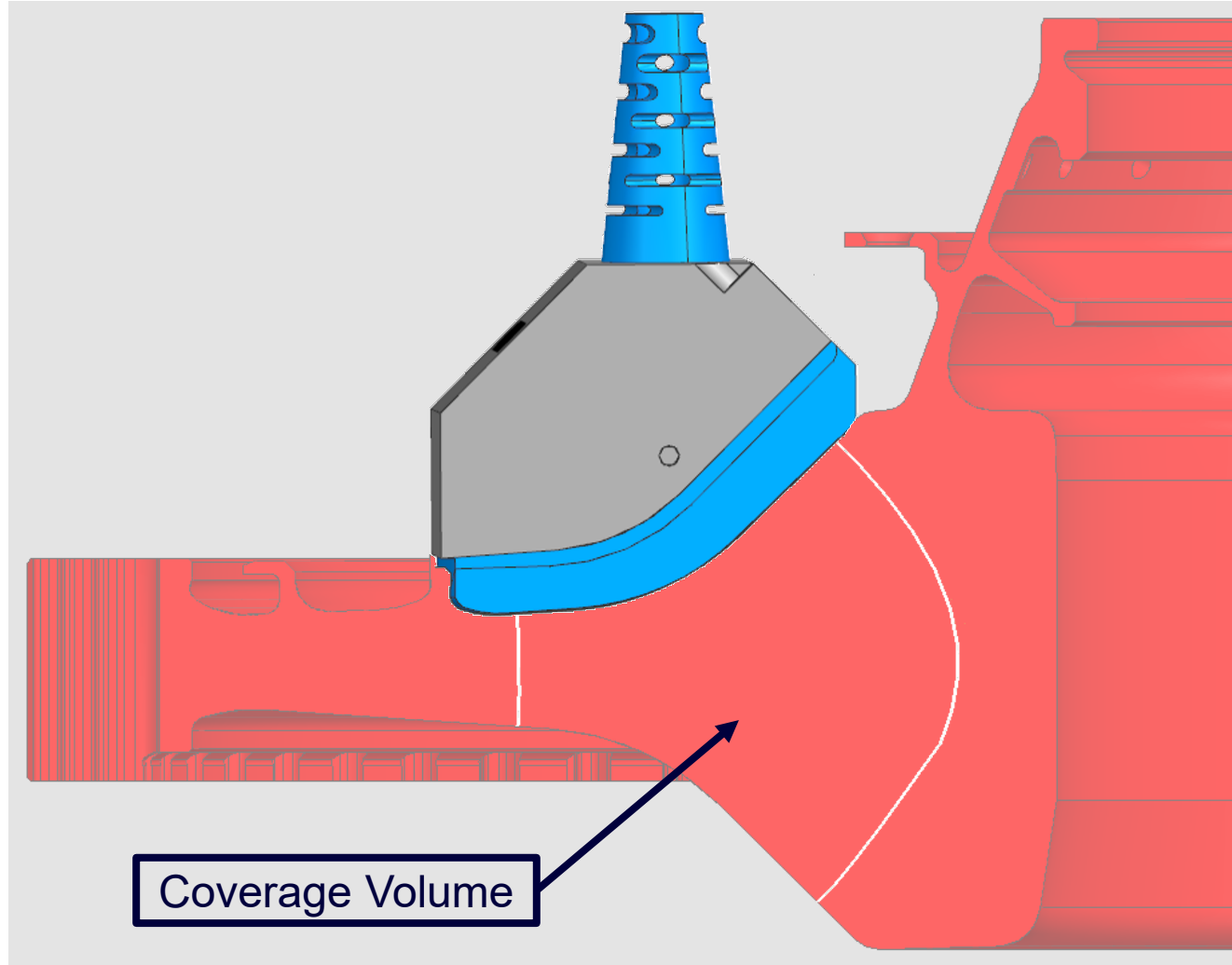


Stage 2 Disk – 20L Coverage



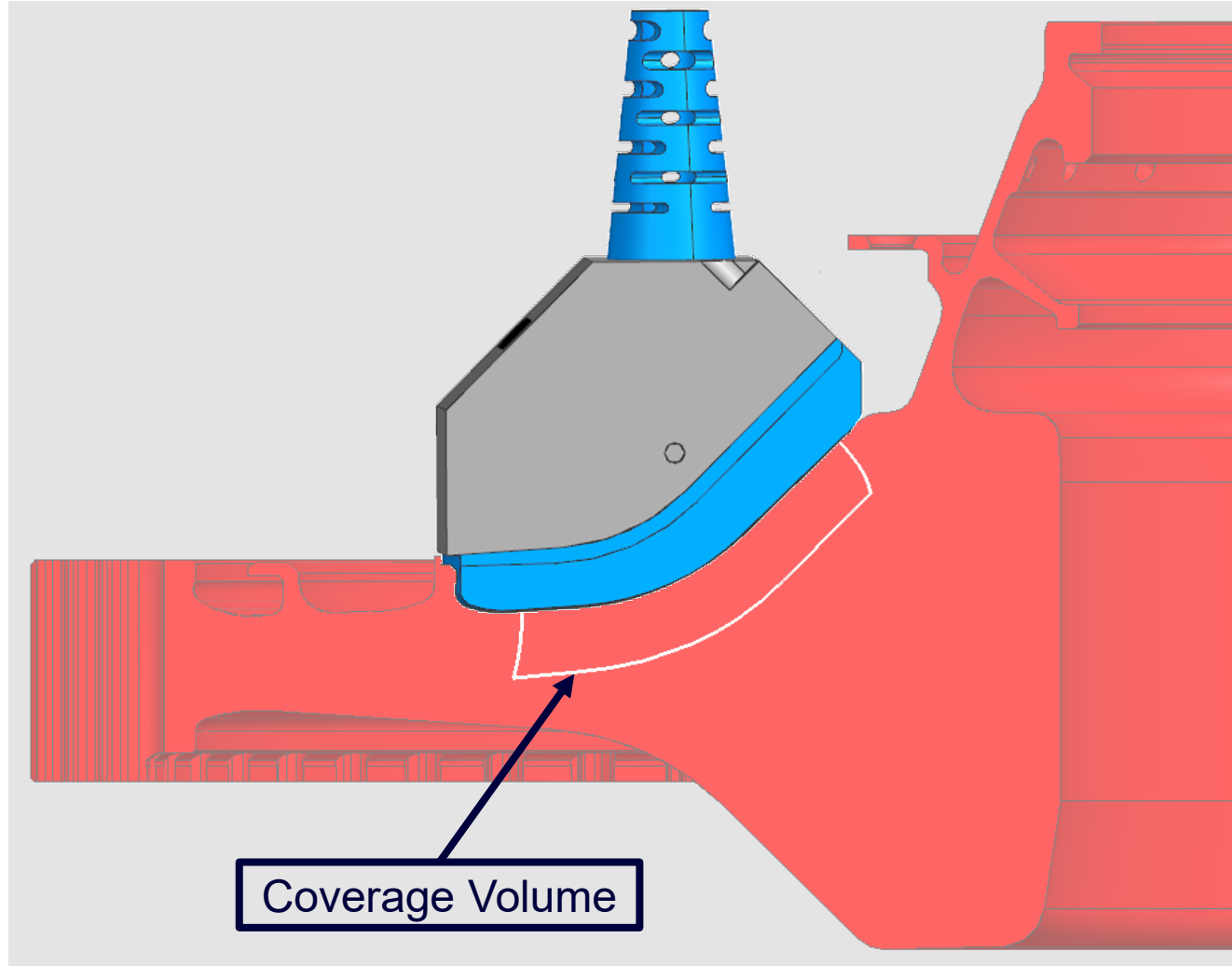
LEAP-1A shown, LEAP-1B similar.

Stage 2 Disk – 45S Coverage



LEAP-1A shown, LEAP-1B similar.

Stage 2 Disk – 65S Coverage

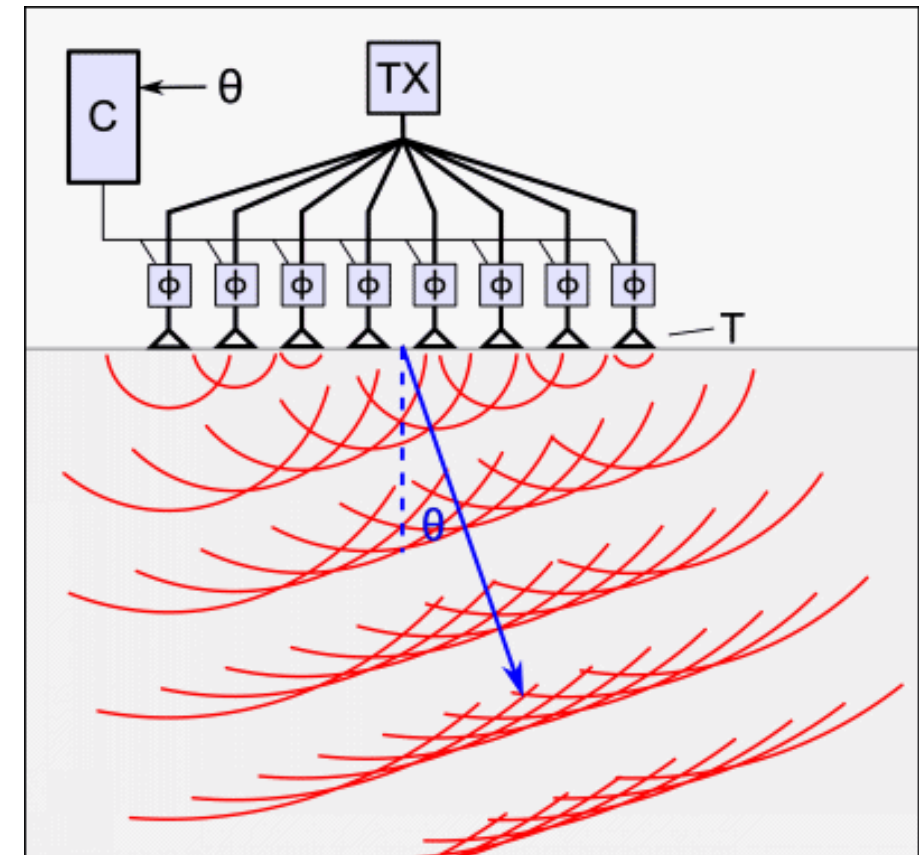


LEAP-1A shown, LEAP-1B similar.

Phased-Array Technology

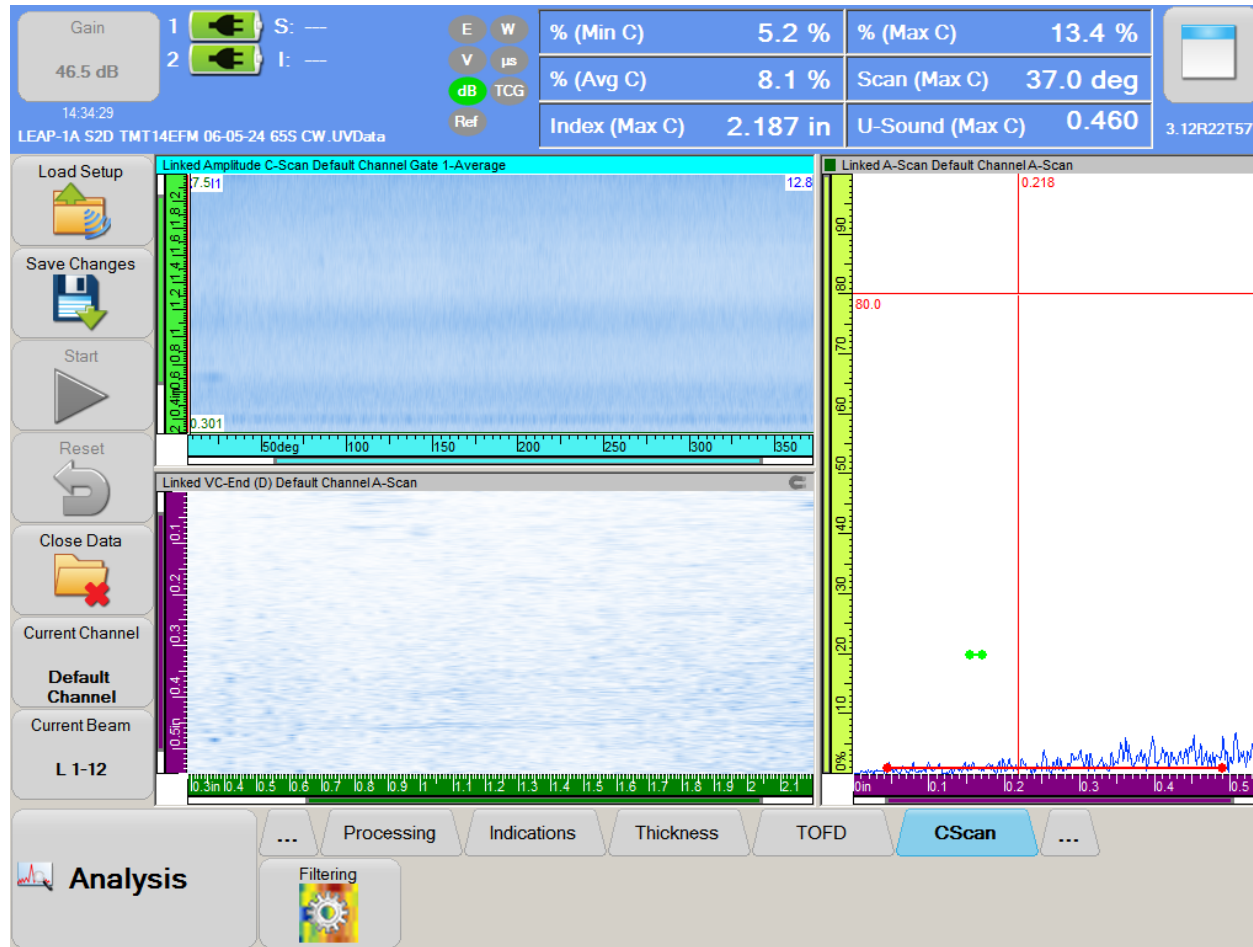
- The advantages of using array technology:
 1. Larger beam footprint / coverage.
 2. Extended coverage with beam steering.
 3. Multi-angle (sectorial) scanning via beam steering.
 4. Multi-zonal focusing via beam steering.
- S2D scans take advantage of the first capability.
- S1D scans implement the first and second capability.
- Long-term goal is to implement capabilities three and four.

Beam Steering with Time Delays



Credit: https://en.wikipedia.org/wiki/Phased_array_ultrasonics

Data Analysis



- A-, B-, and C-scan data presentation for volumetric analysis.
- Full waveform capture
- Amplitude-based rejection criteria with hard threshold.
- Established process for signal-to-noise ratio (SNR) analysis, although not implemented at this time.

Implementation

- Inspection development for both S1 and S2 disks were completed in Q3 2024.
- Equipment manufacturing commenced mid-2024 and is ongoing..
- 20+ global shops currently trained and performing inspections on the S1D.
- The S2D inspection, due to the need of removing the aft seal, has not yet been implemented.
 - Slated for Q2 2026.





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