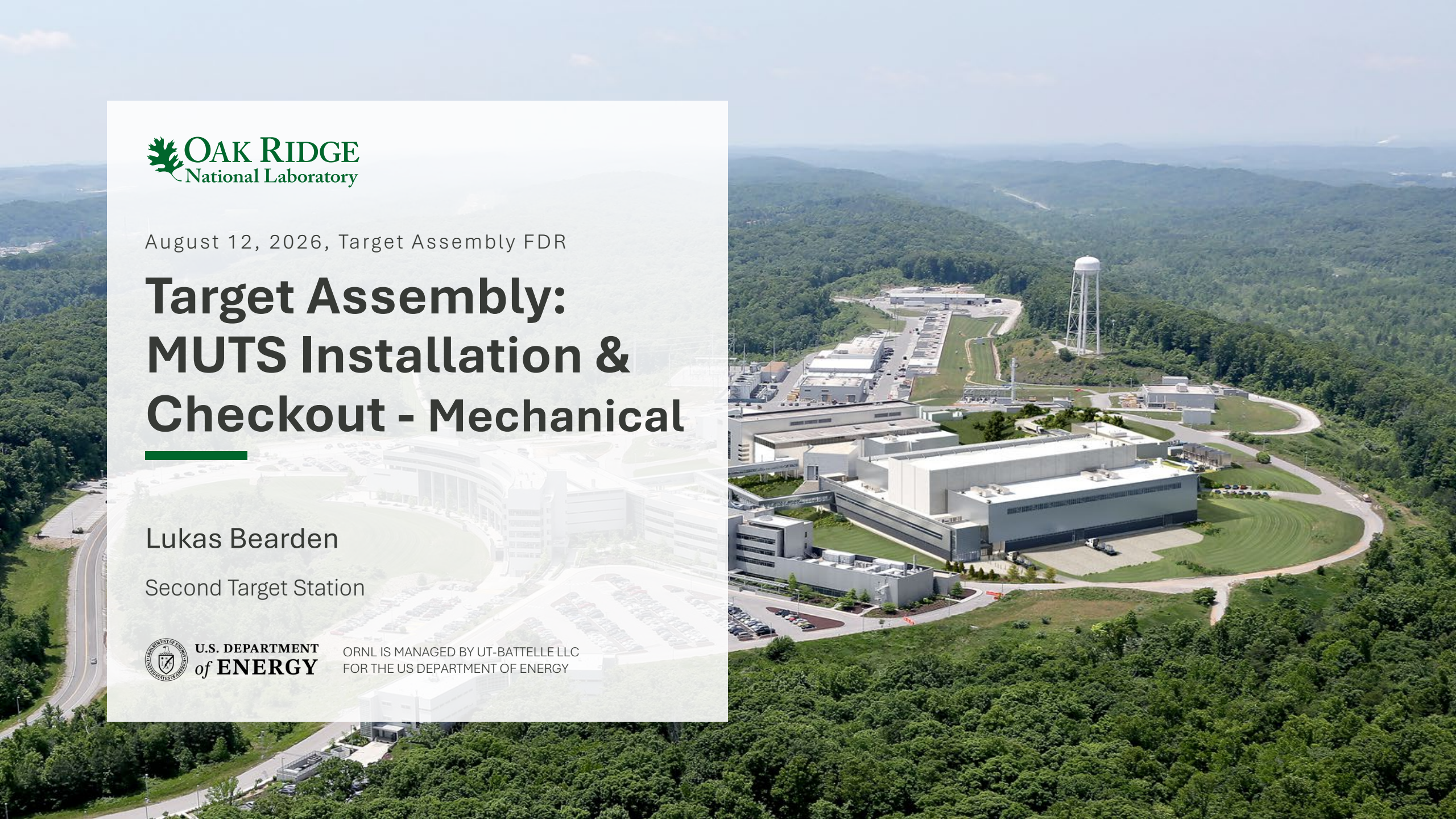

OAK RIDGE National Laboratory

August 12, 2026, Target Assembly FDR

Target Assembly: MUTS Installation & Checkout - Mechanical

Lukas Bearden

Second Target Station

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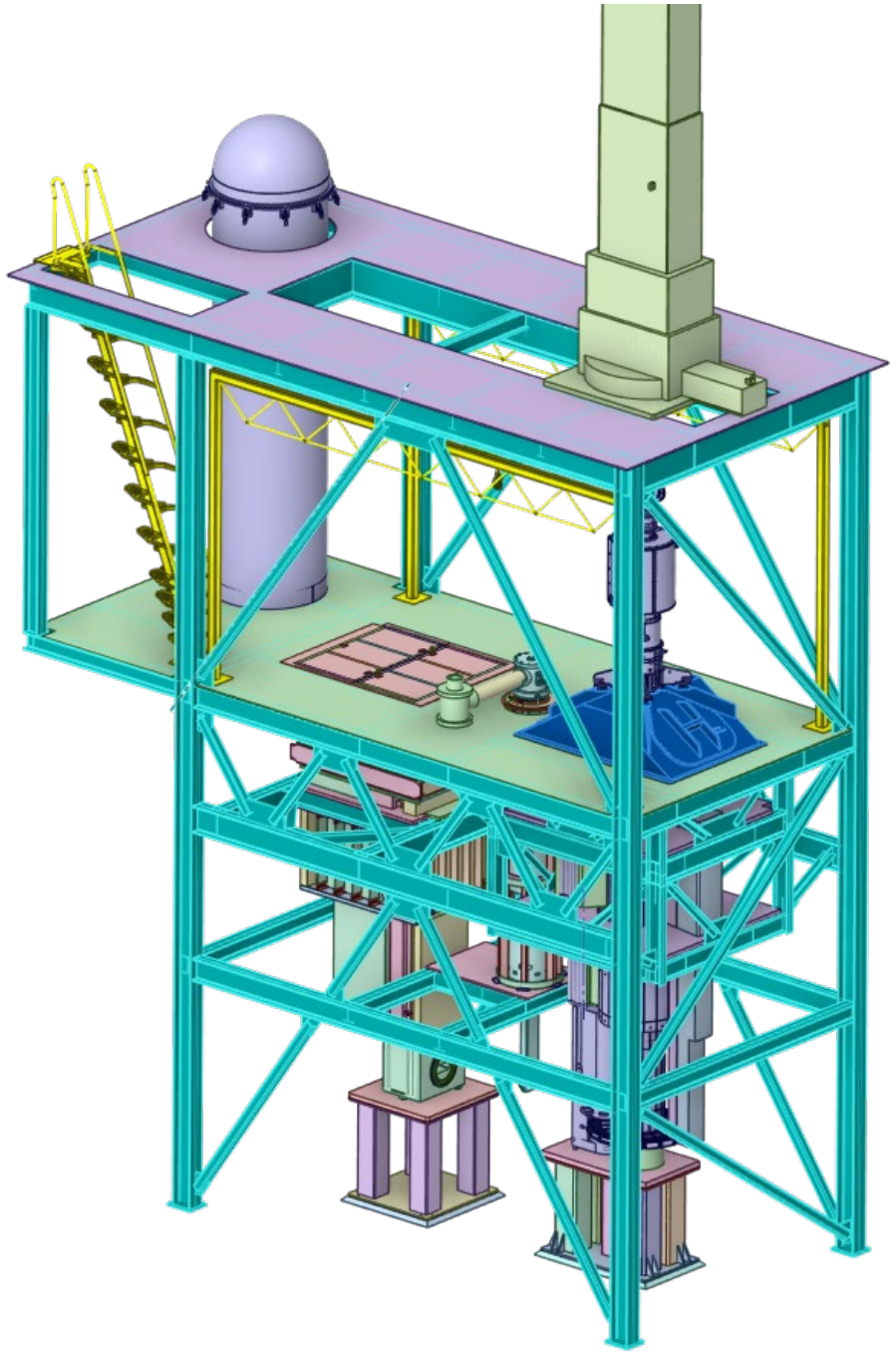
Charge Question 3: Do DACs and other supporting documentation adequately support the final design?

Overview
MUTS: MockUp Test Stand

- Steel frame that represents all the primary mount features and locations of the Core Vessel.
- Location of shaft assembly work
- Location of Target Assembly initial assembly work and verification testing.
    - Rotation
    - Controls tuning
    - Alignment to MRA
    - Test alignment to TVP
    - Remote Handling verification and training

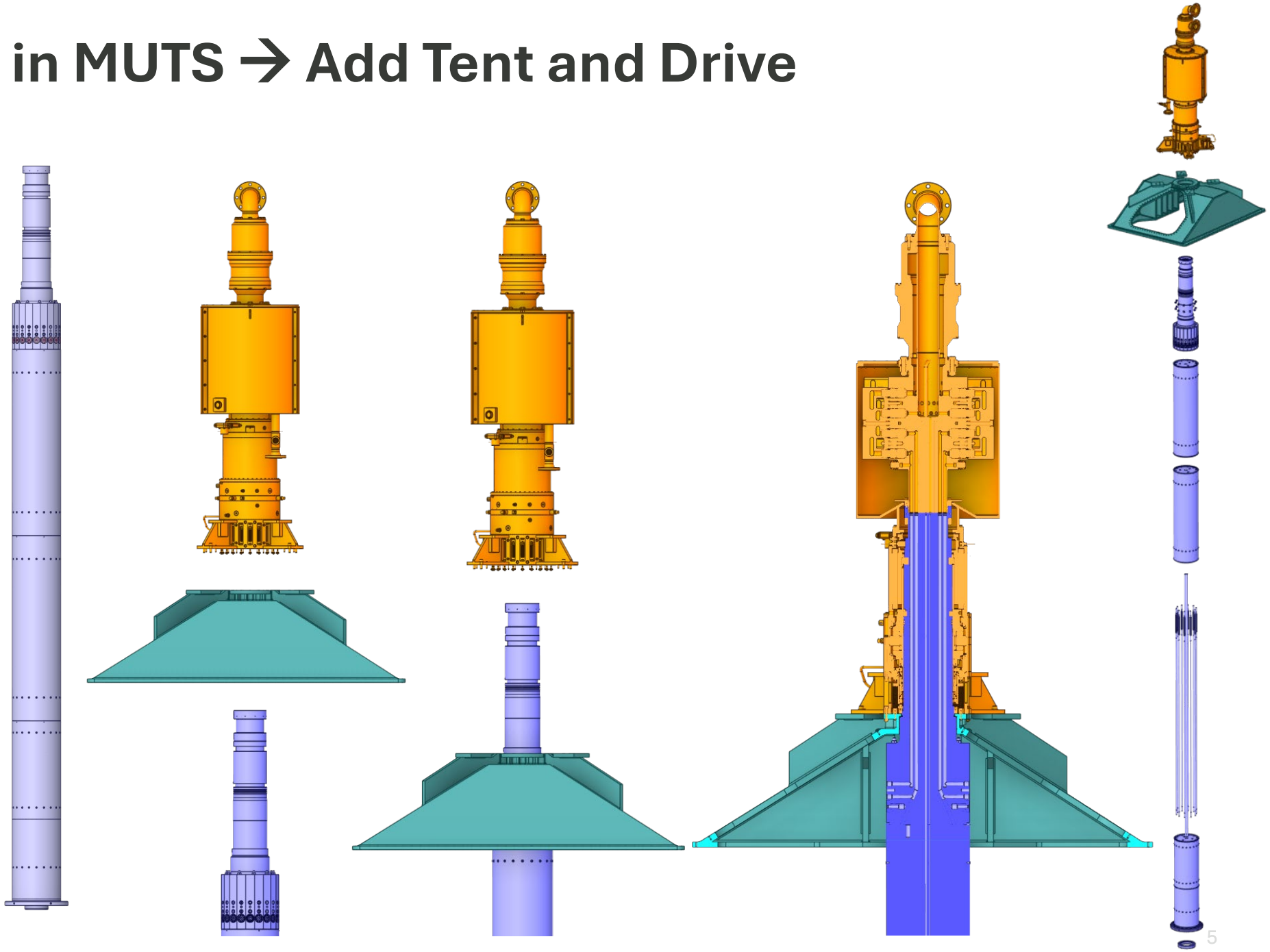


MUTS Context within Facility

- Located downstream of beam and north of the service cell
- Top of MUTS approximately level with high bay
- Accessible via high-bay crane

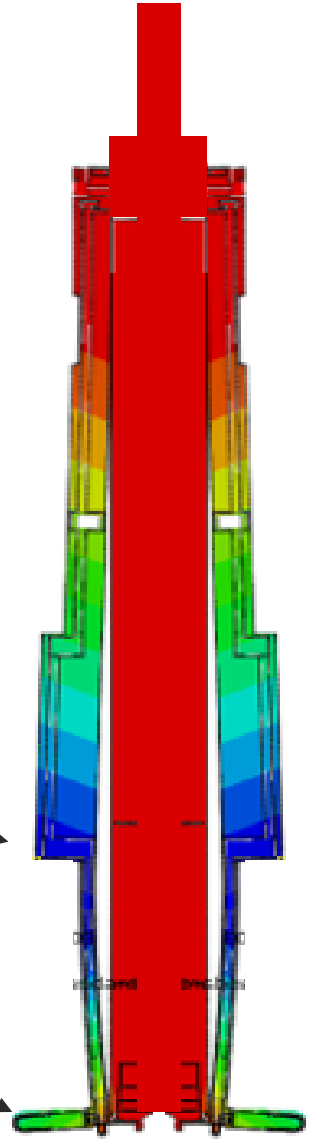
Assemble Shaft in MUTS → Add Tent and Drive

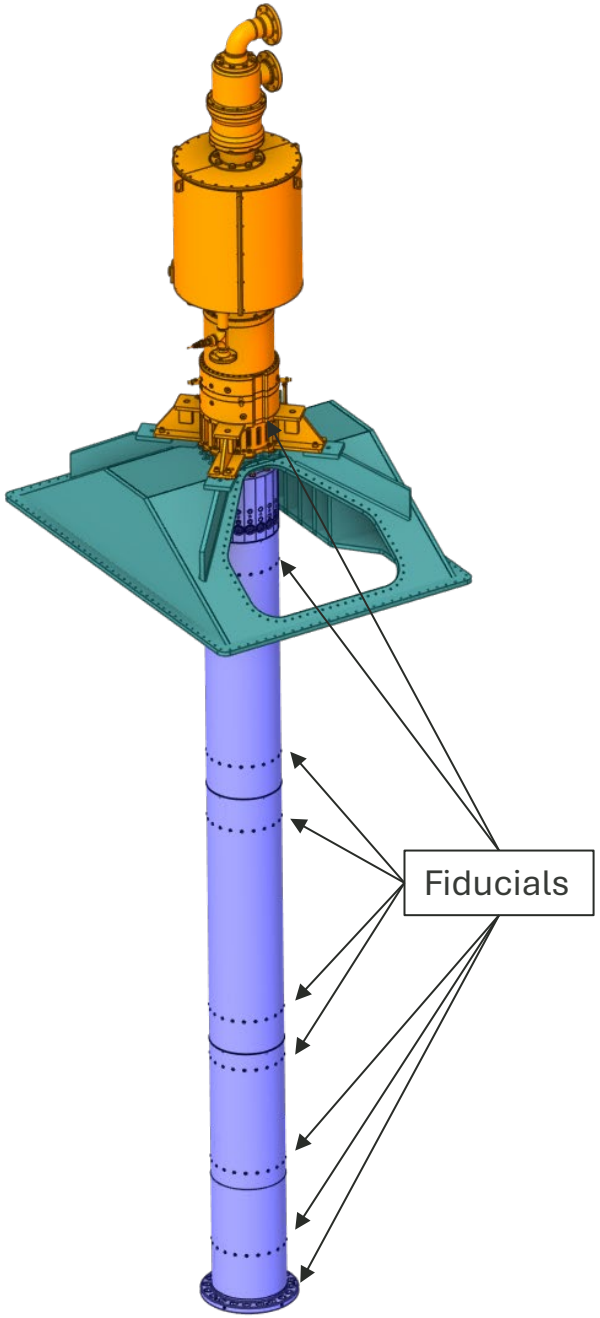
- Build shaft in-place in MUTS
- Install lid “Tent”
- Install Drive assembly and pull shaft up into assembly
- Finish Target Assembly Installation



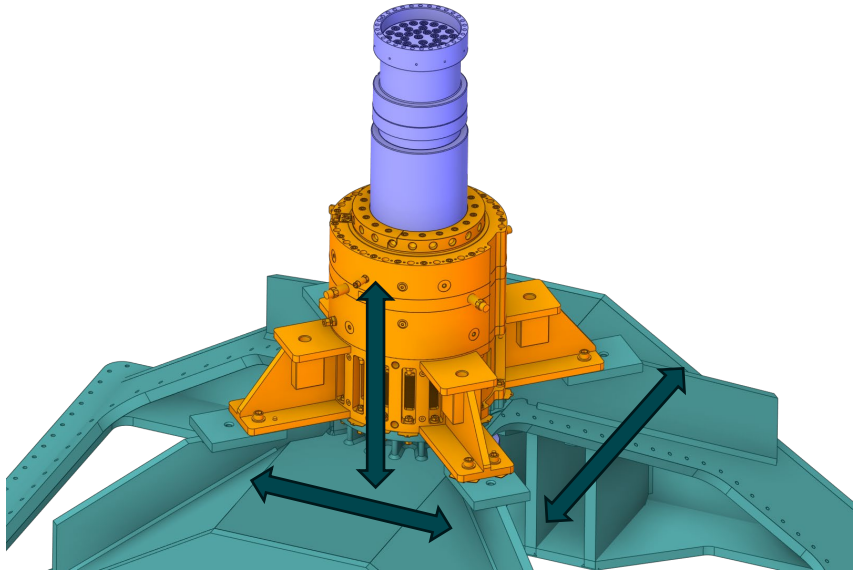
Metrology – Geometry Verification

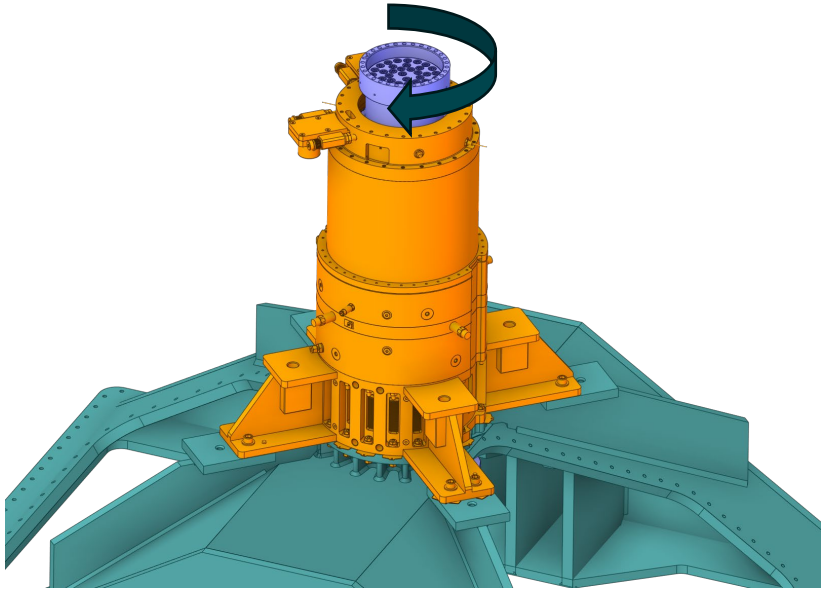
- Fiducial map of entire shaft & drive without segments
- Fiducial map with segments
- Shaft runout
- Fiducial map with segments
- Segment rotation measurement
    - Donut radial deflection
    - Foot vertical deflection
- Pin Pocket clearance verification





Function & Operation Verification

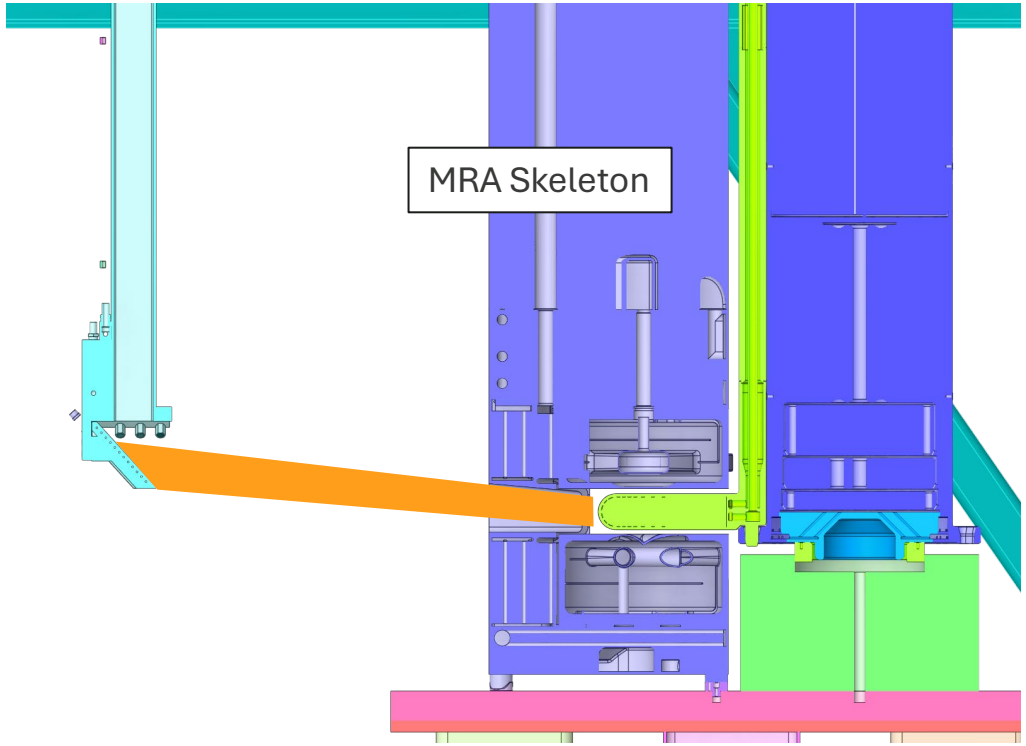




- Test drive leveling (vertical)
- Test drive position adjustment (horizontal)
- Rotation test
- Startup/shutdown speed
- Rotary seal leak rate test
- System pressure-drop test
    - Segments
    - Shaft
    - Assembly
- Remove-install segments
- E-stop test

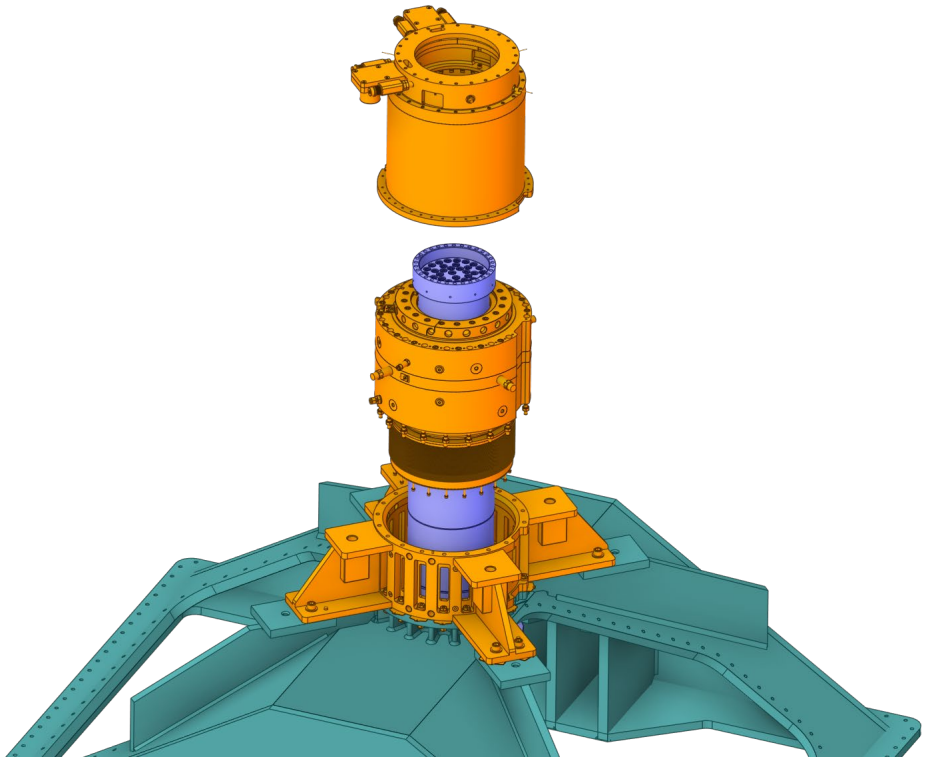
Cross-System Verification

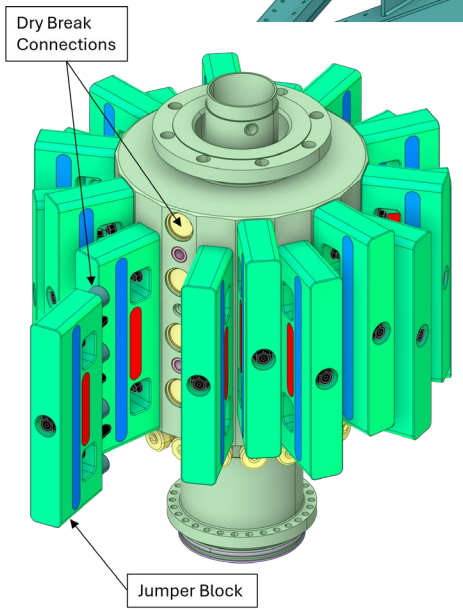
- Test position, fit, and rotate with skeleton MRA
- Target “Nose” view from TVP



Maintenance

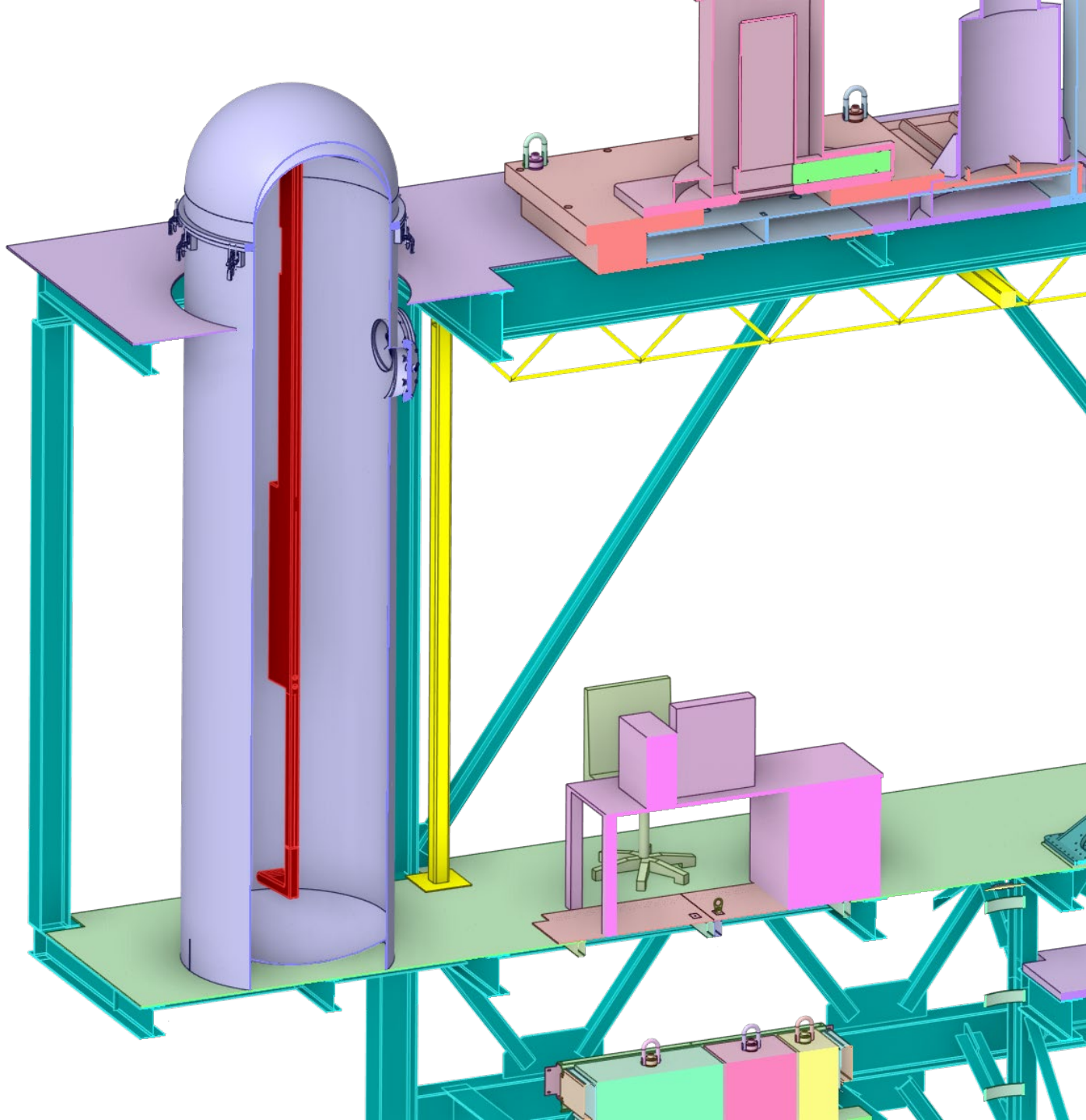
- Test each maintenance event
  - Motor replacement
  - Bearing replacement
  - Resolver replacement
  - Sensor replacement or adjustment
  - Segment replacement
  - Water jumper replacement
  - Water manifold and union replacement





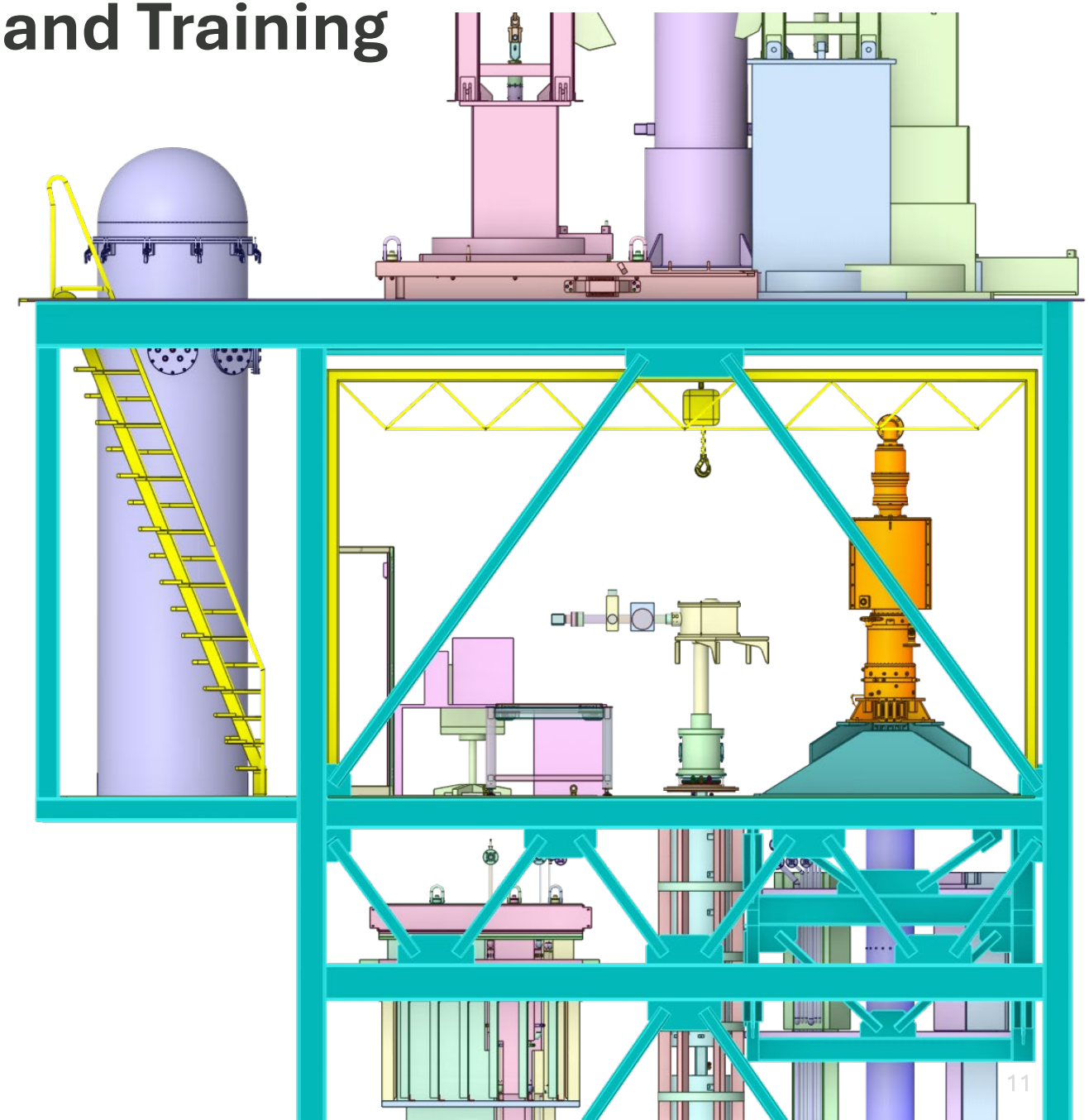
Future Possibilities

- Vacuum leak check Shaft
- Vacuum leak-check individual Segment



Remote Handling Verification and Training

- First segments(s) installed to Target Assembly in MUTS
- Removal process also practiced
- Install 20 segments to test run
    - Installation
    - Rotation
    - Balance
    - Operation/Controls refinement
- Remove 20 segments to move shaft from MUTS to CV
- Assembly and disassembly of Drive serves as a procedural practice of the operations. Further practice enabled by full assembly setup, and hoist/crane internal to MUTS
- Test maintenance access and procedures.



OAK RIDGE National Laboratory

August 12, 2026, Target Assembly FDR

Target Assembly: MUTS Installation & Checkout - Controls

Tommy Michaelides

Second Target Station

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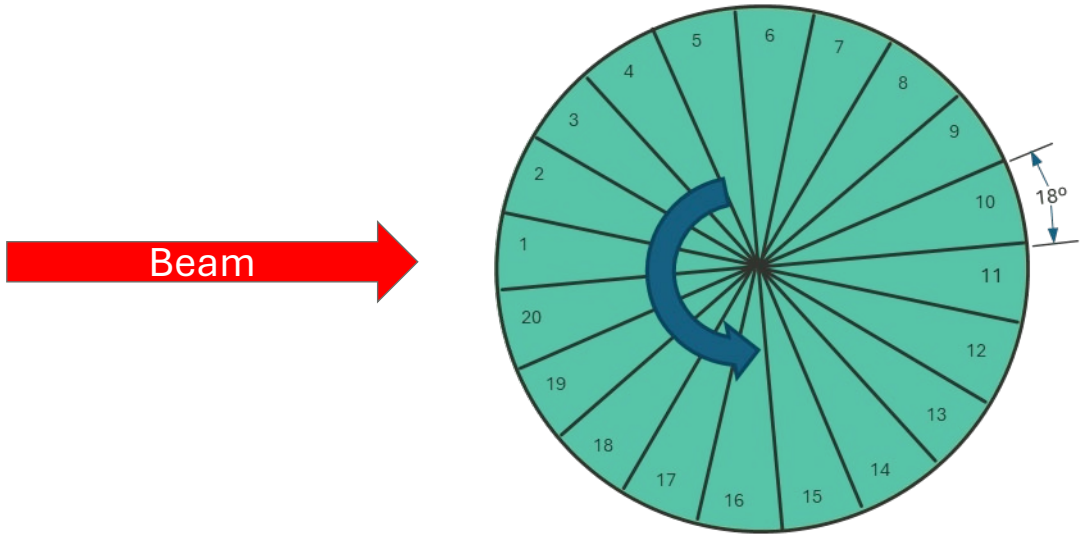
Target Rotation – Controls

- Convert the timing signal to a digital format and use it to coordinate the target's rotation.
- Analyze how to address movement if the timing signal is interrupted.
- Assess the resolver's performance and determine the best way to use it in the program.
- Characterize the signal performance of the eddy current sensors.
- Comprehend the operational principles of the AKD servo drive.
- Evaluate several motion control modes (jogging, electronic camming, S-curve, Torque—hold) to better control the target rotation.
- Mechanical performance of the target wheel, sensor mounting, vibration, etc.

SNS Timing Signal Synchronization

- Verify and validate the timing signal, which is essential for synchronizing the target's rotation with operational requirements.
- The timing signal is converted to a digital format, enabling precise coordination of the target's movement.
- Document and test scenarios where the timing signal might be interrupted, ensuring the system (target rotation) can respond safely and maintain control.
- Angular position will be controlled via the motion control system by monitoring position to ensure the target has rotated 18º per beam pulse and adjusted as necessary.

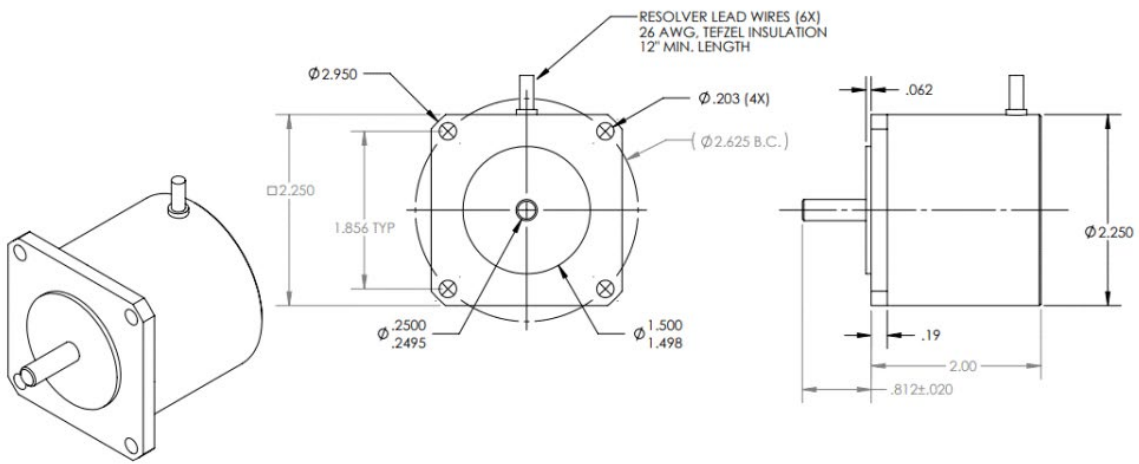


15 Hz beam pulse = pulse every 67ms

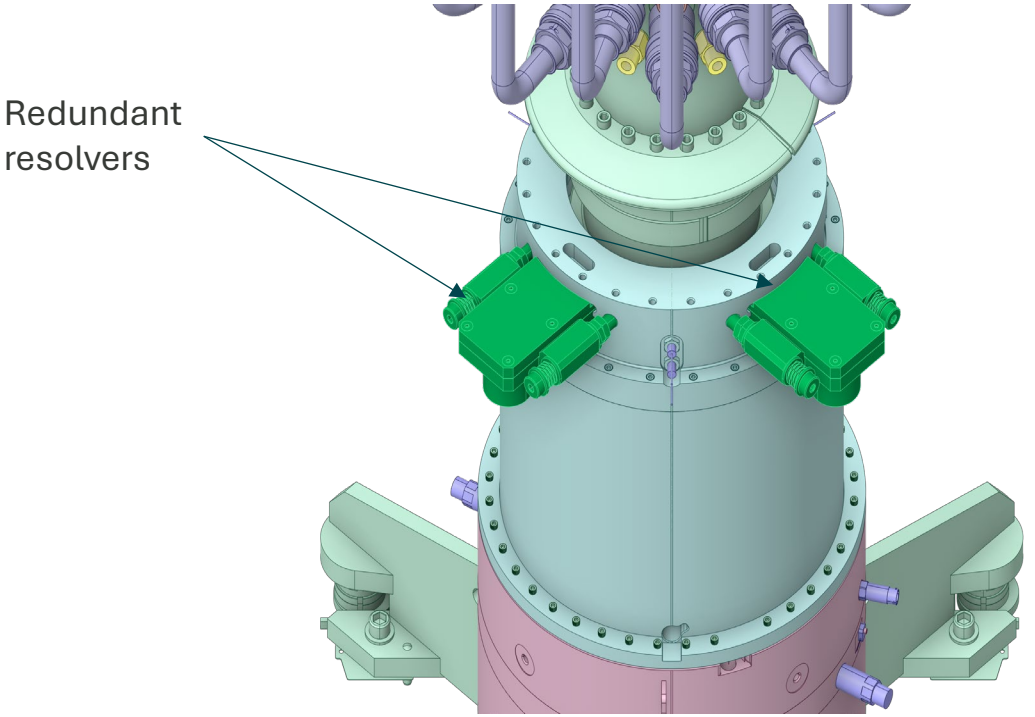
45 rpm = 0.75 rps = 360º/sec
360º/20 segments = **18º per pulse (67ms)**

Resolver Performance Validation

- Two resolvers used to measure rotational position will be evaluated for their performance and reliability.
- The best method for integrating the resolver into the control program is determined, ensuring accurate feedback for rotation control.



COTS - Resolver from Empire Magnetics

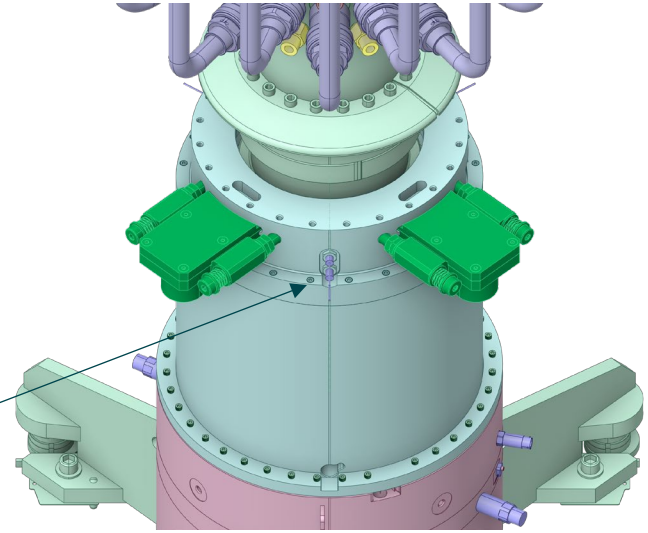


Eddy Current Sensor Characterization

- The signal performance of the eddy current sensors is characterized.
- These sensors are used to detect the homing position, movement and contribute to precise control and monitoring of the target wheel.
- The homing sensors will also be used for target imaging and to track deposited energy per segment

Emerson AMS EZ 1000
Eddy current sensor converter

Eddy current sensor



2 x Homing Sensors
1 x at 0º
1 x 180º

AKD Servo Drive and Kollmorgen Controller Characterization

- The AKD servo drive is responsible for powering and controlling the rotation of the target wheel.
- Understanding its functions is crucial for optimal setup and troubleshooting during testing and production.
    - Tuning and optimizing the drives to the target
- Utilizes deterministic EtherCAT technology and is ready for analog Sine/Cos resolvers

1 x Kollmorgen Controller
2 x AKD Servo Drives
1 x group of remote I/O modules

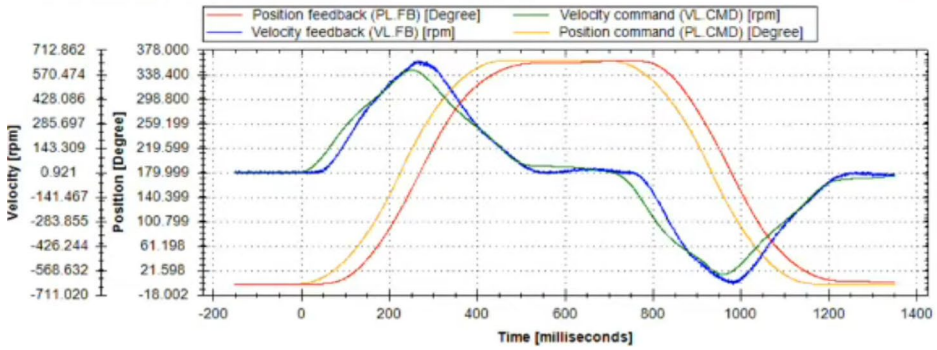
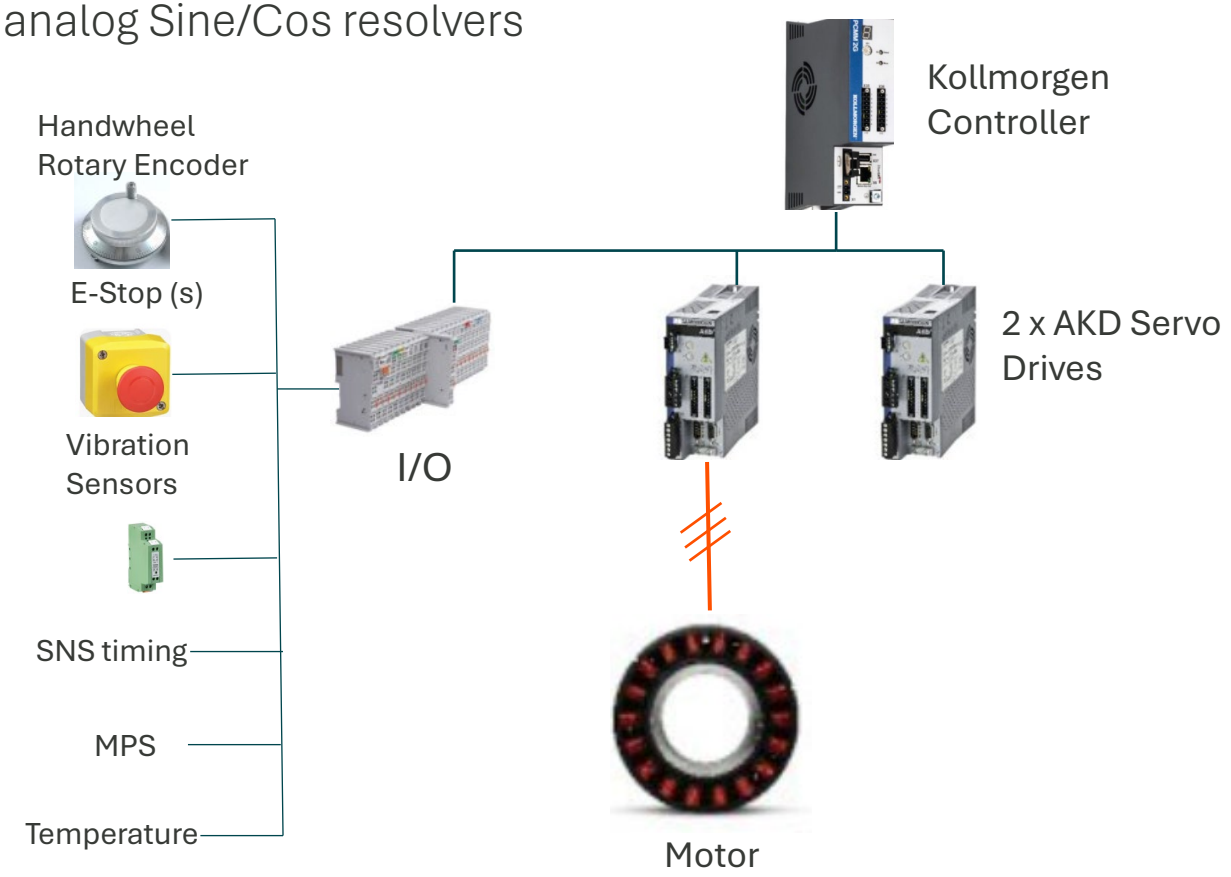


Figure by Kollmorgen - AKD Servo tuning example



Motion Control Modes Evaluation

- Several motion control modes are evaluated to optimize target rotation
- Jogging: Manual movement for setup and adjustment
- Electronic Camming: Synchronizes rotation with external signals or events
- S-Curve: Smooth acceleration and deceleration for reduced mechanical stress
- Torque-Hold: Maintains a specific torque to stabilize the target during operation

Each mode will be tested to determine the best approach for reliable and precise rotation

Why Do These Tests Matter?

- The mechanical and electrical performance of the target wheel is assessed, including sensor mounting and vibration analysis.
- The validation and verifications ensure that the physical components operate smoothly and that sensors provide accurate data for control systems.
- Safety and Reliability: By thoroughly testing controls and rotation, we ensure that the target assembly operates safely and reliably under most conditions.
- Precision: Accurate synchronization and feedback are critical for the success of experiments and operational integrity.
- Troubleshooting: Early identification of issues with sensors, drives, or control modes allows for proactive solutions before deployment.

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