National Radio Astronomy Observatory
VLBA Antenna Memo Series – No. 109
Chantel Flores
TRIP REPORT – North Liberty, October 20-25, 2025

1. Trip Summary

A group from the VLA traveled to the North Liberty, Iowa VLBA station to rebuild all four gearboxes and replace one of the FRM linear shafts:

Chantel Flores

Norman Aguilar

Kole Mishoe

Along with the help of VLBA site techs:

Michael Burgert

Jared Winter

And remote support by:

Lorenzo Benavidez

David Dirymeyer

Kelly Greene

Michael Torres

Brent Avery

2. Plan Summary

Available workdays would be Monday through Saturday to complete all scheduled tasks. Work was planned around the site-specific weather forecast. Work procedures ensured that essential guidelines and best practices were followed to ensure safety when working on site.

3.Trip Details

Departure: Albuquerque, NM [Sun Oct 19th], Arrival: Cedar Rapids, IA [Sun Oct 19th]

Departure: Cedar Rapids, IA [Sun Oct 26th], Arrival: Albuquerque, NM [Sun Oct 26th]

The NL trip was extended by two days due to an elevation drive system failure, which required part replacement that was not on hand. Shipping arrival delayed a sooner return date. Original visit was scheduled for a departure date of Friday, October 24th.

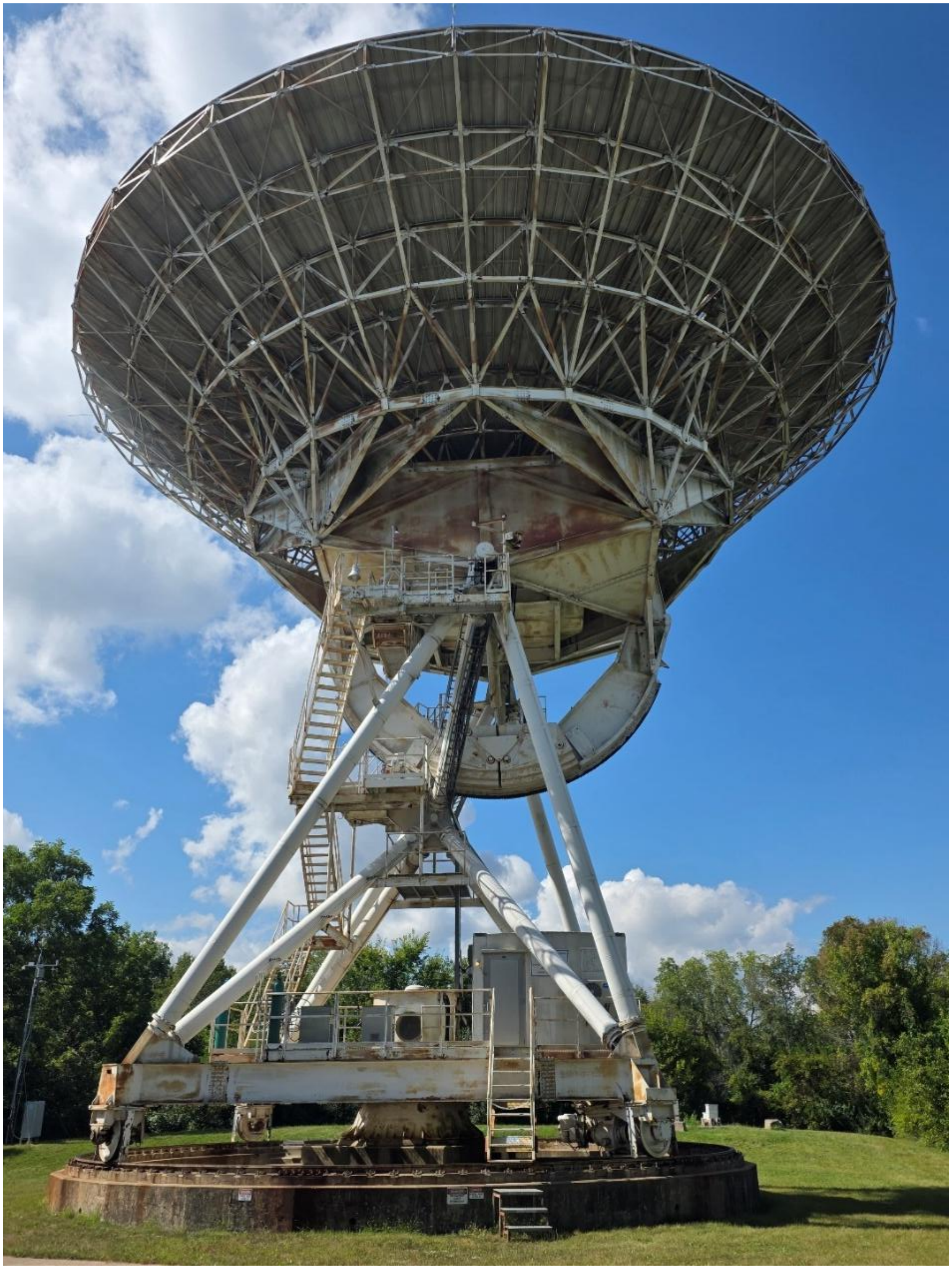

Figure 1: North Liberty, IA

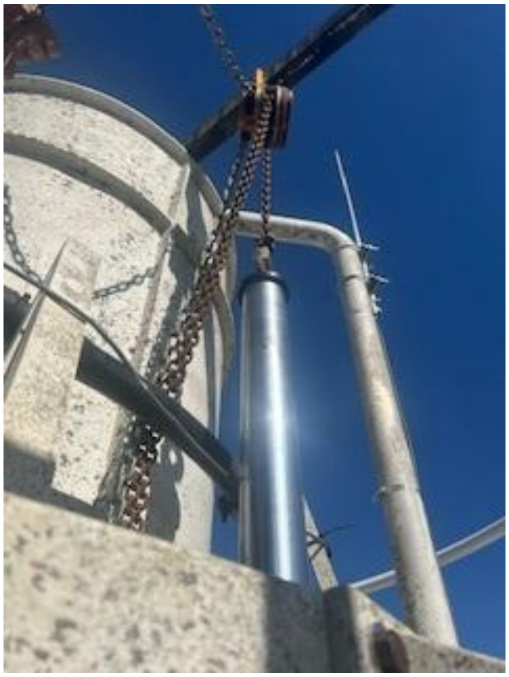

Figure 2: FRM Linear Shaft

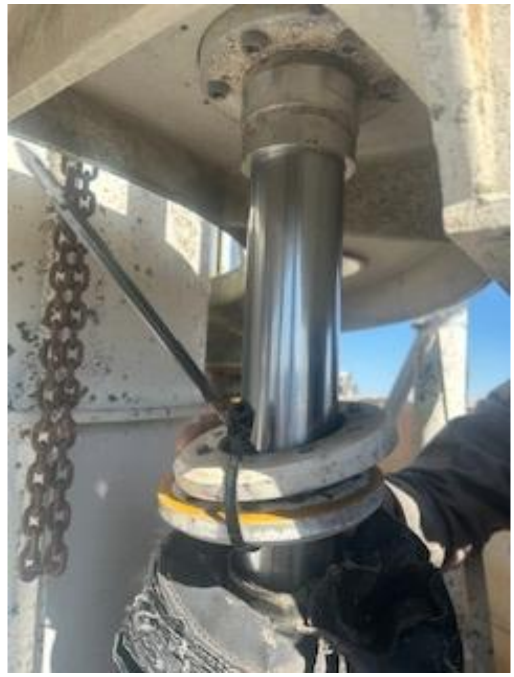

Figure 3: FRM Ringfeder

4. FRM Linear Shaft

One of the four FRM linear shafts was reported to have scoring. It was additionally relayed that there was oil leakage coming from the traversing ring where the linear bearings are housed. The shaft site in question was located below the flex shaft closest to the bevel gearbox (non-focus motor side). The replacement of the linear shaft was performed in situ. Prior to the maintenance visit, the sequence of operations was worked out on the VLBA FRM spare in the AAB. This is the first time a linear shaft replacement has been preformed in the field.

The 53-inch-long Thomson "lite" shaft spans across the three casted 67.5-inch diameter FRM rings. A lifting device was custom made to raise and lower the shaft, which anchored to the top of the subreflector support tube. This aided in the removal and installation of the 37lb shafts. Each of the three rings contain components supporting the shaft. Once the FRM was driven to the desired position, the apex E-stop was engaged on the FRM J-box and the FRM was locked out. We worked within the apex ring breaking loose all fasteners on the various components along the bottom, middle (traversing ring) and top ring. All components [see drawing no. 6100-04 C], fasteners, O-rings, bellows, seals and packing were replaced.

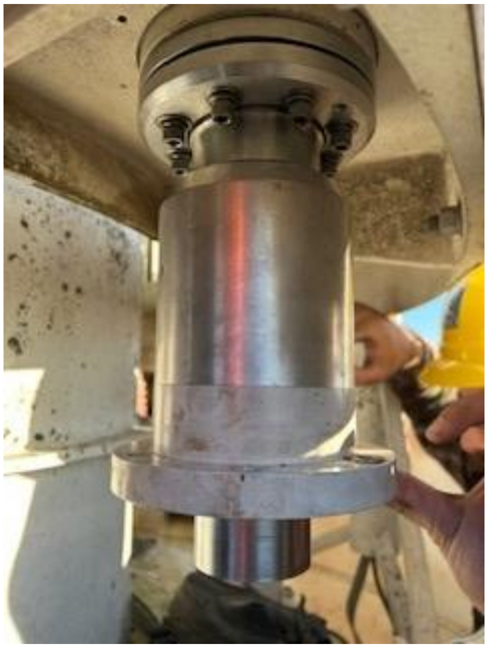

Figure 4: FRM Bearing Mount (Topside)

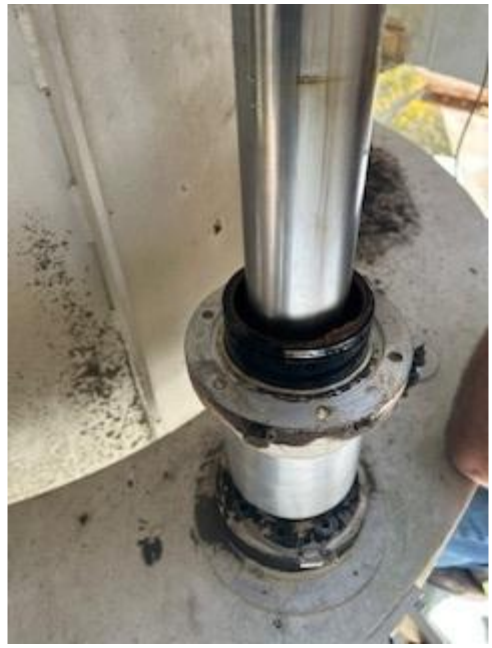

Figure 5: FRM Bearing Mount (Bottomside)

The already assembled bearing mounts brought, required replacement of their wiper seals. This seal lip type includes one external scraper and one inner rubber wiper lip. This style scraper seal creates a tight seal on the shaft and prevents debris from entering the linear bearings. It's important to note that these scrapers are outward facing. Since the ends of our shaft do not have a lead chamfer, the running surface needed to be coated (oiled) to reduce friction between the shaft and the scraper edge during installation.

The middle rings topside bearing mount seal can be round formed by temporarily turning the bearing mount upside down and sliding the shaft through. This allows for the shaft to easily fit through the housing bore during final install without damage to the scraper seal.

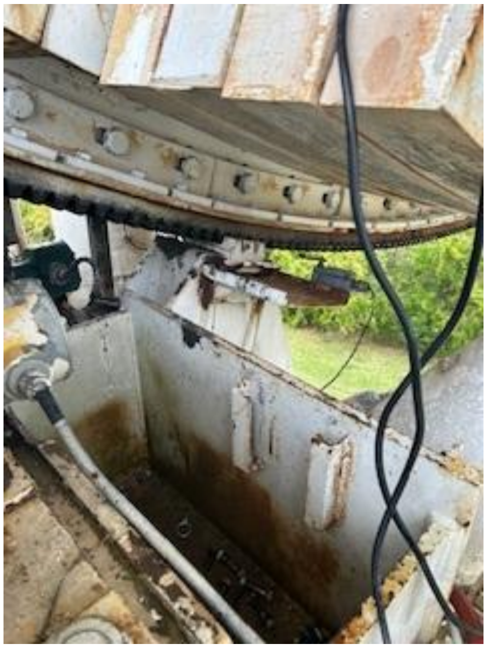

Figure 6: Elevation Stow Pin

In both cases of the FRM linear shaft and elevation gearbox rebuilds, the stow pin was inserted as a safety precaution. The stow pin is a three-tooth gear sector that provides full engagement with the bull gear.

5. Elevation Gearbox Rebuild

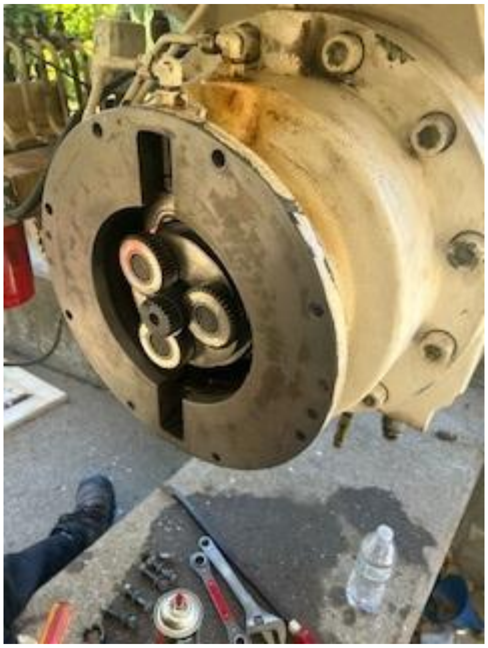

Figure 7: AZ #2 1st Stage

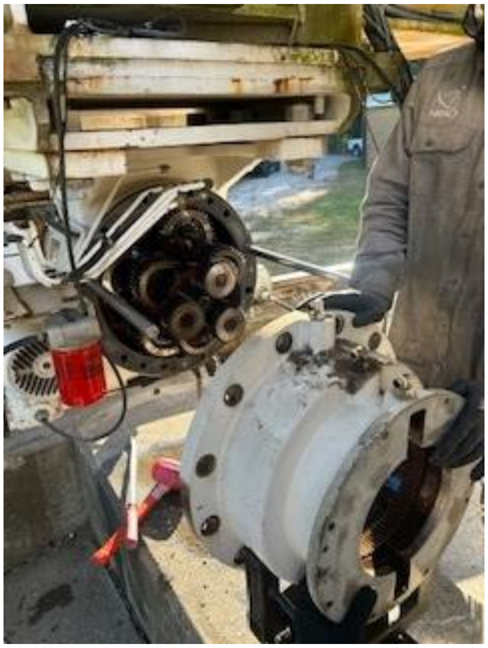

Figure 8: AZ #2 Stages 3-4

Unlike our azimuth drive helical gearboxes at the VLA, the VLBA gearboxes for both elevation and azimuth drive systems are planetary. Each gearbox comprises of four stages gradually decreasing in speed and increasing in both size and torque further into the gearbox. The expected behavior of the smaller stages nearest to the motor, is that they run at a higher speed thus exhibit the most wear. Each carrier stage consists of planet gears, a sun gear and thrust ring. Since this is a multi-stage gearbox, the output of the carrier stage (sun gear) becomes the input for the next stage. This allows for the higher gear reduction to be achieved.

Figure 9: EL #2 Input Shaft

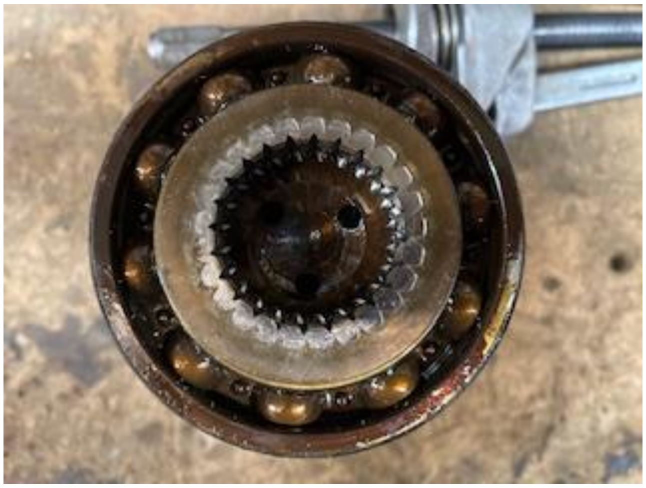

Figure 10: EL #2 Splined Input Shaft Face

High wear and replacement components are typically all sun gears, thrust bearings and thrust washers (behind 1st and 2nd stage sun gears) and shims behind the planetary and sun gears (optional) which deform and flatten over time. These components manage the axial forces and are used to maintain alignment. The elevation gearboxes had the typical rebuild with the replacement of the input shaft due to significant wear found on EL #2 shown in Figures 9 and 10. Oil level indicators were also replaced for EL #2.

Based on replacement needs, additional input shafts will need to be assembled for later gearbox rebuilds. Revisiting collar and bearing removal/installation procedures can improve quality of performance and recovered components.

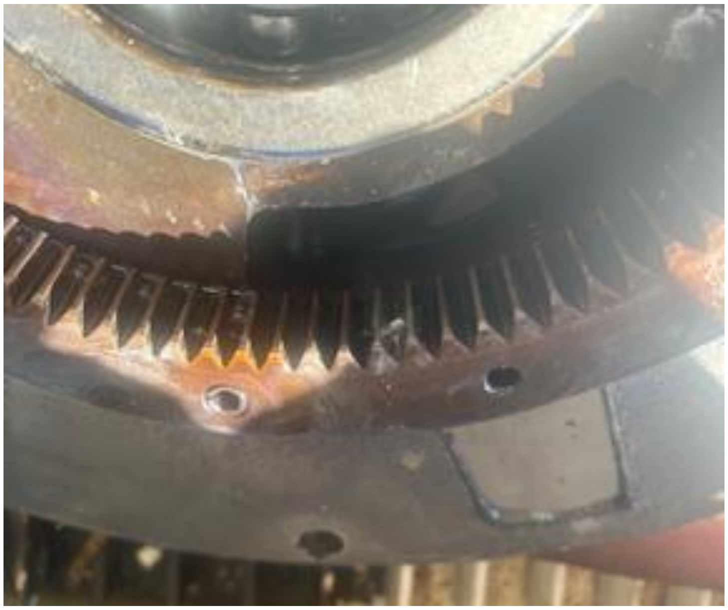

Figure 11: EL #2 Damaged Ring Gear

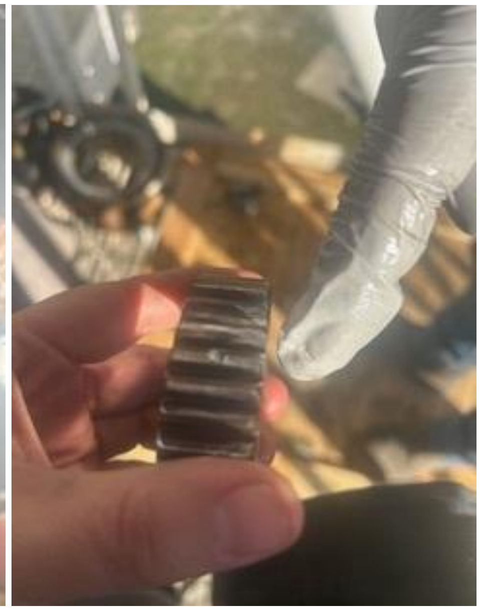

Figure 12: EL #2 Damaged Planetary Gear

During checkouts, elevation movement seized. Site techs deduced which of the gearboxes likely failed based on motor current readings taking the guesswork out of which of the two gearboxes to tear into. Draining of the gear box (7.5 gal) along with the removal of its motor, adapter, shaft coupling and two of the seven oil lines had to be repeated to access the first stage gearbox housing. Right away the input shaft resisted rotation by hand indicating problems within the first stage. This was confirmed immediately when a small piece of metal was found stuck between the teeth of the outer ring gear shown in Figure 11. This was enough damage caused by grinding to break the tooth of both the ring and planetary gear shown in Figure 12. This happened due to one of the rollers falling out of the old thrust bearing which was not recovered during rebuild and managed to wedge its way after install. This soon prompted for in-line and bypass filters to be checked and cleaned as well as thoroughly flushing out the first stage housing on the remaining gearboxes that had yet to be opened.

6. Azimuth Gearbox Rebuild

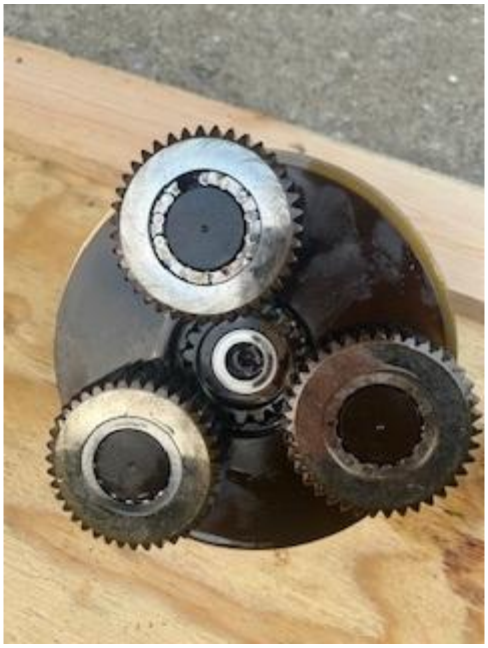

Figure 13: AZ #2 Planetary Gears

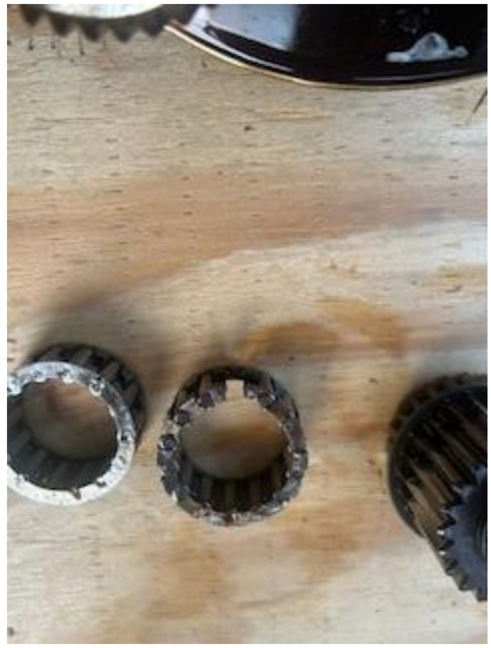

Figure 14: AZ #2 Planetary Gear Bearings

Just like the elevation gearboxes, similar parts were replaced for the azimuth gearboxes. Despite the smooth rotation of the input shaft, what was completely unexpected was the condition of the first stage planetary bearings and later fourth stage sun gear. The cages were worn down exposing the roller bearings. One roller had fallen out of the bearing shown in Figure 14 which was found and collected. During draining of the inline filter, a lot of metal particulates were found in the oil.

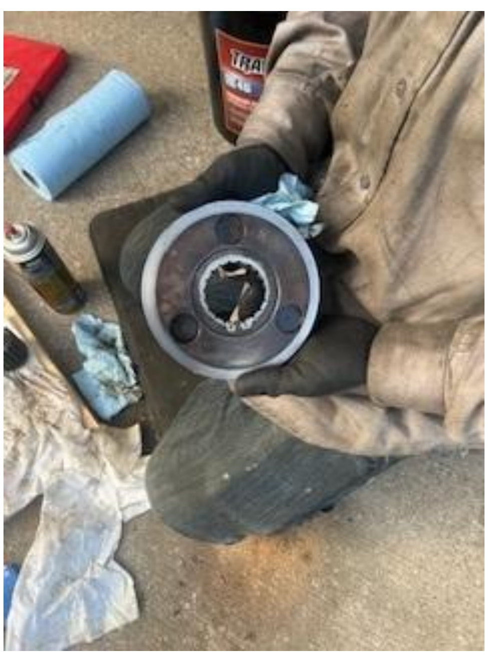

Figure 15: First Stage Carrier (Rear View)

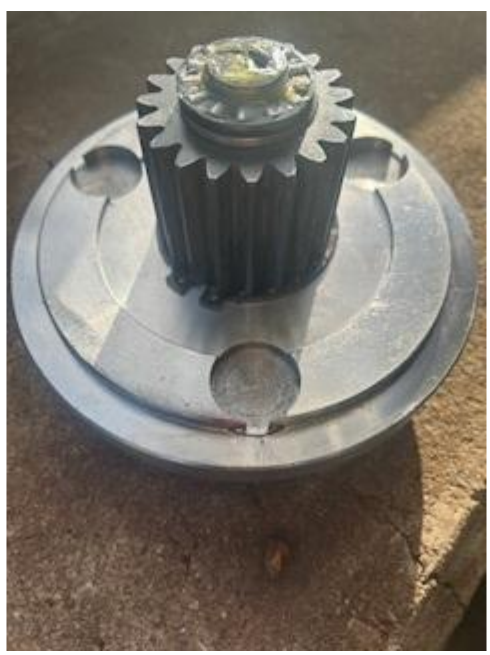

Figure 16: New First Stage Carrier

The desire was to replace the first stage carrier due to that fact the rear ring gear of the second stage sun had worn into the carrier surface shown in Figure 15. However, the replacement carrier was poorly machined, and the material felt substantially lighter than the existing one. One of the site tech made the attempt at removing burrs and protrusions of material left on the part. Given the discoloration on the components within the AZ #2 gearbox we decided to use the original carrier.

The heat scorches indicate that the components have been exposed to high temperatures. This implies either a lubrication failure and/or misalignment. Many of which stem from several underlying issues. If the oil can no longer provide a protective film between the moving parts, there will be increased metal-to-metal contact. By the result of the dark color and sludge formation, it seems like the oil has oxidized.

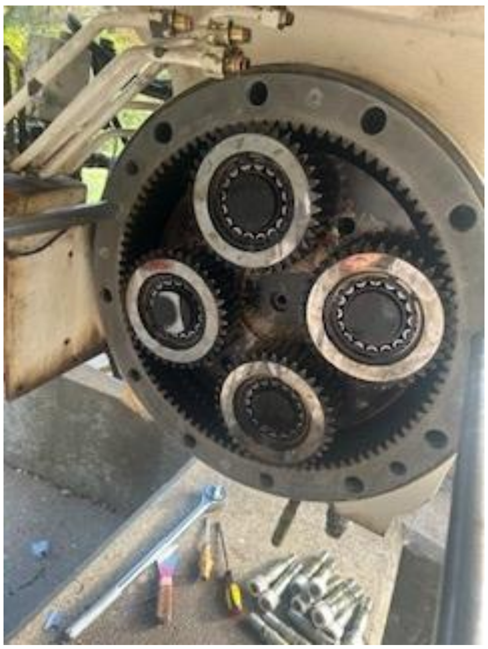

Figure 17: 4th Stage Carrier

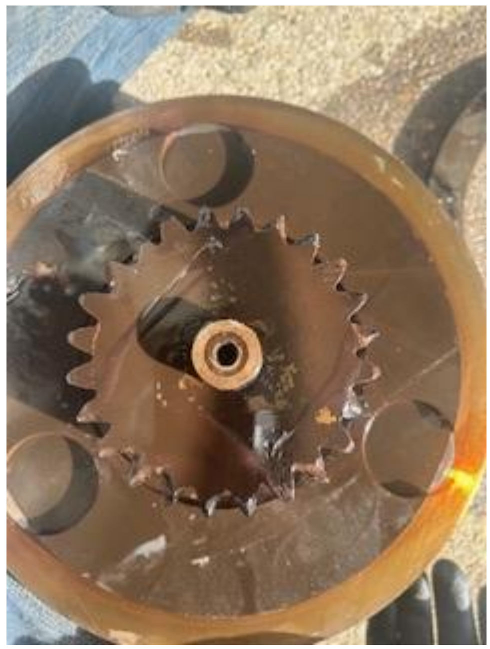

Figure 18: 4th Stage Sun (Rear View)

The most astonishing finding in the AZ #2 gearbox was the 4th stage sun. The rear teeth were chipped as shown from the third stage carrier above in Figures 18-20. Some edges were breaking to the touch. This has not been seen in any of the gearbox rebuilds before.

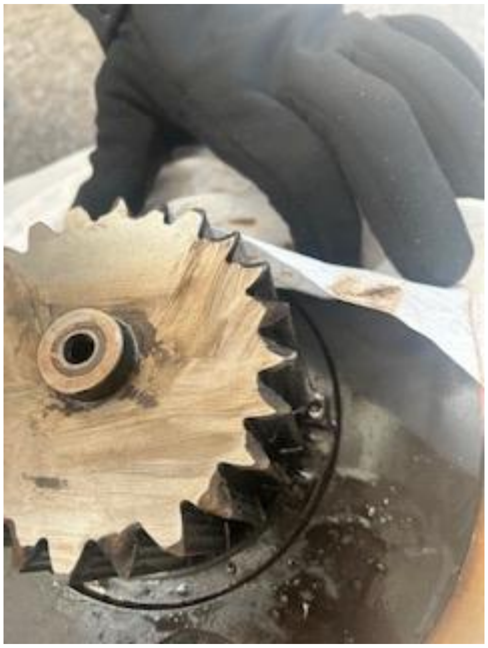

Figure 19: AZ #2 Sun Gear

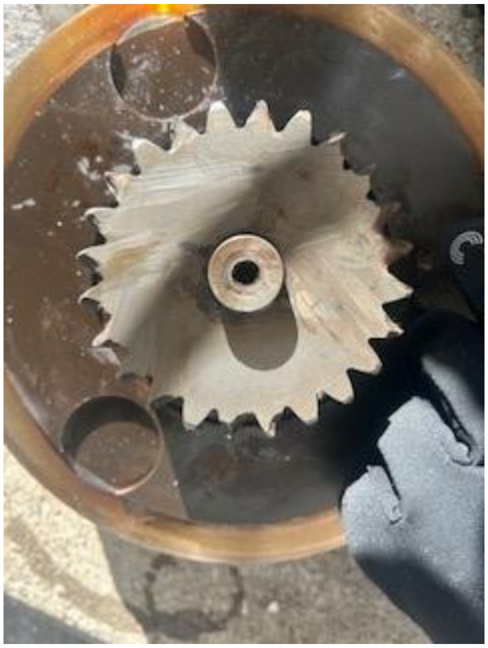

Figure 20: AZ #2 Sun Gear

The condition of the sun gear supports idea that these components have been exposed to intense heat. This has further exacerbated the problem likely hardening this component leading to the gear damage shown in Figures 19 and 20. Further evaluation of this damage will be reviewed when parts return to the VLA.

Additional means for pressing out the sun gear need to be secured. We currently don't have the capability (tonnage required) to press the fourth stage sun gear out from the third stage carrier in the field with our hydraulic press. In anticipation, we brought spare carriers, and Mike Burgert found a local auto shop with this capability ahead of the scheduled trip. This was suggested by the Hancock tiger team as they were faced with this challenge during their gearbox rebuilds.

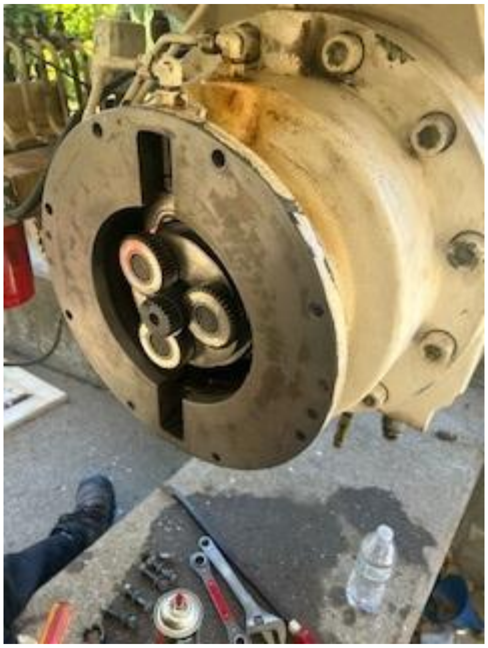

Figure 21: Gearbox housing

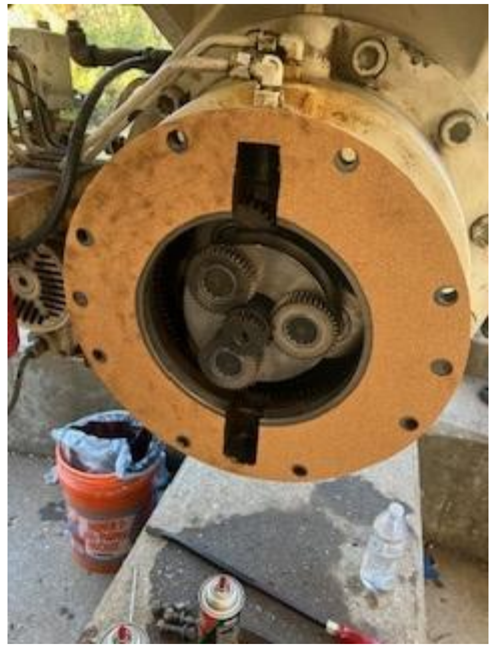

Figure 22: Gearbox with gasket

The gearbox axial clearance and adjustment procedure was followed to address the of the AZ #2 gearbox. 1/16" thick cork gasket was added. This acts as a spacer to reduce compressive forces. Surprisingly, the AZ #1 gearbox was nowhere near the condition of AZ #2.

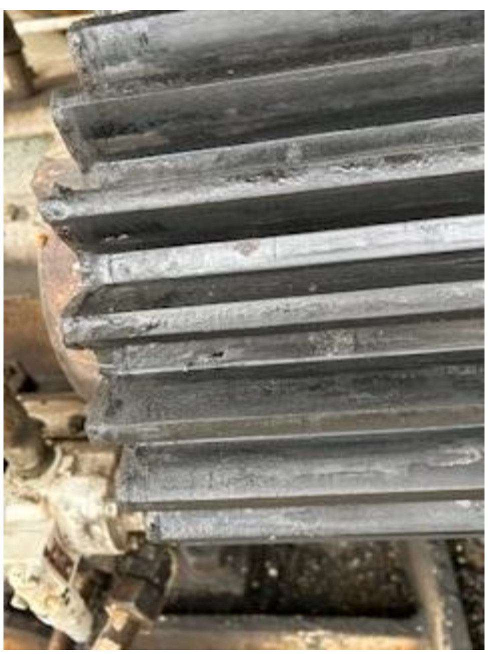

Figure 23: Elevation Pinion Gear

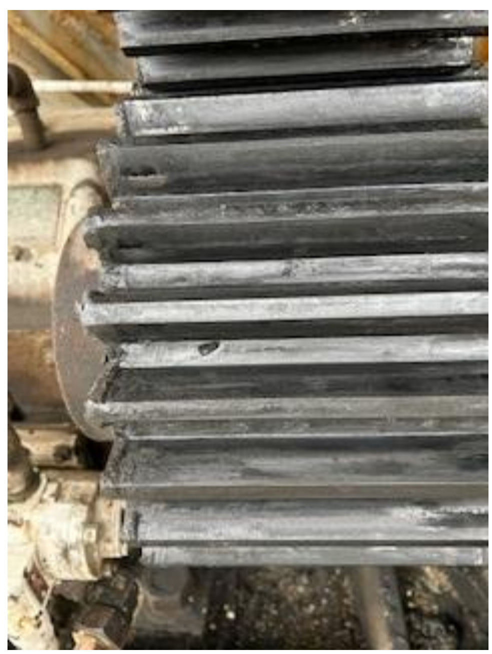

Figure 24: Elevation Pinion Gear

Operation ran smoothly when running elevation however, the pinion gear of EL #2 showed damage on two bottom lands about four teeth apart. This is the surface between two adjacent teeth. As it was noted that the grease dissipates towards the EL2 side of the drive gears, it could be due to misalignment causing concentrated loads on a specific area of the teeth leading to uneven wear and gouging as shown in the figures above. Monitoring these areas will need to continue.

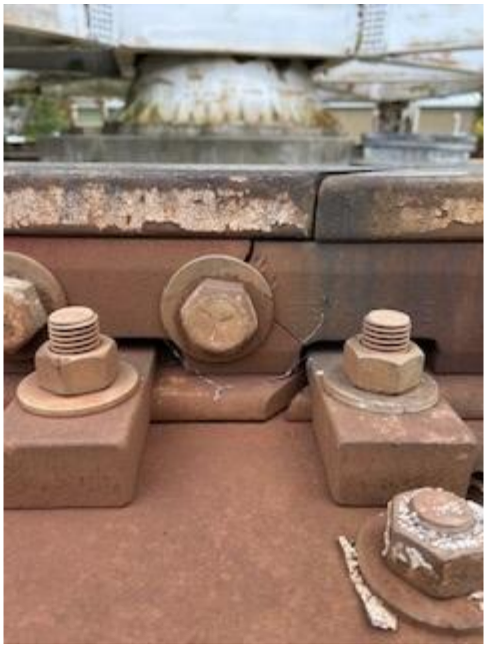

Figure 25: Splice Bar

The rail splice bars were an already identified issue from an earlier engineering inspection, reported in September 2025. Lack of material and time didn't allow for this task to be included in the scope of work for this trip. WO-27394 will infer the amount of raw material needing to be ordered for all VLBA splice bar replacements. Again, North Liberty has identified eight out of the twelve splice bars requiring replacement. Hancock, New Hampshire is the only VLBA site to have the most current modified splice bars installed [see VLBA Antenna Memo 108].

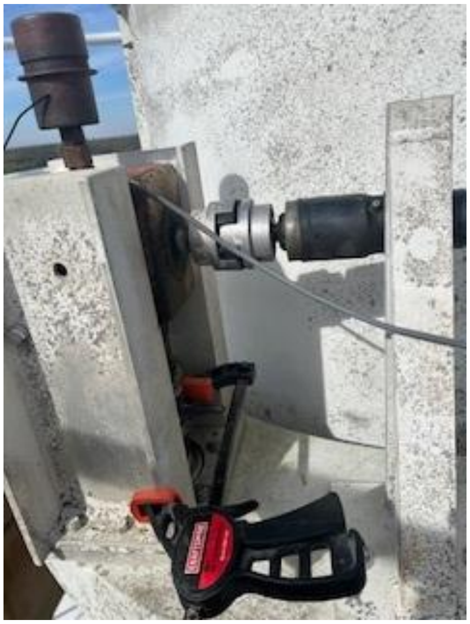

Figure 26: Jaw Coupling/Hytrel Spider

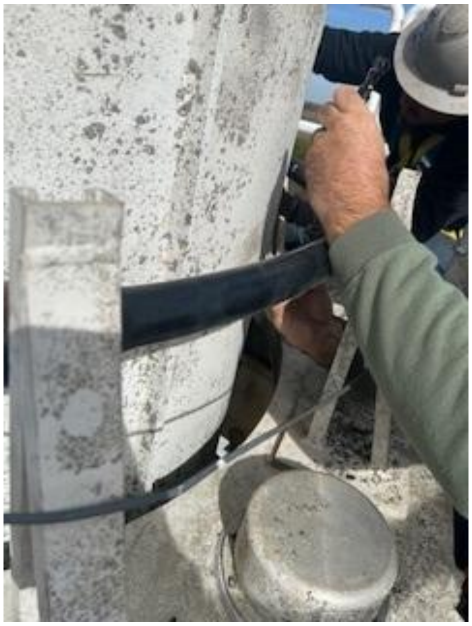

Figure 27: FRM Flex Shaft

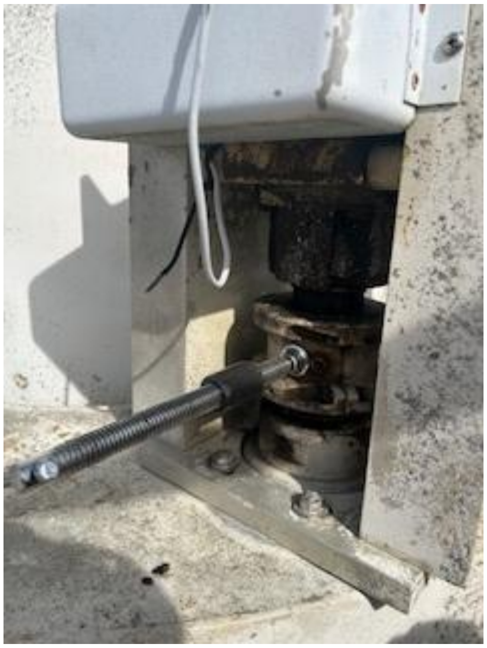

Figure 28: Bevel Gearbox Coupling

Prior to replacing the flex shaft, both bevel gearbox couplings needed to be clamped down as to not unintentionally drive the focus lead screw. Removing the flex shaft can allow for the potential energy in the lovejoy coupling to transmit rotational power to drive the gearbox leading to a misalignment of the FRM. Scribing the position of the flex shaft brackets aided in returning the new flex shaft to its initial position. Sensor cable ties were also replaced. However, we were not able to manage the additional task of replacing the pinion gear (motor-to-ring gear) on the FRM.

7. Report Conclusions

This report provides an overview of the maintenance and repair activities performed. Observations and issues identified during the visit will be followed up on.

Summarily to past maintenance visits, unplanned work and corrective measures were taken. Engineering services and antenna mechanics will debrief after returning to discuss successes, challenges, root causes and ultimately how to improve future outcomes for the upcoming maintenance and tiger team trips.

We would like to thank the entire team for their incredible performance during the maintenance visit. The dedication and creative solutions by all members kept the team moving forward despite the challenges encountered.