National Radio Astronomy Observatory
VLBA Antenna Memo Series – No. 113
Fernando Santoro
INSPECTION REPORT – Brewster, June 10-11, 2026

1. Trip Summary

An engineering scout trip was conducted at the Brewster, Washington VLBA station on June 10-11, 2026. The engineering inspection was represented by:

Fernando Santoro

Continuous support was provided by the Antenna Mechanics group and Engineering Services, together with hands-on support from the VLBA site tech:

Jesse Fulmer

Edward Gossett

2. Executive Summary

This engineering inspection trip report summarizes inspection activities performed at the BR VLBA antenna from June 10-11, 2026 (Figure 1).

Overall, the Brewster antenna and site were found to be in good condition. The site landscape was clean and very well maintained, with effective weed control throughout the area. No weeds were observed around the concrete foundation of the pintle bearing room (Figure 2).

The rail system is generally flat and in good condition, with no major concrete or grout defects observed. Rail gaps, splice joints, and rail elevations were measured and documented for future comparison. Two splice bars showed visible cracking and are already scheduled for replacement during the upcoming Tiger Team visit. The rail ends should be inspected and any cracks documented once the splice bars are removed.

The azimuth drivetrain operated normally during the inspection, with no unusual noise, wear, or alignment concerns noted. The AZ1 and AZ2 gearboxes are planned for rebuild during the upcoming Tiger Team visit. Localized concerns were identified at the AZ2 drive-wheel outer bearing, where grease leakage suggests a possible seal issue, and at the AZ1 idler-wheel outer bearing, where limited grease and minor surface damage were observed. Both items require additional inspection during the Tiger Team visit.

The FRM rotation issue remains open, although the mechanism operated within positional specification during the visit. Encoder calibration should be checked, and replacement of the motor, brake, and encoder assembly with a newer unit should be considered for diagnostic comparison.

The overall structural condition of the antenna, including the lower structure, backup structure, dish panels, feed cone, torsion-rod assemblies, and associated platforms, was good. Minor paint deterioration, localized surface rust, and cosmetic coating discoloration were observed in several areas. These items can be addressed through cleaning, localized surface preparation, and touch-up painting during the upcoming Tiger Team visit.

The Pintle Bearing Room, cable wrap, grounding system, compressors, landscaping, and general site infrastructure were also found to be in good condition. Minor PM recommendations include sealing small gaps around the pintle bearing grout interface, adding a weather seal to the pintle-room plexiglass cover, replacing aging FRM bellows, replacing the jib-crane cable, and addressing minor corrosion on selected fasteners and painted surfaces. Overall, the inspection confirmed that the Brewster station is in good operational condition.

Figure 1: Brewster, WA

Figure 2: Brewster, WA Concrete Foundation

3. Rail System

The overall foundation and rail system of the Brewster antenna is in acceptable condition. No major cracks, spalling or visual deterioration between edges and around plates were observed in the concrete rail foundation or grout (Figure 3). All rail clips were found to be of the same type.

Figure 3: Rail System Condition (Bolt #1, #41, #92 and #101, respectively)

Gaps between rail sections were measured and assessed (Table 1). These gaps are necessary to accommodate thermal expansion and contraction. However, excessively large gaps, as well as the absence of adequate gaps, can potentially lead to running-surface damage, rail creep, or damage to associated components. The maximum gap found was below 1/32 inch, and the rail centerlines were reasonably well matched in elevation (Figure 4, Figure 5, and Figure 6). However, the rail ends were observed to have a slight opposing twist, resulting in slight out-of-level running surfaces, “in” and “out” of the rail ends. Although this condition does not currently indicate a problem, it was documented and will be monitored over time for future assessment.

Table 1 – Measurements between rail sections

Bolt #	Gap	Δheight "center"	Δheight "in"	Δheight "out"
1	< 1/32" (largest gap is 0.030 (Bolt #81)	All match in elevation	+0.012"	-0.018"
21			+0.008"	-0.011"
41			+0.040"	-0.016"
61			+0.042"	-0.037"
81			+0.039"	-0.035"
101			+0.027"	-0.006"

A dynamic test was also performed by running the antenna across the rail gaps in both clockwise and counterclockwise directions. During this test, the rail ends were observed not only to move vertically as they were loaded and unloaded by the antenna wheels, but also to twist relative to one another as the antenna passed over the gaps. Although it was not possible to measure the vertical motion during this inspection, videos were recorded and will be archived for future reference and comparison.

Figure 4: Rail Gaps (Bolt #1 and #21, respectively)

Figure 5: Rail Gaps (Bolt #41 and #61, respectively)

Figure 6: Rail Gaps (Bolt #81 and #101, respectively)

Splice joints between rail sections are more prone to failure largely because they are among the weakest areas of the rail system. The inner and outer splice bars were visually inspected at the six intersections around the rail track. Two outer splice bars showed apparent signs of cracking at bolt #61 (Figure 7) and bolt #81 (Figure 8). The crack at bolt #61 was significantly larger than the crack at bolt #81. All splice bars are scheduled to be replaced with new components during this year's upcoming Tiger Team visit. Once the splice bars are removed, it is recommended that the exposed rail ends be inspected by the Tiger Team. Any cracks should be measured and reported to Engineering Services for continued monitoring and assessment.

Figure 7: Outer Splice Bar at Bolt #61

Figure 8: Outer Splice Bar at Bolt #81

The rail head profile was not measured during this inspection. However, based on the apparent continuity and alignment of the rail heads at the various intersections, no rail-profile issue is currently suspected.

The grounding cables and associated terminations are in good condition as shown in Figure 9, with no visible signs of degradation. These grounding cables are located between bolts #20 and #22, and bolts #80 and #82.

Figure 9: Rail Ground and Grounding Wires

The Brewster rail elevations were measured using a Brunson optical level. Compared with the measurements reported in August 2004 in VLBA Antenna Memo No. 56, the rail profile remains relatively flat. Using the raw data, with no first-order tilt removed, the total elevation variation was less than 0.092 inch (Figure 10). These were static measurements taken with the antenna parked; therefore, no load-related variation from the antenna wheels was present. Measurements were taken from two instrument locations near the Pintle Bearing structure. Four common measurement points were used to combine the two data sets and adjust them to a common elevation reference.

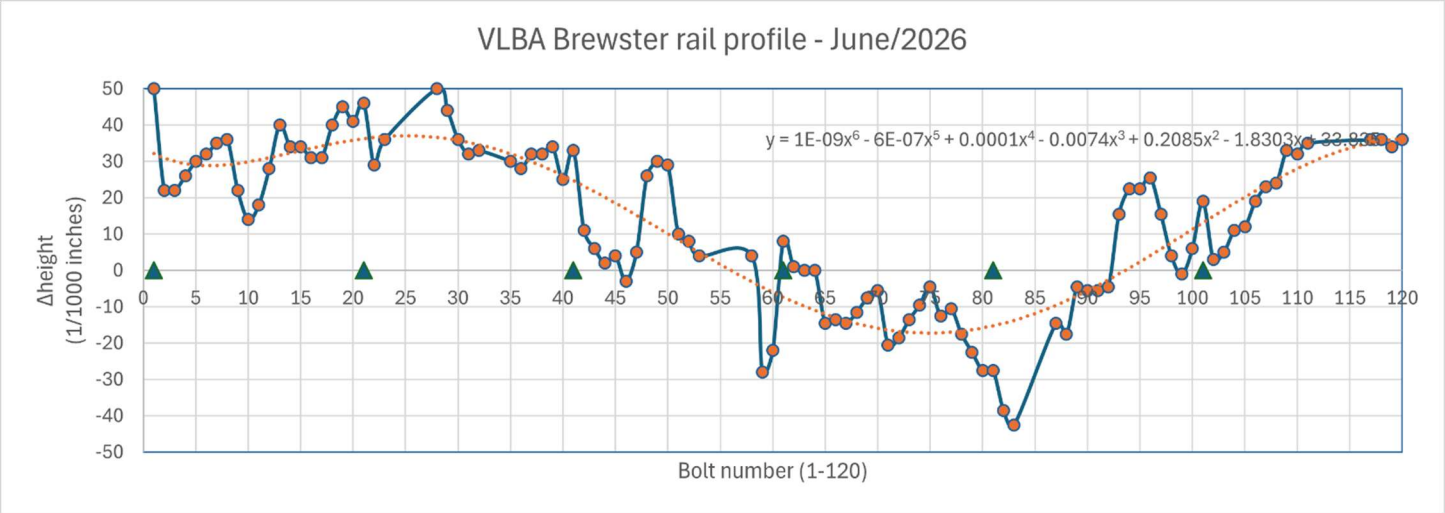

Figure 10: Brewster AZ Rail Elevations

The green triangles along the horizontal axis in Figure 10 identify the bolt numbers corresponding to the rail-section intersections. The orange dotted line represents the best-fit polynomial trendline for the measured data. Bolt numbers with no associated measurements identify locations where the view was obstructed by the drive wheels or idler wheels.

4. Pintle Bearing Assembly

The pintle bearing room was found to be in good overall condition, externally and internally (Figure 11). No signs of water infiltration or condensation were observed. Only a few minor drops of grease were observed at the pit bottom. The site techs were advised to clean the inner grease gutter whenever grease accumulates in one area, as this could eventually lead to leakage into the bottom of the pit, as well as the cable wrap brackets.

Figure 11: Pintle Bearing Room Access Hatch, Cable Wrap and Port Hole

Paint spalling was observed at several locations inside the Pintle Bearing Room (Figure 12). These areas will require cleaning and may need to be repainted during this year's upcoming Tiger Team visit (time permitting).

Figure 12: Pintle Bearing Room Access Hatch, Cable Wrap and Port Hole

The structural elements of the cable wrap were free of standing water, debris and grease accumulation. A very minor separation was observed between the pintle bearing assembly and the surrounding foundation concrete. As implemented at some VLBA sites, applying a suitable caulking material to seal gaps at the grout interface between the concrete foundation and the steel structure would help prevent moisture infiltration.

The AZ encoder was visually inspected and appears to be in good condition.

The porthole to the Pintle Bearing Room was inspected and found to be in good condition (Figure 11). However, the plexiglass cover does not currently have a weather seal. Minor superficial rust was observed at the flange interface, suggesting that water may be entering through this area.

5. Pedestal Platform

Rust-Oleum primer was applied at a few locations near the pedestal platform (Figure 13). It is recommended that these areas be properly painted during this year's upcoming Tiger Team visit.

The compressors are operating normally, with pressure readings of approximately 280 psi. This is within the acceptable range recommended by the Cryogenics group, which is below 295 psi and may be adjusted based on ambient temperature and operator experience. Recharge is performed twice per week, typically on Tuesdays and Fridays.

The Pedestal Room appears to be in good condition, both internally and externally. Installation of a new air-conditioning system was underway during the inspection visit.

Figure 13: Pedestal Platform - Stairs Handrail

6. Azimuth Drive System

The AZ1 and AZ2 gearboxes are scheduled to be rebuilt during this year's upcoming Tiger Team visit. No apparent issues were observed within the azimuth drivetrain. The antenna was rotated in both directions and exhibited normal operating noise and behavior.

It was observed that both drive wheels have inner solid pillow blocks and split outer pillow blocks, while both idler wheels have split pillow blocks. The solid pillow blocks on the drive wheels could be replaced with split pillow blocks during scheduled bearing replacements for those wheels.

The outer bearing of the AZ2 drive wheel leaks grease toward the inner side, possibly due to a damaged seal (Figure 14). This condition appears to be diverting grease away from the outer side of the bearing, reducing lubrication effectiveness and raising concern about the bearing's condition. The issue was observed after the grease cover was removed for inspection. Further inspection is recommended during this year's upcoming Tiger Team visit, along with replacement of the seal on the inner side, as needed. A rubber gasket was permanently installed on the outer side of both AZ drive wheel bearings (Figure 14).

Figure 14: AZ2 drive wheel - bearing leaking, cover removed, and outer rubber gasket installed

On the outer bearing of the AZ1 idler wheel, very little grease was observed between the roller elements and the outer race after the split pillow block was removed. Minor scratches and evidence of light grinding were also observed on the split pillow block and on the outer surface of the bearing (Figure 15). Further investigation and assessment are recommended during this year's upcoming Tiger Team visit. One possible cause is a restriction or blockage in the grease passage between the grease fitting and the roller bearing.

Figure 15: AZ1 idler wheel split pillow block

The bypass filtration system for the AZ gearboxes, including the nitrile/neoprene hose lines, was inspected and appears to be in good condition. No hose cracking or history of frequent hose replacement was reported.

7. Elevation Drive System

The EL1 and EL2 gearboxes are scheduled to be rebuilt during this year's upcoming Tiger Team visit. No major issues were observed within the elevation drivetrain. The antenna was rotated in elevation and exhibited normal operating noise and behavior. The EL1 gearbox has a slight oil leak at the input-shaft oil seal (Figure 16). Both the input shaft and the oil seal are already scheduled to be replaced with new components during this year's upcoming Tiger Team visit.

Figure 16: Pinion Gear and Bull Gear

Open-gear grease is used to lubricate the sector (bull gear) and pinion gears (Figure 17). SilverStreak Multi-Lube from Schaeffer's is currently being used at the Brewster site and appears to adhere well to the gear surfaces without running off. No signs of abnormal wear, misalignment, or unusual noise were observed in these components. A few external drivetrain components would benefit from cleaning and repainting during this year's upcoming Tiger Team visit (Figure16 and Figure 18).

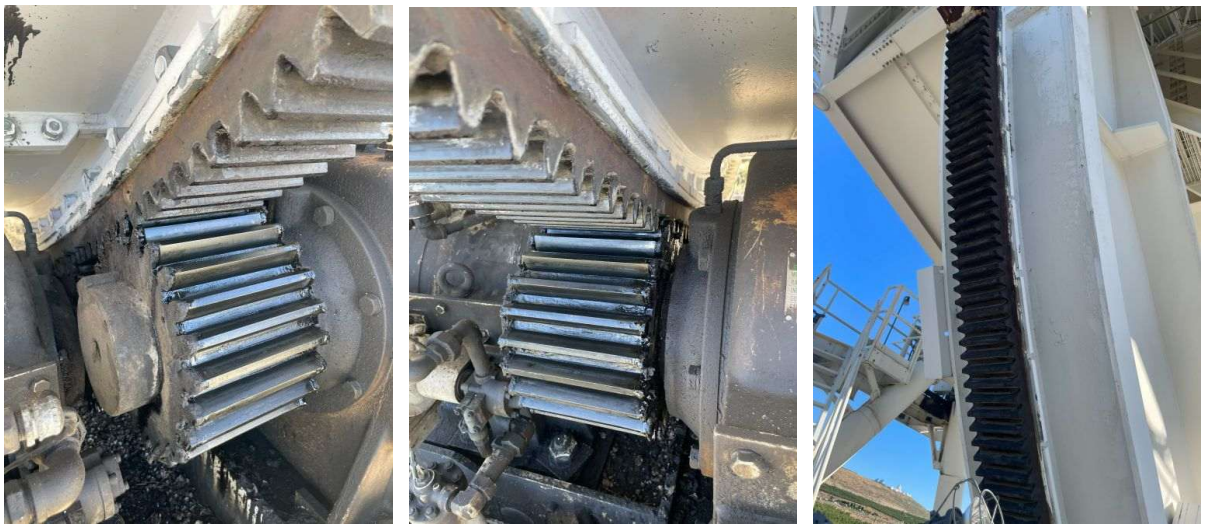

Figure 17: Pinion Gear and Bull Gear

Figure 18: Elevation Drive

The bypass filtration system for the EL gearboxes, including the nitrile/neoprene hose lines, was inspected and appears to be in good condition (Figure 19 and Figure 20). No hose cracking or history of frequent hose replacement was reported.

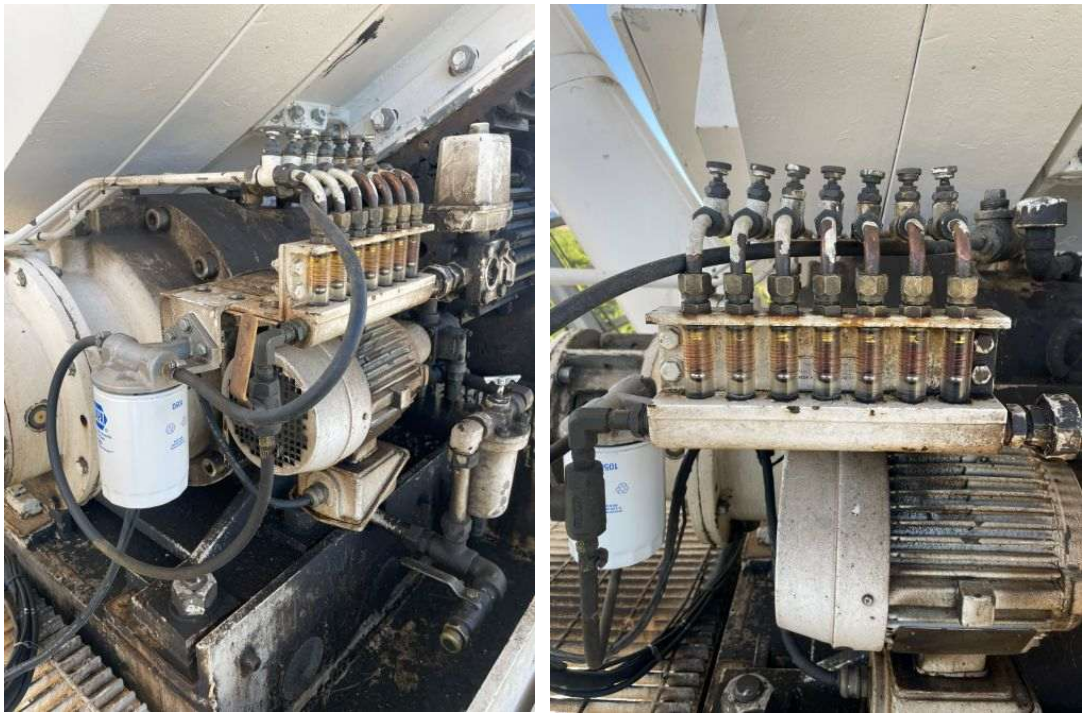

Figure 19: Elevation Drive EL1 Bypass Hose Lines and Filter Lines

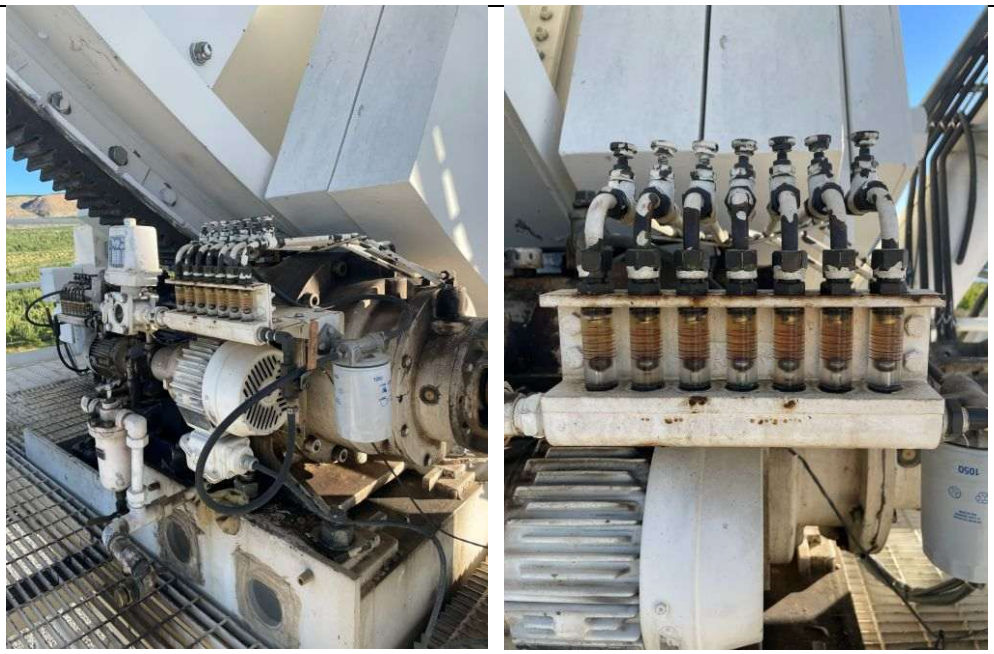

Figure 20: Elevation Drive EL2 Bypass Hose Lines and Filter Lines

8. Elevation/Yoke Platform

Except for very minor areas of surface rust, the structural components associated with the elevation and yoke platforms were found to be in good condition. This includes platforms/gratings, stairways, counterweight, backup structure, and associated fasteners (Figure 21 and Figure 22). No significant signs of structural deformation, cracking, loose members, or advanced corrosion were observed during the visual inspection. It is recommended that some of these areas with rust be painted during this year's upcoming Tiger Team visit.

Figure 21: Stairways, Platforms, Gratings, Decks

Figure 22: Stairways, Decks, Catwalks, Counterweight

The jib crane appears to be the original unit and is in good overall condition (Figure 23). However, given its age, it is recommended that the cable be replaced with a new one as a preventive maintenance measure.

Figure 23: Jib Crane on the Elevation Encoder Deck

9. Vertex Room

The vertex room has been well-maintained with no concerns identified (Figure 24).

Figure 24: Views of Vertex Room

10. Main-Dish Backup Structure, Dish and Feed Cone

The main-dish backup structure is a trussed network that supports the reflector panels, subreflector support structure, elevation bearings, and the sector gear/counterweight structure. No significant corrosion requiring paint remediation was identified (Figure 25 and Figure 26). Only a few minor rust spots and affected fasteners were observed. It is recommended that these areas receive protective paint coatings during this year's upcoming Tiger Team visit.

Figure 25: Main-Dish Backup Structure Joints and Beams

Figure 26: Main Dish Backup Structure Central Frame and Fasteners

The dish panels were visually inspected and found to be in good condition, with no apparent issues in alignment or mating between adjacent panels (Figure 27). Minor cleaning of the top surfaces can be performed during this year's upcoming Tiger Team visit (time permitting).

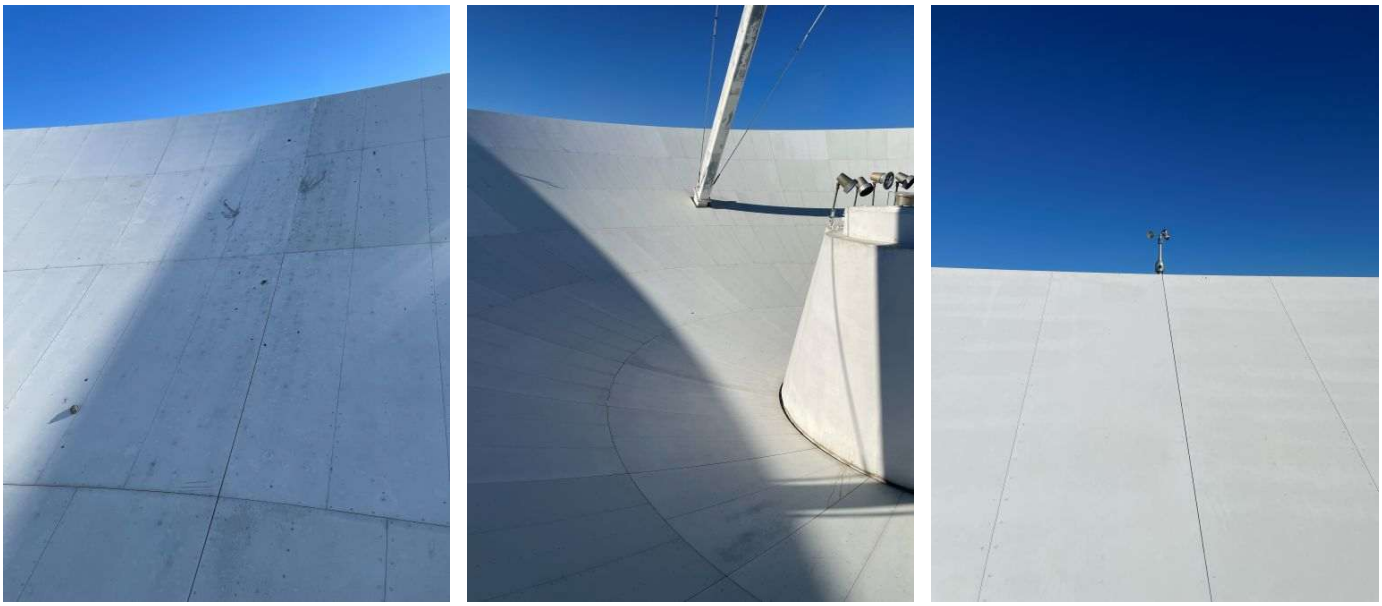

Figure 27: Main Dish Panels Top Surface

The feed cone was found to be very well maintained, with no visible cracks, insulation delamination, or accentuated discoloration of the textured surface (Figure 28 and Figure 29). All feed-heaters are in good condition. No action is required at this time.

Figure 28: Feed Cone side views

Figure 29: Feed Cone detailed views

Two torsion-rod assemblies are attached to each of the four Apex Quad-Legs, providing a stiff load path for the guywire system. No significant sag was observed in any of the guy wires (Figure 30, Figure 31, Figure 32 and Figure 33). The painted surfaces appear generally with good overall coverage. However, localized areas of uneven finish and light discoloration were observed on structural members from the main-dish area up to the apex. These areas do not appear to show any corrosion or coating failure, but they should be cleaned and monitored. During the next planned painting work, localized surface touch-up coating would improve appearance and provide continued protection.

Figure 30: Apex Quad-Leg, Torsion Rod and Guywire 1

Figure 31: Apex Quad-Leg, Torsion Rod and Guywire 2

Figure 32: Apex Quad-Leg, Torsion Rod and Guywire 3

Figure 33: Apex Quad-Leg, Torsion Rod and Guywire 4

The dichroic panel and the ellipsoidal reflector were inspected and found to be in good condition (Figure 34). The associated support and attachment hardware also appear to be in good condition.

Figure 33: Dichroic Panel and Ellipsoidal Reflector

11. Apex, Subreflector and FRM

The apex structural assembly was thoroughly inspected and was found to be in good condition (Figure 34). No significant corrosion, distortion, cracking, or other signs of structural degradation were observed. Surface condition was generally good, with no visible issues affecting the integrity of the assembly.

Paint fading was visible on the subreflector (Figure 35), along with moderate areas of topcoat delamination. Compared with other sites, however, the subreflector surface remains relatively uniform and is among the less affected exterior surfaces. Preventive maintenance should include sanding, filling, and repainting the affected areas during this year's upcoming Tiger Team visit.

All four FRM rubber bumpers were inspected and found to be in good condition.

Two of the four FRM linear-shaft bellows were opened to allow visual inspection of the enclosed linear-shaft surfaces (Figure 36). The shafts were found to be in good condition, with no significant dents, scratches, scoring, or other visible damage. Lubrication also appeared adequate on the inspected shafts. A few orange and black bellows are in poor condition and should be considered for replacement during this year's upcoming Tiger Team visit to provide continued protection for the FRM internal components.

Figure 34: Apex Structural Assembly

Figure 35: Subreflector Assembly

Figure 36: FRM Linear Shaft and Dust Cover Bellow

The FRM flex drive shaft was also inspected and found to be in good condition, with no visible signs of wear. There are some initial signs of leaking that should be monitored and reported (Figure 37).

Figure 37: FRM Flex Drive

Actions were taken to better understand and assess the FRM rotation issue reported in WO-27786, “BR rotation not getting to position.” This included a thorough discussion with the site techs and the development of a proposed set of mechanical inspections for the FRM. The gear ring and pinion were inspected and showed no signs of wear or damaged teeth (Figure 38).

Figure 38: FRM Rotation Gear Ring and Pinion

It was also confirmed that the encoder is properly attached to the flexible coupling on the rear side of the brake and that all associated components were securely and stably positioned. One recommendation resulting from this scout trip is to check the encoder calibration as part of the continued assessment. If feasible, the motor, brake, and encoder assembly should also be replaced with a newer unit for diagnostic comparison and verification.

Although the issue report remains open, the FRM rotation operated normally throughout the inspection visit. The FRM was manually moved to positions 7 (6 cm) and 8 (7 mm), which were recorded as E4A6 and C447, respectively. Fiducials were used as reference marks. The FRM was then commanded to these positions and locked with minimal positional errors. This test was performed clockwise and counterclockwise.

Also, with the brake engaged, the barrel was checked manually for rotational play. A total motion of approximately 0.3 degrees was observed. This appears to be a normal condition and has also been noted at other sites, including HI and PT.

The focus motor was reported to be old, and no spare motor is currently available. It is recommended that a newer motor be installed and that the original motor be removed for a complete rebuild. This work does not need to be performed during the upcoming Tiger Team visit and can be scheduled separately. For reference, the BR FRM focus mechanism generated position errors during the inspection days. However, limited available time did not allow for a detailed inspection or further troubleshooting.

Although the FRM rotation position errors were within specification during the inspection, the reported rotation issue is not considered resolved. Further investigation is ongoing.

12. Antenna Structure

The Lower Structure was visually inspected and appears to be in good condition overall, aside from minor areas with corrosion, paint failure and paint spalling (Figure 39). It is recommended that these areas be repainted during this year's upcoming Tiger Team visit. Also, a few fasteners on the Lower Structure are rusted, with corrosion present on some bolt heads and on some nuts only (Figure 40). They appear to be #3/4-20 hex-head bolts, approximately 3 inches long. It is recommended that these fasteners are replaced with galvanized fasteners during the upcoming Tiger Team visit. An updated count of fasteners needed can be requested, if required.

Figure 39: Lower Structure

Figure 40: Fasteners on the Lower Structure

The Quadrapod Support Structure was also visually inspected and appears to be in good condition (Figure 41).

Figure 41: Quadrapod Support and Adjacent Structure

13. Grease Sampling

Grease sampling helps to assess the wear debris for predictive maintenance of these bearings. As planned, and following the same approach used during the FD scout trip, "grease thief" kits were used to collect and store grease samples from twelve different locations. These locations are:

1. AZ1 outer bearing outer side
2. AZ1 outer bearing inner side
3. AZ2 outer bearing outer side
4. AZ2 outer bearing inner side
5. AZ1 idler bearing outer side
6. AZ1 idler bearing inner side
7. AZ2 idler bearing outer side
8. AZ2 idler bearing inner side
9. EL1 outer bearing
10. EL2 outer bearing
11. Pintle bearing outer side
12. Pintle bearing inner side

The collected grease will be sent out to a lab for basic ferrous grease testing to identify iron-based particles.

14. Generator

The Brewster site has a new generator installed on a new concrete slab (Figure 41).

Figure 41: Site Generator

15. Report Conclusions

This report provides an overview of the general findings for the Brewster VLBA site. Observations and issues identified during the inspection will be strategically deferred to upcoming scheduled tiger teams. The Facilities Condition Assessment Report (FCAR) inspection grading scale was used to assign an overall score to the antenna based on criteria for each antenna system (within engineering services). It is the recommendation of this document that all site findings be addressed.

General Inspection Findings (priority level highlighted below)

Rail System:

Replacement of all 12 splice bars (page 5)

Medium

Inspect/report rail ends for cracks (page 5)

Medium

Pintle Bearing Assembly:

Exterior sealing/caulking (page 8)

Low

Paint spalling cleaning and repainting (page 8)

Medium

Pedestal Platform:

Paint areas with rust-oleum and rust (page 8)

Medium

Azimuth Drive System:

Rebuilt AZ1 and AZ2 gearboxes (page 9)

High

Fix outer bearing leakage of AZ2 drive wheel (new gasket) (page 9)

High

Inspect/report/fix outer bearing greasing of AZ1 idler wheel (page 10)

Medium

Elevation Drive System:

Rebuilt EL1 and EL2 gearboxes (page 11)

High

Clean and repaint EL drivetrain components (page 11)

Medium

Elevation/Yoke Platform:

Clean and repaint minor rusted areas (page 13)

Medium

Replace jib crane steel cable (page 14)

Low

Main Dish:

Paint minor rusted areas of backup structure (page 15)

Low

Minor cleaning of dish top surface (page 16)

Low

Local paint of Apex Quad-Legs structure (page 17)

Medium

Apex, Subreflector and FRM

Repainting of subreflector (page 20)

Medium

Replace deteriorated red/black bellows (page 20)

Medium

Inspect/report FRM flex drive shaft for leaks (page 22)

Low

Antenna Structure

Paint minor areas on the Lower Structure (page 24)

Medium

Replace fasteners - #3/4-20 hex-head bolts x 3” (page 24)

Low

Performance Findings

Overall Rating:	**Grade:**
Brewster	**2**
Antenna shows minor wear and tear from normal use with minor maintenance needed. Refer to the Facilities Condition Assessment Report (FCAR) inspection grading scale.	

FCAR inspection grading scale

Grade 1

- New system or new construction.
- Meets design goals and demands of facility or instrument.
- Full safety systems are in place and functioning as designed
- Components of system (steel, piping, fittings, pavement concrete, masonry, etc.) show no leaks, cracks or other imperfections
- Electrical components (enclosure, wires, connectors, raceways, batteries, etc.) show no obvious physical damage, exposed conductors, leaks, or other imperfections.
- Electronics such as displays, LED indicators function as expected, are clearly visible, and are free of cracks, discoloring, and errors.
- Cooling pathways have no visible signs of damage at inlet/exhaust vents and have no obstructions that could diminish air volume.

Grade 2

- System, part, or facility shows minor wear and tear from normal use.
- May be slightly outdated in design or esthetics without functional impact, minor improvements needed.
- Full safety systems are in place and functioning as designed however they may show aesthetic wear from the elements (ex: sun bleaching, or cracking of plastic handle covers, etc.)
- Fluid based systems (water, oil, hydraulic fluid, etc.) have no visible corrosion or deterioration however there is a history of small repairable leaks either documented or shown in stains and dried puddles near the fitting or fixture.
- Components or sub-components of structural systems (steel, piping, fittings, pavement concrete, masonry, etc.) show minor cosmetic cracks or misalignment or signs of superficial damage and/or the beginnings of oxidation or light rust.
- Structural components of electrical/electronic systems are present but may show minor visible damage such as dings or paint smudges from normal use and all mechanical components like hinges and latches are fully operational.
- Electrical components such as connectors, wiring, and switches present no damaged insulators or exposed conductors.
- Electronics such as displays, LED indicators function as expected, are clearly visible, and are free of cracks, discoloring, and errors.
- Batteries are within their expected life and show no leaks or damage.
- Cooling pathways have no visible signs of damage at inlet/exhaust vents and have no obstructions that could diminish air volume.

Grade 3

- System, part, or facility still meets its needs and is considered within its useful life. However, some deterioration exists, repairs are needed and maintenance needs are significant.
- Paint or finishes are showing more than the normal wear and tear and peeling or coming loose and will require significant remediation to correct.

- Full safety systems are in place but concerns are beginning to arise and become evident (ex: workarounds or temporary repairs).
- Fluid based systems (water, oil, hydraulic fluid, etc.) leak intermittently and have early signs or documentation showing deterioration in piping, fittings, or fixtures.
- Components or sub-components of system (piping, fittings, pavement, concrete, masonry, etc.) have minor sagging, noticeable cracks and/or rot that needs to be repaired with the possibility of small areas that need to be removed and replaced (ex: several bricks/CMU, areas of wood rot, or pot holes that can be filled or repaired without a large removal).
- Steel components are showing moderate misalignment. Freckled rust and corrosion have been initiated in broad areas and cracks that have self-arrested or been arrested by drilling holes or applying additional plating.
- Structural components of electrical/electronic systems are present but may show minor visible damage such as dings or paint smudges and some mechanical components like hinges and latches show minor misalignments that do not significantly inhibit operation. Rubber bumper stops may show signs of deterioration but are still in place and functional.
- Electrical components such as connectors, wiring, and switches present no damaged insulators or exposed conductors.
- Electronics such as displays, LED indicators function as expected are beginning to show early signs of wear, however they continue to be clearly visible, and are free of cracks, discoloring, and errors.
- Batteries are nearing the end of their expected life but show no leaks or damage.
- Cooling pathways may present minor cosmetic issues like faded paint or dings, but inlet/exhaust vents have minor obstructions caused by light dust and debris that could diminish air volume.

Grade 4

- System, part, or facility has reached the end of its useful life deterioration is clear and present and repairs are significant and replacement is immediate.
- Paint or finishes are peeling off or missing in aggregated patches that are coming loose and will require significant remediation to correct.
- Safety systems are in place however they are beginning to show safety issues and damage or missing components has become evident and repairs are absent or inconsistent with manufacturer recommendations.
- Fluid based systems (water, oil, hydraulic fluid, etc.) leak continually and requiring constant maintenance along with documented deterioration in piping, fittings, or fixtures.
- Components or sub-components of system (piping, fittings, pavement, concrete, masonry, etc.) show significant sagging, obvious open cracks and/or rot that penetrates through or extends further than twice the cross-section of the member. Repair is not an option and complete replacement of the part(s) or member(s) is required. Large pieces of pavement or concrete/masonry structures need to have large sections removed and replacement.
- Steel components are showing serious separation and misalignment. Section loss or pack rust is present but does not necessarily require structural review for repairs to be developed by in-house repair personnel.

- Structural components of electrical/electronic systems may be missing or needing replacement and may inhibit operation. Shows visible damage such as dings or paint smudges from that require repair and some mechanical components like hinges and latches have misalignments that hinder or prevent operation. Rubber bumper stops may show signs of deterioration and/or are missing preventing their function which can lead to additional damages.
- Electrical components such as connectors, wiring, and switches may show minor damage such as fading, rubbing, or discoloration but have no exposed conductors. These components will require replacement if these conditions exist.
- Electronics such as displays, LED indicators function as expected, are clearly visible, but may show minor cracks, discoloring, and errors. Repairs or replacement are required.
- Batteries are at the end of their expected life and may show leaks or damage. Replacement is required.
- Cooling pathways may present damage or significant dust and debris that may diminish airflow. Inlet/exhaust vents have minor physical obstructions that require repair or replacement.

Grade 5

- System, part, or facility is past its useful life and has critical defects affecting its functioning. Excessive repairs required to prop up the item or system. Beyond repair and in need of immediate replacement.
- Paint or finishes are peeling off or missing in aggregated patches that are coming loose and will require significant remediation to the base material to correct.
- Safety systems are failed, removed, nonexistent, nonfunctioning, or bypassed making the environment, part, or facility is a safety concern for human, facility, or operations.
- Fluid based systems (water, oil, hydraulic fluid, etc.) have leaked dry and/or there is full deterioration in piping, fittings, or fixtures causing multiple blowouts or leaks within the part, system, or infrastructure. Leaks could also be widespread causing collateral damage to other systems, parts, or areas not directly connected with the leaking system.
- Components or sub-components of system (piping, fittings, pavement, concrete, masonry, etc.) show significant sagging, obvious cracks and/or rot that penetrates through or extends further than twice the cross-section of the member. Repair is not an option and complete replacement of the part(s) or member(s) is required.
- Pavement or concrete structure is cracked and spalling in a manner that effects its functioning and operation. Emergency support may need to be installed to create a safe environment until repairs are complete.
- Steel components show complete separation and misalignment, fasteners have failed and members are rusted through. Degradation requires structural review to confirm repair and current or future safety of operation.
- Structural components of electrical/electronic systems such as panels, rails, screws, air dampers, rubber components are missing or damaged and inhibit operation. Parts to repair the system are no longer available and replacement of that system is required.
- Electrical components such as connectors, wiring, and switches may show damage such as melting insulators, frayed wires, exposed conductors that pose a safety threat to human, facility, and/or operations. Parts to repair the system are no longer available so replacement of that system is required.

- Electronics such as displays, LED indicators do not function as expected, are not clearly visible, shows cracks, discoloring, and errors replacement is required.
- Batteries are past the end of their expected life and show leaks or damage. Removal and replacement of components is required and system may need to taken offline for health and human safety.
- Cooling pathways are damaged and are impacting airflow. Inlet/exhaust vents have obstructions that cannot be repaired. Replacement of that system is required.