NATIONAL RADIO ASTRONOMY OBSERVATORY

Socorro, New Mexico

VLBA Antenna Memo Series No.94

St. Croix VLBA Antenna Structural Repair, Surface Preparation and Re-Coating

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Revision A. (Jon Thunborg, Kevin Baker)

1 Executive Summary

In September of 2017, the island of St Croix was hit by two category 5 hurricanes: Irma, on September 6, and Maria, on September 20. In response, on December 18, the US House of Representatives introduced HR Bill 4667 to fund hurricane and wildfire disaster relief. This bill funded a proposal to recommission the Very Long Baseline Array (VLBA) antenna on the island of St Croix and improve the site infrastructure to improve its survivability in the face of future severe weather events. The proposal funded site repairs and improvements.

The St Croix antenna is located very close to the ocean, in what is considered an atmospheric marine corrosion zone. The salt laden air from the ocean accelerates the corrosion of the antenna structure. This corrosion increases the structures vulnerability to weather events such as hurricanes. In order to prolong the life of the structure, severely corroded sections of the antenna were repaired and the entire antenna was cleaned using Ultra High Pressure (UHP) Water Jetting. The entire antenna was then repainted to inhibit future corrosion.

Figure 1: St. Croix VLBA Site

2 Antenna Assessment

The condition of the antenna was assessed by Jon Thunborg and Ron Taylor in September of 2018. Corrosion was discovered ranging from minor surface rust to severe corrosion. For the purposes of this paper, severe corrosion is defined as places with the paint mostly to completely gone, heavily corroded, deep pitting, large areas of flaking, or measurable cross sectional material loss. Most of the severe corrosion was on the catwalk bar grating where the coating gets abraded and on the structure where there are pockets to trap water or debris. There was also severe corrosion on the cable trays and places where brackets were welded onto the antenna after the initial painting. Additionally, the coating system was showing signs of failure on the sharp edges at the corners of the beams, on the bolted connections and in the pockets on the structure that trapped water and debris.

3 Contracting

The necessary structural repairs identified were diverse. Furthermore, it was expected that additional structural damage would be found upon removal of the existing paint. In order to repair as much structure as possible with the available budget, the structural repair RFP was issued as a time and materials contract, as opposed to a lump sum contract. This allowed the NRAO engineer overseeing the work to prioritize repairs as the degree of damage was revealed.

The UHP/Coating RFP was issued as a lump sum contract, as the Scope of Work (SOW) for this phase was clearly defined.

After a competitive bidding process, the structural repair contract was awarded to Tang How Brothers and the UHP/Coating contract was awarded to Phoenix International.

4 Structural Repair

Throughout the structural repair portion of this project, Engineering Services developed the following prioritization of repairs.

Table 1: Structural Repair Tasks

1. Repair corroded steel on lower portions of the quad legs
2. Replace corroded cable trays and brackets
3. Replace the condenser platform
4. Repair the shear panels at the vertex room level where the drain holes have corroded through
5. Repair corroded sections on the hand rails
6. Drill weep holes where significant water ponds to allow water to drain

Tang How Brothers completed items 1, 2, and 3 of Table 1: Structural Repair Tasks. The contractor, further, completed an estimated 75% of item 4 within the allotted time and budgetary constraints.

4.1 Quad Leg "A"

The quad legs are the hollow square tubes that support the subreflector and Focus Rotation Mount (FRM) assembly. The quad legs are made of 12 gauge (0.109") sheet steel that are welded to ½ steel plates at the lower connections. Debris from inside the steel tube collects at the connection between the steel plate and the tube and promotes corrosion.

Figure 2: Quad Leg Connection to Support Structure

On a previous maintenance visit (Thunborg, St. Croix VLBA Antenna Painting and Surface Preparation Requirements, 2007), NRAO staff cut away the lower section of the tube and welded ¼" galvanized steel plate in its place. During this maintenance visit, Tang How Brothers performed similar repairs on quad leg "A". However the thickness of the replacement plate was not recorded. Weep holes were added to allow water to drain from the interior cavity of the quad leg.

Figure 3: Repaired Quad Leg with Weep Holes

4.2 Cable Tray and Bracket Replacement

The cable trays and their support brackets suffered corrosion to the point of failure. The corrosion at the support tube, Figure 4, was initiated because the cable tray was welded onto the support tube which compromised the galvanized coating. Repair work involved cleaning the corrosion, welding a steel cap over the corroded area and welding the new bracket onto the cap. Figure 5 shows the welded cap and the new aluminum cable tray.

Figure 4: Typical Corrosion at Bracket Connection

Figure 5: Completed Cable Tray Connection Repair with Cable Tray Installed

4.3 Condenser platform replacement

Figure 6: Condenser Platform Pre-Replacement

The condenser platform and its points of connection to the antenna was in a highly corroded state. Engineering Services determined that its replacement was preferable to attempting repairs to the platform. Tang How Brothers fabricated and installed a replacement.

Concurrent with the fabrication work, the existing platform was removed and new connection points were installed.

4.4 Shear panels at vertex room level

The shear panels at the vertex room level (also referred to as tank sections) of the antennas have holes corroded through them in all the corners were water gets trapped. Repairs to these panels were begun during the 2016 maintenance visit (Thunborg, St. Croix VLBA Antenna Painting and Surface Preparation Requirements, 2007).

Tang How Brothers continued this repair effort. Corroded sections of the shear panels were cut away and patched and covered by ¼ inch thick galvanized steel patches, which were welded in place. Weep holes are cut out at the lower

Figure 7: Shear Plate with Weep Holes

portions of the patches to eliminate water being trapped in the corners of the structure.

Due to funding and schedule constraints, structural maintenance concluded with approximately 75% of the shear panels repaired.

4.5 Remaining Structural Tasks

Figure 9: Typical Hand Rail Corrosion

Items 5 and 6 of Table 1: Structural Repair Tasks remain incomplete. Item 5 may become a safety hazard if left unchecked. However, Engineering Services has deemed that the hand rails do not pose a safety hazard at this time. Item 5 will be added is planned as a task for the next tiger team visit to the St. Croix facility. Engineering Services considers item 6 to be beneficial to the longevity of the structure. The weep holes will be added as supplemental task for future visits, to be completed as time allows.

Figure 8: Structural Connection that Ponds Water

5 Coating System

The new coating system consists of Spot Prime of B62S00100 -Epoxy Mastic Aluminum II to stripe coat on sharp edges such as bolts and gusset plates, Full Prime Coat of B58W00610 Macropoxy 646 fast cure as the full prime coat and B65W00651 HS Polyurethane as the top coat. Phoenix Tech International provided a 5-year warranty for this paint system.

5.1 Application

Figure 10: Antenna Support Structure with Top Coat

The first step in the process was to use a UHP jetting process that employs 40,000 psi water jets to strip corroded areas down to bare metal and to remove the old top coat from some areas of the antenna. Most of the antenna area was simply washed as the existing coating was in condition that allowed the new coating to be applied directly.

The UHP cleaning process was immediately followed by a stripe coat. Stripe coating is the application of paint to edges and seams at higher risk of corrosion. The stripe coat serves as an additional layer of protection in these high risk areas. The stripe coat was followed by a prime coat and top coat, covering the antenna structure in its entirety.

Figure 11: Antenna Support Structure with Top Coat

6 Recommendations

As mentioned paragraph 4.5 above, Engineering Services recommends that remaining structural damage be addressed during future tiger team visits. Additional time will be allotted to upcoming tiger team visits to facilitate these additional tasks. There is no need to schedule a dedicated visit to complete repairs. In the meantime, site techs will be tasked with maintaining the coating systems to limit corrosion as future damage occurs.

It is further recommended that an antenna engineer be assigned to perform a structural survey of the Saint Croix antenna and all VLBA antennas in corrosive environments. This individual will produce a report detailing the need for structural repairs and mitigations to ensure the longevity of the VLBA sites at risk from their corrosive environments.

7 References

Thunborg, J. E. (2007, May). St. Croix VLBA Antenna Painting and Surface Preparation Requirements. *VLBA Antenna Memo Series No. 68*.

Thunborg, J. E. (2016, September). St Croix Mechanical Repair Trip Report. *Antenna Memo Series No. 92*.