NATIONAL RADIO ASTRONOMY OBSERVATORY
Socorro, New Mexico

VLBA Antenna Memo Series No. 89

Azimuth Rail Repair at Fort Davis, Texas
June 17 – June 25, 2013

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1.0 EXECUTIVE SUMMARY

The Fort Davis VLBA azimuth rail was spalling on the top surface where weld metal had previously been deposited. Both damaged rail sections were removed and replaced with new rail sections. The new rail sections were successfully leveled and bedded in epoxy grout. All of the antenna azimuth rail splices were updated with a more robust splice bar design that significantly reduced the rail deflection at the splices.

There are at least two other VLBA rail sections that will need to be replaced, one at Fort Davis and one in Pie Town. Sufficient budget and manpower will need to be allotted to facilitate these repairs.

2.0 INTRODUCTION

In February of 2013, the Fort Davis site technician (Jason Candelaria) reported that the surface of the azimuth rail was deteriorating as shown in the photographs below.

Further inspection revealed that the surface of the rail was failing where weld metal had previously been deposited on the surface. Presumably this weld metal was deposited during antenna construction to repair a low spot in the azimuth rail. This type of repair is subject to fatigue spalling and should be discouraged on future antenna construction projects.

A maintenance team traveled to Fort Davis to replace the two failed rail sections. This report documents the results as well as the tools and procedures used to conduct this repair.

3.0 PROCEDURE

The following section records the procedure that was used to replace the rail. Also included are problems encountered during the project and additional tools or fixtures that would be helpful if this process is repeated.

3.1 Measure existing rail

A target was placed on the idler wheel and a wild optical level was used to measure the rail height over all 120 rail bolts. The antenna was parked and locked out so that it was completely off the rail that was being replaced. We measured and recorded the existing rail arc length by placing a flexible tape along outside surface of rail head. We used the protractor head on a combination square to measure and record the splice angle relative to the outer surface of rail head.

Recorded Arc Length ____26' 4.5"_______
Splice Angle ______46º____

3.2 Demolition

We removed the rail clips, splice bars and rail plate nuts. The rail clip nuts are recessed in a pocket that is too small for a traditional socket. Therefore we used a 1 ¼ "socket with the outer diameter turned down to a diameter of less than 1 13/16". The 1"-8 unc studs that hold the rail plates down are sufficiently long that a traditional socket cannot be used. We fabricated a special deep well socket by welding a short piece of pipe between two sockets. Two of these deep sockets are needed as the rail plate nuts can be either 1 ½ or 1 5/8 wrench size.

After all rail clips and spice bars had been removed, the rail section was pried up until it was free for its entire length. The rail was then lifted away using the crane.

We used demolition hammers to loosen and remove the rail plates.

The old grout was removed to a depth of at least 2” below the rail plates.

3.3 Cleanup

The Vulchem, grout and rust was then scraped from the rail clips and rail plates. The tops of the rail plates were then sanded smooth to facilitate alignment of the rail. The Vulchem was very hard to remove from the rail clip counter bores. We used a 2” cup brush for this task but it would be prudent to design a tool for this on the next rail replacement. The splice plates were also cleaned and sanded smooth.

We removed the lower rail plate nuts and chased the threads with a 1"-8 UNC die. Cutting oil was used to help preserve the threads. An impact wrench and deep well socket that fit the die holder greatly facilitated this task.

The Grout requires a clean surface free of all grease, oil and old material for proper bonding. Therefore, a pressure washer was used to remove all loose grout, dust and oil from the foundation. The foundation was then thoroughly dried using compressed air.

3.4 Prepare Rail

Cutting the rail sections to the correct angle and length proved to be more difficult than expected. The rail is made of alloy steel that does not appear to be homogeneous. Hard spots within the steel made it impossible to cut the rail with the horizontal band saw that we brought along for this purpose. Therefore, we were forced to cut the rail with a hand held abrasive wheel saw. An adjustable angle guide for the abrasive wheel saw should be designed and built for the next rail replacement.

After the rail was cut to the approximate length and angle, a hand held grinder was used to bring the rail to its final dimensions.

The next step in the process was to use a hydraulic rail drill to bore the 1-3/16" holes needed to accommodate the splice bar bolts. The hydraulic power unit needed to supply oil to the drill would not start, so we modified the drill so that it could be powered with the skid loader hydraulic system. This modification worked quite well and may become the preferred method to power the rail drill.

3.5 Reassembly

The rail plates were reinstalled and roughly leveled using an optical level. The rail was then set in place.

The splice bars and splice plate clamps were then tightened on the existing rail and loosely installed on the new rail. This allows movement along the rail as the rail was forced into the proper radius using the skid loader to supply the driving force.

Once the rail was properly positioned, the rail clips were installed and all the splice bar bolts and clamps were then properly torqued.

3.6 Precision leveling

A precision optical level positioned near the pintle bearing and aimed at a target on the rail was used to set the rail to the proper height. A small portable light was used to illuminate the target. The level bubble on another optical level was used to level the rail from side to side.

Great care was used to ensure that the rail was set to the correct height before grouting. The rail measurements measured in Section 3.1 were input in an excel spreadsheet that used a least squares curve fit to generate the proper heights to minimize rail flatness with the overall rail tilt removed. The rail was kept shaded during measuring to minimize thermal distortions from solar heating.

3.7 Setting forms

6" Masonite house trim coated with packing tape was used to create forms. The Masonite forms were then secured to the foundation using "Blue Screws" and wood wedges..

Silicone caulk and caulk cord was used to seal the forms and prevent the grout from leaking out of the cracks. We found that the caulk cord worked best as we did not have sufficient time to allow the silicone caulk to dry.

3.8 Grouting

Dayton Superior Epoxy Grout J55 was used to bed the rail. Protective clothing, eye protection and gloves were used while mixing and pouring the epoxy grout. The grout is extremely sticky and we found it useful to tape our gloves to our sleeves with duct tape to prevent the grout from pulling our gloves off.

Parts A and B of the grout were combined and thoroughly mixed before being combined with part C in a skid loader cement mixer. Two 2 cu ft. units of grout were mixed at a time.

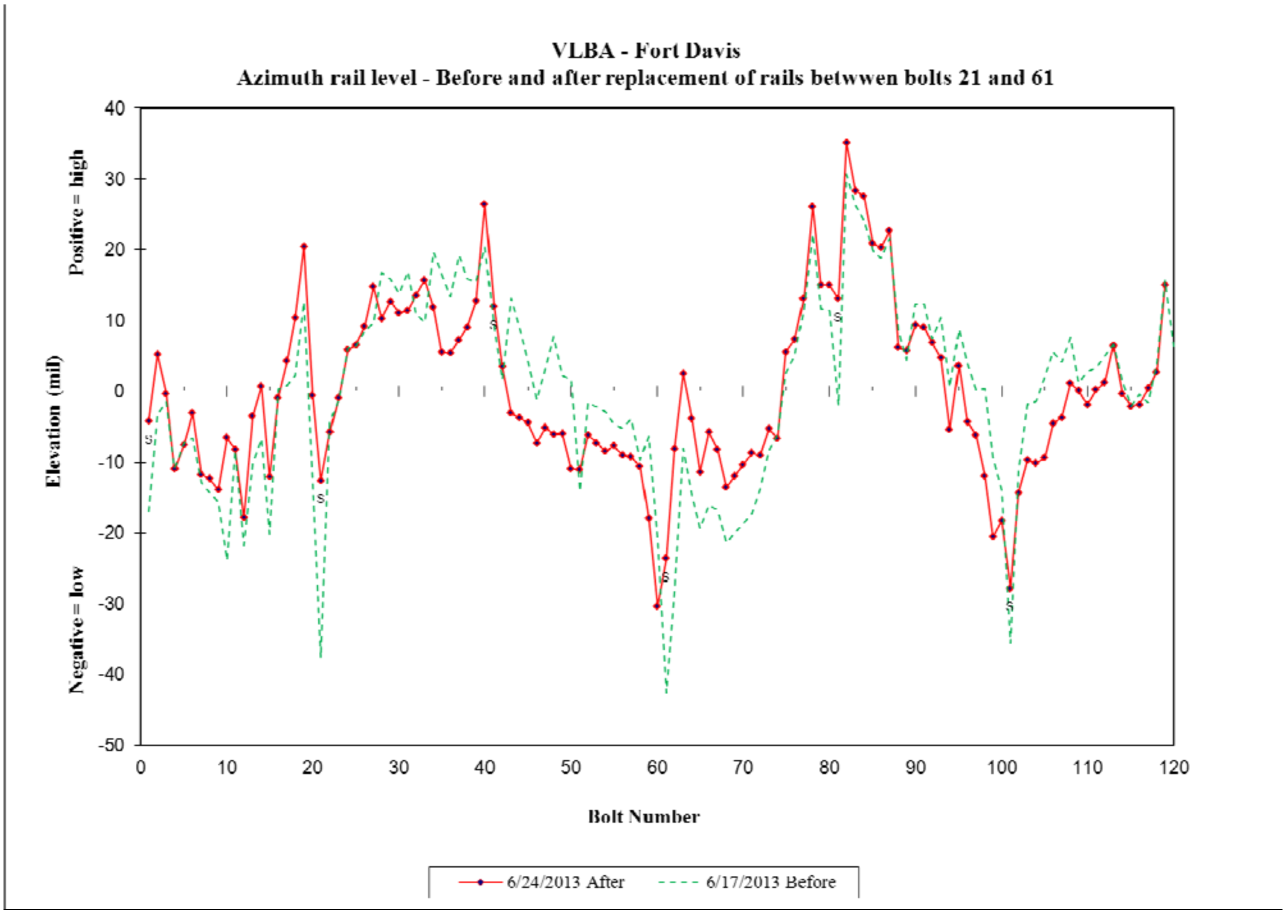
After thoroughly mixing the grout, It was loaded into 5 gallon pails and poured into the forms. The grout was always poured from one side of the rail and then allowed to flow under the rail and rail plates. This procedure was followed to ensure that air did not become trapped under the rail or rail plates.

The working time of the grout at 95º F is approximately 45 minutes. Therefore, the cement mixer and all of the equipment had to be thoroughly cleaned soon after it was used.

3.9 Cure and remove forms.
The grout was allowed to cure for 24 hours before the forms were removed and the antenna was allowed to roll over the azimuth rail. The antenna was then positioned so that the second rail could be replaced using the same procedure.

4.0 RESULTS

A wild N2 precision optical level was used to measure the height of the antenna wheel as it traveled over the rail. The general rail tilt was then removed using a least squares curve fit and the rail flatness at the rail bolt positions (approximately every 3 degrees) is charted below.



The two new rail segments are located between bolts 21 and 61. It is interesting to note that the two new rails were positioned without load so that the elevation error would be as near zero as possible. However, when measured under load the new rail position is remarkably similar to the original rail.

A precision level was used to set the level across the rail. This is to ensure that the wheel travels down the middle of the rail and does not run on one side or the other. The wheel path evinced by the shiny area in the attached photograph proves that the track is indeed level with the wheel.

The photos below show the rail splices in order at bolts 21, 41 and 61.



The specification calls for the gap between the rails to be less than 1/16 of an inch. The gap on the third rail goes from touching on one end to almost 3/16" on the other because the angle of the two rails is not identical. Although this exceeds the specification, the part of the gap over the rail web is still less than 1/16" and therefore I do not feel that it will be problematic.

The rail splices are at bolts 1, 21, 41, 61, 81, and 101. The flatness at the rail splices is improved because new rail splice bars were installed on all the splices. The old splice bars shown below were notched to make room for the rail clamps. These bars are prone to breaking at the notches and are not stiff enough to adequately reduce rail deflection at the splices. The new design utilizes un-notched splice bars and shortened rail clips.


5.0 CONCLUSIONS AND RECOMMENDATIONS

There is an additional area (near bolt 11) on the Fort Davis rail where weld metal was deposited on the surface. This area has not deteriorated yet but may in the future. The Pie Town Rail section that broke and was welded back together in 2010 is also beginning to show signs of a crack at the weld. This rail may also need to be replaced soon.

The crack shown below was revealed when a rail was removed. This particular rail was replaced. However, this may be an indication that we have other cracked rails out in the array and a detailed inspection might be warranted. A simple visual inspection is not possible because this part of the rail is hidden beneath the splice bars.

We currently have just one extra rail section that can be used if a VLBA rail fails. We have two rails that will likely need to be replaced soon and an indication that there may be cracks in some of the other rails. We should procure another 3 sections of rail in preparation for imminent rail failures. Three rail sections will cost approximately $12,000. There is also about $10000 - $20000 needed for grout, equipment rental and travel costs for each rail replaced.

6.0 AKNOWLEDMENTS

Thanks to the VLA Track Crew whose efforts were critical to the success of this repair. Pictured above (from left) are Track Crew Members: Adrian Pino, Rob Simpson, Tony Herschbach, Frank Martinez, Paul Savedra, Alfonso Benavidez and Engineer Jon Thunborg. The VLBA site technicians Jason Candelaria and John Jordan also greatly supported this effort.

APPENDIX A. Required tools and Material

Tool List	# Req
Material required to change one rail	
Rail section and spare	2
Rail grinder & power unit	1
Rail saw	1
Rail saw adapter for angle cut on crane rail	1
Dayton Superior J55 Grout 2 cu ft units	7
Splice bars for all splices	6 pair
Splice bar bolts and nuts 1-1/8 - 7 unc x 6" long A490	36
Coupling nuts	10
Studs 1" -8 unc	10
1-8 unc nuts and washers	120
Tie plate bolts, nuts and washers 3/4-10 unc x 3 1/4 A325	80
Tap and Die for stud bolts	4
Skid steer	1
Skid steer demolition Hammer + spades & points	1
Hand demolition hammers	4
Extension cords	3
Form material 16' masonite 6" and 8"	64'
Blue screws 1 -1/4 and 2 1/2 inch long	100
Blue screw drill driver	
Wood blocks to support forms	18
Form seal caulk	6
Caulk cord	10
Skill saw	1
Packing tape	12
Wild optical level and mag base target	1
Strait edge	1
Hand grinders	3
Grinding wheels	6
Crane	1
Rail tongs	2
Spreader bar for lifting rail	1
Tyvek suits	50
Gloves	12 pr

Face shields	6
Dust masks	24
Skid steer cement mixer	1
Wheel barrow	1
Garden hose and nozzle	2
Air compressor	1
Air hose	4
Air nozzles	2
Shovels	2
Brooms	2
Rail wrenches	set
Impact wrench and sockets	2
Pressure washer	1
Precision level "starrett"	1
Combination square sets	2
Turned down socket for rail clips	3
1-1/2 deep socket for rail plate nuts	2
1-5/8 deep socket for rail plate nuts	2
Small pry bars for lifting rail clips	2
Hammer and cold chisels	1
Wrench set	1
Welder and leads for attaching lightning ground	1
Measuring tape for rail chord length	1
Large pry bars for lifting and moving rail	2
Tools for scraping Vulchem	4
Tool to clean Vulchem from rail clip counterbores	2
Torpedo level	1
Paint mixer	1
Drill motor for paint mixer	1