VLBA ANTENNA MEMO SERIES #9

TRIP REPORT
KITT PEAK PINTLE BEARING LEVELING
4-19-98 To 4-25-98

G.A. Stanzione

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Kitt Peak Pintle Bearing
Summary

A crew of five arrived at the KP site on 4-20-98. The crew consisted of John Wall, Ramon Molina, Marlin Smith, Dave Alderman, and Guy Stanzione. Jack Meadows, Ron Bates and Paul Rhodes were already present at the site.

After a safety meeting the antenna was positioned, locked out electrically and the dish stow pin installed. We then proceeded to install a working platform inside the pintle area and separate the antenna azimuth position encoder from the foundation post. The antenna azimuth position was recorded prior to separating the encoder and a benchmark was also established on the building wall with the use of a laser attachment. Bolts were numbered and then removed from the top and bottom of the bearing. Three were left in the top so the bearing could be raised with the antenna and the bottom seat could be cleaned. Hundred (100) ton jacks were positioned at each wheel. Six alignment bolts were placed in the bottom of the bearing.

With the antenna separated from the foundation we positioned 4 crews of two persons at each jack. Our intent was to try an raise the antenna simutaneously in equal increments (of approximately 1/8") to a final height of 2" above the rail. At each ½" increment a ½" shim would be placed between the jack and the structure. At full jack extension (2.25") a 2" block of steel shim would be placed between the antenna wheel and rail. The antenna would then be lowered back onto the 2" block transferring the antenna load back to the rail.

We brought all jack pressures up evenly. At 4800-5000 psi the idler wheels lifted off the rail. The idler wheels should have lifted at approximately 3800 psi based on the weights given in the RSI drawings. We continued increasing the jack pressures at the drive wheels until the gauges read 8000 psi. At the specified weights the antenna drive wheels should have lifted at approximately 8000 psi but did not. We continued to increase the jack pressures to 10,000 psi (plus). The antenna still would not lift. We positioned an additional (fifth) 100 ton jack under azimuth drive #1 wheel. This helped immediately and allowed us to seesaw from one drive wheel to the other lifting the antenna while keeping the jack pressures in the 9,500-10,000 psi range. Based on these pressure readings the VLBA Antenna could be approximately 30% heavier then indicated in the RSI drawings.

Instead of trying to lift the antenna at all four jacks simultaneouly we decided to shift from the drive side to the idler side lifting the antenna approximately 1/4" per side at a time. This approach seemed to work fine. The antenna was raised and set on the 2" shim blocks in two hours.

At construction Devcon Liquid Shim was used to level the Pintle Bearing to the bearing seat. The Devcon liquid shim present on the bottom seat did not have any uniform thickness or pattern. It ranged in thickness from approximately 1/32"-3/32". We proceeded to clean the seat and the liquid shim came off easily.

The bearing was then leveled with reference to gravity. A precision level was used (.0005" per foot) attached to a four foot carpenters level. The bearing was leveled to within .0015" per foot or approximately .006". Gap measurements between the bearing and bottom seat were taken to determine the shim requirements. The measurements were taken to the right of each bolt hole. Shim stacks were calculated and placed varying from 0-.228". The bearing was lowered to the bottom seat and the bolts installed and torqued to a 1000ft-lb. We checked level again and found that it had changed slightly from .006" to .009"overall. The crew proceeded to clean the upper bearing seat. The liquid shim came off easily as it did on the bottom seat. Six alignment bolts were placed in the top of the bearing. The antenna was then lowered to 1-3/4" at the wheels. This allowed us to place some of the top bolts and take the top gap measurements. The antenna was lowered to ½" at the wheels leaving enough space to insert shim packs. After the shims were placed the antenna was lowered and placed back on the rail. Some binding at the bolts occurred and we could not start about 15 of the bolts. As we tightened the bolts that were already in place we were able to get the remaining bolts started and eventually torqued. Shim stacks at the top varied from 0-.280". Due to taper or waviness in the seat there wasn't complete contact of the seat across all the shim stacks. After torquing complete contact was made.

The Servo Tech Dave Alderman started his alignment procedure at about 11:00 am on 4-23-98 and finished on 4-24-98 at about 11:00 am (10hrs.). Alignment (total indicated runout) with the center post was .004" which is within the operating specification for the encoder (< .007"). The benchmark on the building was slightly off in elevation but was very close in azimuth. The encoder was repositioned to match original azimuth position on the data converter.

A table of shim placement (page 11) by bolt number top and bottom is attached. Additional plots (Page 10) were prepared checking for tilt associated with the lower and upper bearing seats. The lower seat did exhibit some tilt (.022") and is very wavy. Shim stacks ranging from 0-.228" were required to remove the tilt and seat waviness. The top seat exhibited more tilt (.117") than the lower seat. Shim stacks ranging from 0-.280" were placed to remove waviness and tilt from the upper seat.

Results and Conclusions:

A combination of waviness and tilt in the bearing seats are probably what caused the bolts to break. The areas of maximum shimming align well with where the bolts (# 35-39) were found broken. The effects of this tilt and waviness would result in cyclical loading of the bolts and bearing as the antenna rotates with respect to the bottom seat. This concurs with what Jim Ruff and crew found on their initial visit to Kitt Peak (copy of their trip report page 12).

A plot of the normalized readings (with tilt) and residual (waviness) are attached. Waviness in the lower and upper seats exceeds .125" over 90 degrees. The bearing manufacturer recommends that waviness not exceed .010" over 90 degrees. There is also approximately .022" of tilt in the bottom seat and .117" of tilt in the top seat. Waviness and tilt in the

bottom and top seats were removed relative to the bearing, with the shim stacks. The bearing is level to within an estimated .009" and loading will be more uniform through 360 degrees.

Remaining questions to be discussed are: 1) Why the 100 ton jacks could not lift the drive side wheels? 2) The need to further inspect the remaining VLBA antenna Pintle Bearings? 3) How much does the antenna actually weigh? 4) What effects if any would the additional weight have on the mechanical and/or scientific operation of the antenna? 5) refine the jacking procedure if other antenna bearings have to be leveled? 6) Has the Pintle Bearing incurred any damage? A future test memo will be issued discussing these questions.

Kitt Peak (KP) VLBA Pintle Bearing Leveling
Trip Period 4-19-98 to 4-25-98
Daily Log

4-20-98

1. Arrived at KP site on Monday morning 4-20-98.

2. Site Techs (Jack Meadows and Ron Bates) positioned the antenna to a predetermined position. This antenna position gave minimum distance from concrete spokes to lower antenna structural beams.

3. The antenna was locked out and Dave Alderman installed his lock on the servo drive cabinet. Dave located azimuth position using a laser. A mark was placed on the building wall and recorded the ACU readout. The antenna dish stow pin was installed.

4. The mechanics proceeded to install a platform in the pintle area and remove the grease ring to allow easy access. And numbered all the bolts. Completed by noon.

5. The encoder bracket was separated from the stationary post by 1:20 pm.
Note! When the bolts were removed the two plates sprung ~1/4"vertically and ~1/2" to the west.

6. We broke loose all the bolts with the hydraulic torque wrench and removed them with the pneumatic impact wrench. We started at 1:30pm with the bottom and then proceeded to the top flange removing all the bolts by 4:00 pm. Three bolts (#1, #20, #40) were left in the top flange (120 degrees apart) to hold the bearing in place while the antenna was raised.

7. Jacks were positioned (centered) on the concrete spoke and centered on the beam web at each wheel (ref sketch). A dimension was taken from the center line of the jack to the center line of the antenna beam. The dimensions ranged from 21-5/8" to 26-9/16" indicating that the concrete spokes are not exactly 90 degrees apart.

4-21-98

1. Checked jack positions, and assigned four crews of two persons, one at each jack. Started jacking at about 9:15am.

2. **Jacks at drive wheels would not lift**. The gauge pressures were at the maximum reading of 10,000 psi+. Drive side jacks should have lifted at about 8,000 psi based on the weights given from RSI drawings. A suggestion was made to position a fifth jack at azimuth drive #1. As soon as we applied the jack pressures started to shift and relieve from both azimuth drives #1 and #2. By seesawing from az#1 to az#2 we were able to start lifting the drive side.

Instead of trying to lift the antenna simultaneously at all four jacks we decided to lift half the antenna at a time shifting from the drive side to the idler side. We proceeded to raise the antenna in 1/4" increments shifting sides. We shimmed at the jacks between the jack body and the antenna structure and between the wheel and the rail.

The gap that developed at the bearing varied. In order to get the 2" shim between the wheels and the rail we added a ½ " shim at the ram. This gave us more lift. With the 2" shim at the rail the gap at the bearing ranged from 1-3/4" to 2-1/8" (In clockwise rotation Az#1 gap 1-7/8", Az#2 gap 2-1/8", Idl #1 gap 2", Idl#2 gap 1-3/4"). It was decided the gap was sufficient to clean the bearing seats so we didn't try to lift the antenna further. We finished jacking at about 11:10am. Placed 6 alignment bolts (evenly spaced) in the bottom of the bearing. Intent is to guide the bearing when it is lowered and hold it in position.

3. The bearings seat was cleaned by 1:30pm. There was liquid shim on the bottom seat. It ranged in thickness from ~1/64 @ bolt #9 to 3/32" @ bolt @#34. The liquid shim pattern was very erratic. We proceeded to lower the bearing enough to insert the precision level and leveled the bearing. The bearing was leveled so the bubble was within 4 graduations of being symmetrical around the center. The level is accurate to .0005" per foot. We were using a four foot level so we were approximately .006" off level. We placed the level between two of the holding bolts #20 and #40 at bolts #22 and #38. Checked and leveled 90 degrees off initial orientation.

4. With the bearing leveled we measured the gap at each bolt. Determined shim requirements using Programmed calculator supplied by JRuff by 4:00pm. Decided to call it a day.

4-22-98

1. JRuff had shim stock precut by Machine Shop. There were four sizes of shim material which were color coded (Yellow (.020"), Tan (.0075"), Green (.003"), Aluminum Sheet (.060")). We prepared the shim stacks and placed them. The bearing was lowered using the three bolts left in the top and torqued to 1000ft-lb.
Note! Prior to torquing the bearing seat was not making full contact with the shim stacks. This can be attributed to either taper or waviness due to welding distortions on the seat. Full contact was made after torquing.

2. Cleaned the top seat. Very little liquid shim on the top seat. Placed 6 alignment bolts (evenly spaced) in the top of the bearing. Intent is to guide the Pintle housing when it is lowered.

3. Lowered the antenna approximately 1" at the rail and placed the new mounting bolts in the top of the bearing. We encountered binding of some bolts and could not start other bolts in several areas. The Alignment bolts also bound up as we lowered the

antenna. As we tightened the mounting bolts manually we were able to get the other bolts started.

4. Took all the gap measurements at each bolt. Lowered the antenna again and stopped at ½" shim at the rail. The jacks were relieved.

4-23-98

1. The shim stacks were placed on the top of the bearing and the antenna lowered by 10:00am.

Note! Prior to torquing, the bearing seat was not making full contact with the shim stacks on the inside edge. A .017" feeler gauge could be placed at the front edge of the shim stack. This is due to either taper of the seat or waviness caused from welding distortions. The manufacturer recommends no more then .0025" taper per radial inch of bearing seat. Full contact was made after torquing.

2. Torquing was completed by 11:00 am.

3. Servo began work on Encoder alignment.
Dave checked the laser mark on the building and found it to be relatively close to the original mark. There were problems positioning the lower plate that fastens to the cable wrap post. There were only three jacking bolt nuts (a fourth one had been broken off). In the future we decided that it would be much easier if there were 6 jacking bolts. This would be a simple field modification.

4-24-98

1. Dave Alderman worked on encoder alignment and finished by 11:00am. The Encoder alignment with the stationary post was within .004" TIR. The encoder was also repositioned to match the original azimuth position on the data converter.

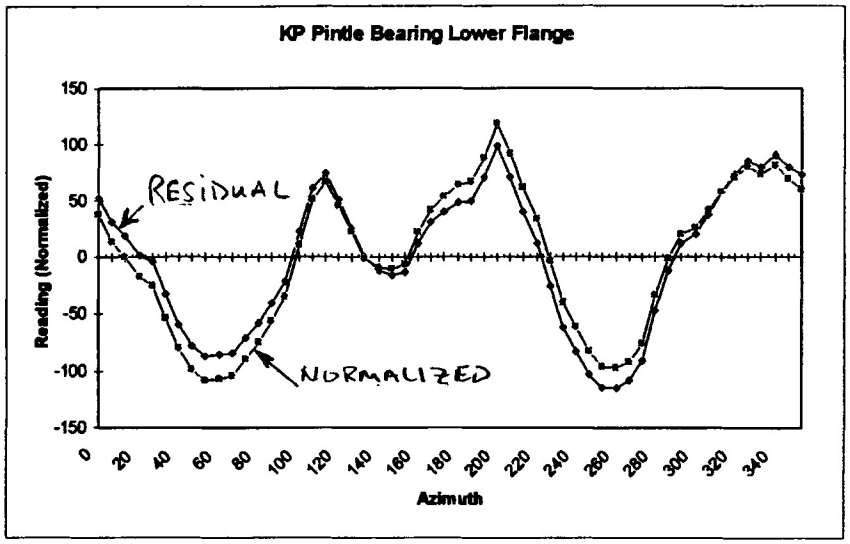
2. The mechanics jacked the wheels up one at a time removed wheel pillow block covers, inspected the bearings and rotated the outer races. It took about four hours to complete the job. No large chunks of metal were found. Grease samples were taken for analysis.

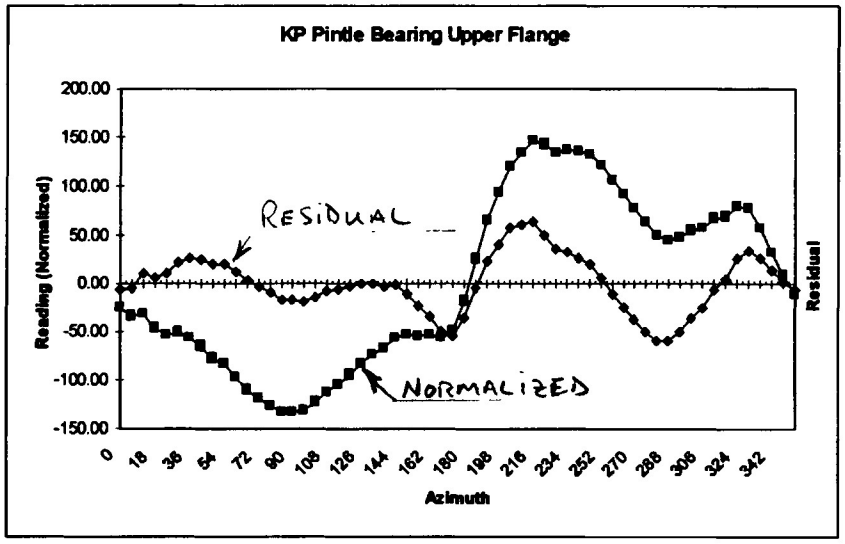
KP PINTLE BEARING
Procedure:

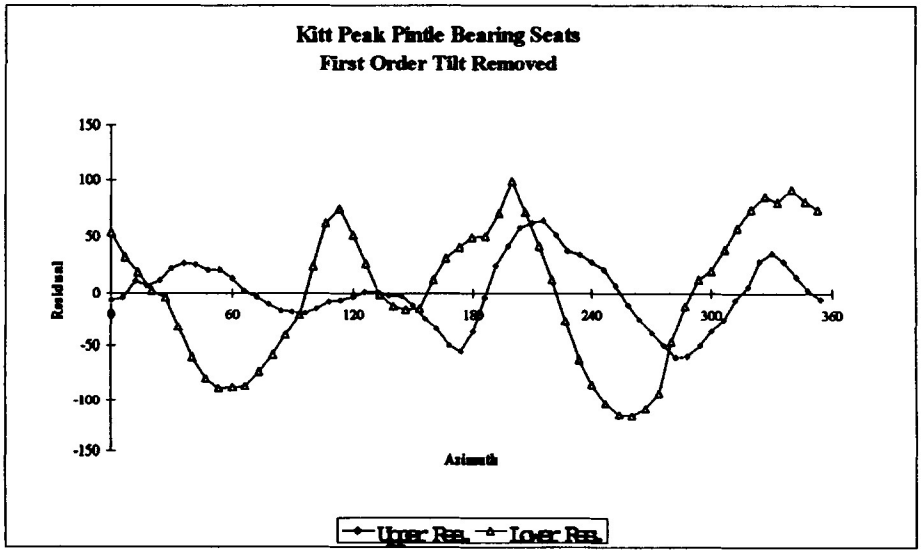
Position Antenna,
Electrically Lock Out,
Install Platform in Pintle area,
Clean excess grease,
Remove Grease Ring,
Locate antenna position on ACU, and with laser tool,
Separate Encoder from cable wrap, Scribe/Blue, Follow Servo Procedure,
Number all bolts top/bottom,
Remove bolts from bottom and top of bearing,
Leave three (3) bolts in the top 120 degrees apart,
Place extra long bolts in bottom (6),
Place Stands and Rams, Locate off rail to center off beam,
Shim top of ram piston to take out excess clearance (~3/4"to 1-1/2"),
Raise antenna gradually and evenly adding shim stock as it's raised to max. stroke,
Each ram operator **will use** gauge strips (1/8, 1/4, gauge strips) to control raising antenna. Everyone raises 1/8" at a time.
SOMEONE IN PINTLE AREA CHECKING FOR CONNECTED AREAS?
At max. Height (shim to 2" at ram), ram will be over extended. Place blocks @ wheels and relieve rams?? Transfer load to wheel blocks, Practice control while transferring load.
Clean bottom seat removing old liquid steel. Devcon (978-777-1100 Steve Leslie)
Rough Level bearing using 4' level. Use precision level for final level adjustment
Loosen the 3 bolts (~1 turn) at top of bearing to level.
Measure gap between bottom of bearing and bearing seat. **Determine shimming** and place.
Lower bearing with three top bolts onto shim 2 turns at a time
Place new bolts at bottom of bearing and torque (1000ft#)
Clean old liquid steel from top seat
Measure gap between top of bearing and top bearing seat. **Determine shimming** and place
Transfer antenna load to rams, remove wheel blocks.
Lower antenna gradually removing ram shims. Each ram operator **will use** gauge strips (1/8, 1/4, gauge strips) to control raising antenna. Everyone raises 1/8" at a time.
Check remaining gap around top of bearing, and shim as required (should be the same all around). Place new bolts at top of bearing and torque (1000ft#).
Install/reconnect encoder frame
Install grease ring
Remove platform

Equipment:
VCR with tapes
Hydraulic Torque Wrench, **Follow up on del. 4-9-98 R Molina**
Compressor, Follow up on del.for 4-17-98 **R Molina**
Bolts, & Washers, Follow up on del. **R Molina**
Extra 6" long bolts, **R Molina**
Jacks, fifth jack and stand also, Complete **J Wall**
Stands and Shim stock, Bearing shim stock, Complete **J Wall**
Torch, grinding tools, sockets, welding supplies etc.???, Complete **J Wall**
Chisels to remove liq shim, **J Wall**
Dial Indicator and magnetic bases, Complete **J Wall**
4' Levels, and Precision level, **machine Shop, G Stanzione**
2"x5"x12" Wheel Blocks, **J Wall**
Plywood, Channel brackets-platform, wood screws, **J Wall**
MEK/Acetone, Rags, **J Wall**
Respirators Masks, with cartridges, **J Wall**
Jims calculator, measuring gun **(with 1-1/4" pad), G Stanzione**
Jims, Plastic Shim Stock, **J Wall**
Grease **J Wall**
Work Clothes, Gloves, Glasses, Hard Hats, Safety Shoes, **J Wall**
C-Clamp
Exhaust Fan for Pintle area if needed,

Hotel Res.: Smugglers Inn, Tucson
Vehicles: Truck with camper, and Van
Leave time/date: 4-19-98 @ 2pm from Socorro. Take truck into Socorro (Dave Alderman).
Who drives what: Dave will drive truck, Guy will drive van, JWall &MSmith will drive personal vehicles


KP Pintle Bearing Lower Flange
Reading (Normalized)
RESIDUAL
NORMALIZED
Azimuth


KP Pintle Bearing Upper Flange
Reading (Normalized)
RESIDUAL
NORMALIZED
Residual
Azimuth


Kitt Peak Pintle Bearing Seats
First Order Tilt Removed
Residual
Azimuth
Upper Res.
Lower Res.

Kitt Peak Pintle Bearing

Bolt	Degrees	Bottom	Shim Req'd Delta	Broken Bolts Found In January 1998 In Bold Bolt	Degrees	Top	Shim Req'd Delta
1	0.0	471	146	1	0	561	109
2	6.7	494	123	2	6	571	99
3	13.3	508	109	3	12	567	103
4	20.0	526	91	4	18	583	87
5	26.7	533	84	5	24	589	81
6	33.3	562	55	6	30	588	82
7	40.0	589	28	7	36	593	77
8	46.7	607	10	8	42	602	68
9	53.3	617	0	9	48	614	56
10	60.0	615	2	10	54	620	50
11	66.7	613	4	11	60	633	37
12	73.3	598	19	12	66	647	23
13	80.0	583	34	13	72	655	15
14	86.7	564	53	14	78	663	7
15	93.3	543	74	15	84	670	0
16	100.0	497	120	16	90	669	1
17	106.7	457	160	17	96	668	2
18	113.3	441	176	18	102	660	10
19	120.0	463	154	19	108	649	21
20	126.7	485	132	20	114	641	29
21	133.3	509	108	21	120	631	39
22	140.0	518	99	22	126	619	51
23	146.7	519	98	23	132	610	60
24	153.3	515	102	24	138	603	67
25	160.0	487	130	25	144	592	78
26	166.7	466	151	26	150	590	80
27	173.3	454	163	27	156	591	79
28	180.0	444	173	28	162	589	81
29	186.7	441	176	29	168	593	77
30	193.3	419	198	30	174	586	84
31	200.0	389	228	31	180	555	115
32	206.7	416	201	32	186	511	159
33	213.3	446	171	33	192	471	199
34	220.0	475	142	34	198	443	227
35	226.7	512	105	**35**	204	416	**254**
36	233.3	548	69	**36**	210	402	**268**
37	240.0	570	47	**37**	216	390	**280**
38	246.7	591	26	**38**	222	395	**275**
39	253.3	604	13	**39**	228	402	**268**
40	260.0	606	11	40	234	399	271
41	266.7	600	17	41	240	400	270
42	273.3	585	32	42	246	403	267
43	280.0	542	75	43	252	414	256
44	286.7	510	107	44	258	430	240
45	293.3	488	129	45	264	444	226
46	300.0	483	134	46	270	458	212
47	306.7	467	150	47	276	473	197
48	313.3	450	167	48	282	487	183
49	320.0	437	180	49	288	491	179
50	326.7	427	190	50	294	488	182
51	333.3	435	182	51	300	481	189
52	340.0	426	191	52	306	478	192
53	346.7	439	178	53	312	469	201
54	353.3	448	169	54	318	467	203
55				55	324	456	214
56				56	330	459	211
57				57	336	479	191
58				58	342	504	166
59				59	348	528	142
60				60	354	548	122

NO BOLT PLUG

Trip Report (JRUFF)
Kitt Peak Pintle Bearing
1/19 & 20/98

Ramon Gutierrez, John Wall and Jim Ruff went to check out broken bolts in the pintle bearing.

Procedure:

- There were three bolts broken and one missing when we arrived. They were all adjacent to each other, at the point where the diagonal beam from Az 2 drive wheel meets the pintle housing.
- We visually checked a grease sample and so no evidence of metal flakes.
- We mounted two dial indicators. One indicated from the upper mounting plate to the inner bearing ring (vertical). The other from the inner ring to the ID of the upper plate (radial). While moving in az, we measured 0.039" vertical TIR and 0.014" radial TIR. The movement was in two smooth waves, approximately 180° apart.
- By moving them over the high points, we were able to remove an additional 5 bolts, one of which was cracked about ½ way through. Repeating the dial indications, we saw 0.060" vertical TIR and 0.006" radial TIR. (We indicated from the plate ID to the bearing ID for the second run.)
- Next, we used a 13/16 EZ-Out to remove the broken bolts.
- We then loosened four bolts from the bottom mounting plate at the low point of the bearing. We indicated from the bottom plate to the top plate, and from the top plate to the inner ring. 0.004" TIR was measured between the plates. No motion was seen between the top plate and the bearing.
- One bottom bolt was extremely hard to remove. There was an eccentric ring of "Plastic Steel" between the bolt and the bottom plate. This ring wedged the bolt in very effectively.
- We then replaced the nine top and one bottom bolt with new Grade 8 bolts. The new bolts were positioned over a high spot and torqued to 1000 ft-lbs. It took repeated passes to bring the bolts up to torque, indicating the top plate and pintle bearing can were being pulled down by the bolts.

Conclusions:

- The pintle bearing is not flat. It appears to have been pulled down into the (non-flat) bottom plate, resulting in two waves of something like 0.080" amplitude.
- Moving in azimuth develops large cyclical stresses in the bearing, bolts and mounting as the top assembly is forced to conform to the wavy bottom. This cyclical stress probably caused the original bolts to fail in fatigue and loosen.
- Since the bearings have been in service for many years with no evidence of damage, it may not be necessary to correct the problem. However, we should do a finite element analysis to make sure.
- Correcting this problem would require removal of the top and bottom bolts, setting the bearing flat and parallel to the az rail, shimming under the bolts, and retorquing. A big job. Possible alternatives would be to somehow release the bearing bolts to allow the bearing to float over irregularities in the bottom plate.
- This problem is not acerbated by deviations of the rails from flatness.
- It appears the bearings were all installed using the same procedure. This raises the possibility that other sites may have similar problems.