Instructions on improving the Losmandy OPW PE behavior

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Overview: getting the best PE from the Losmandy OPW and precision brass worm

Online reports by other owners suggest that the OPW can typically give about 2 to 4 RMS arcsec PE. I was able to get below 1 arcsec PE by making several modifications to the OPW, described below. The steps were: replace 2 facing bearings with ABEC-7 stainless steel bearings (Boca bearings). Install a special Belleville spring washer on one end of the worm. Put shims around the bolts holding down the gearbox. Adjust the worm to ring gear spacing to avoid stalling the RA motor.

Parts:

Bearings were:
SR4-ZZC #7, 1/4 x 5/8 x 10/51 inch, Stainless Steel Radial Bearing
$12.95 each on eBay
http://www.ebay.com/itm/350886411467?_trksid=p2060778.m2749.l2649&ssPageName=STRK%3AMEBIDX%3AIT

Belleville washers were:
http://www.mcmaster.com/#belleville-disc-springs/=v70176

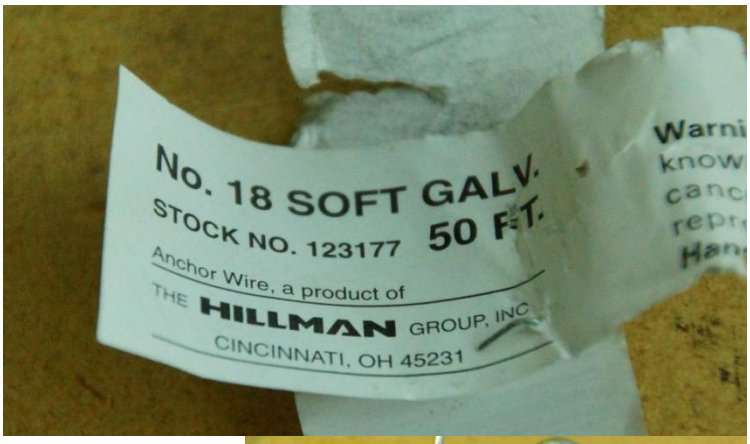
Belleville Disc Spring for Ball Bearings, Bearing #R4, .406" ID, .618" OD, .0216" High

R4	0.406"	0.618"	0.0216"	0.0089"	7	10	**94065K32**	2.76

Step A: getting out the existing rear bearing (if stuck)

The front bearing block has access to push out the two bearings once the worm is removed (and removing the worm may require some filing to remove deformation from the setscrews).

If you want to lift out the back bearing from its block, here is a simple puller made from a bolt and some heavy 18 gauge steel wire. Here is the wire that I used:
I bent pieces of that wire into shape by hand, with small pliers. You put the hooked wires through the center of the bearing, then insert the bolt that keeps the wires from pulling back out. Then gently pull out the bearing. If you need this....



Step 1: take a bolt with diameter smaller than (the bearing ID + 2 wires).
Step 2: screw on a large nut (square one shown)
Step 3: wrap 2 wires around the bolt and pass the wires around the nut

Step 4: insert the 2 wire hooks through the center of the bearing

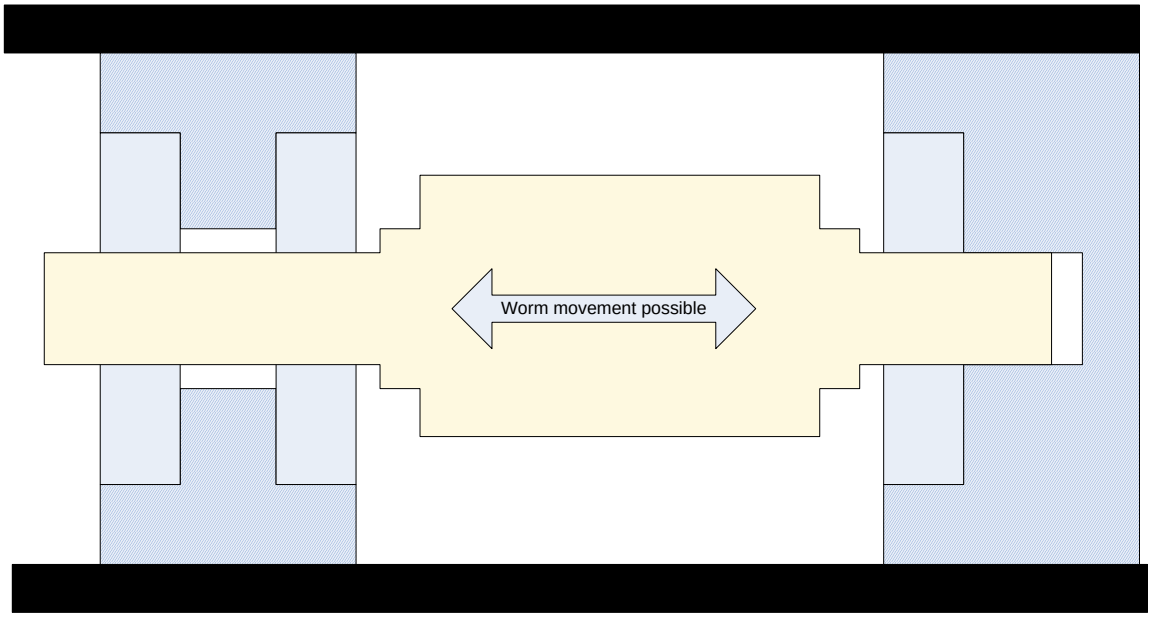
Step 5: screw down the bolt, so it prevents the hooks from being pulled back out.

Step 6: pull out the bearing from the block.

Step B: Putting in the Belleville washer

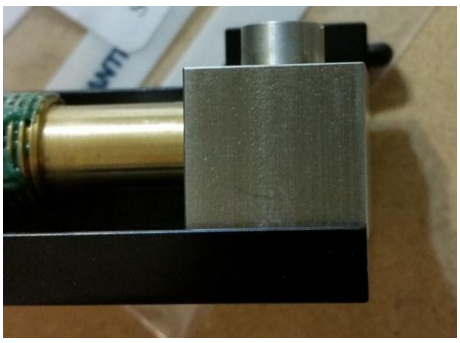
Here is the original problem (showing the Losmandy OPW One Piece Worm block), there will be a gap between the (brass or steel) worm and the facing inner bearings, due to temperature differences between the aluminum (black) and the worm (shown).

Normal OPW without a Belleville washer installed, allows the the worm to shift along its axis, between the two facing bearings. (Drawing not to scale)

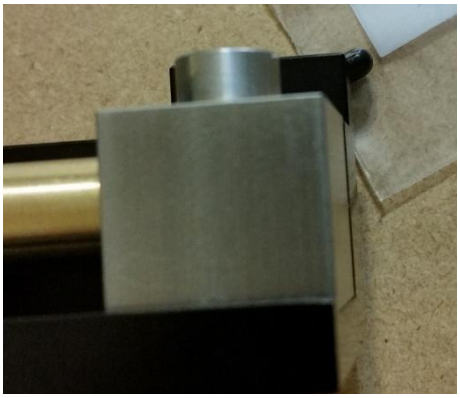


Once the bearing is out, put the Belleville washer in so that the curved out part faces the worm and bearing. This puts the larger outer edge against the worm block.

After you put in the washer, you should see the outer bearing block slightly extend past the end of the OPW:



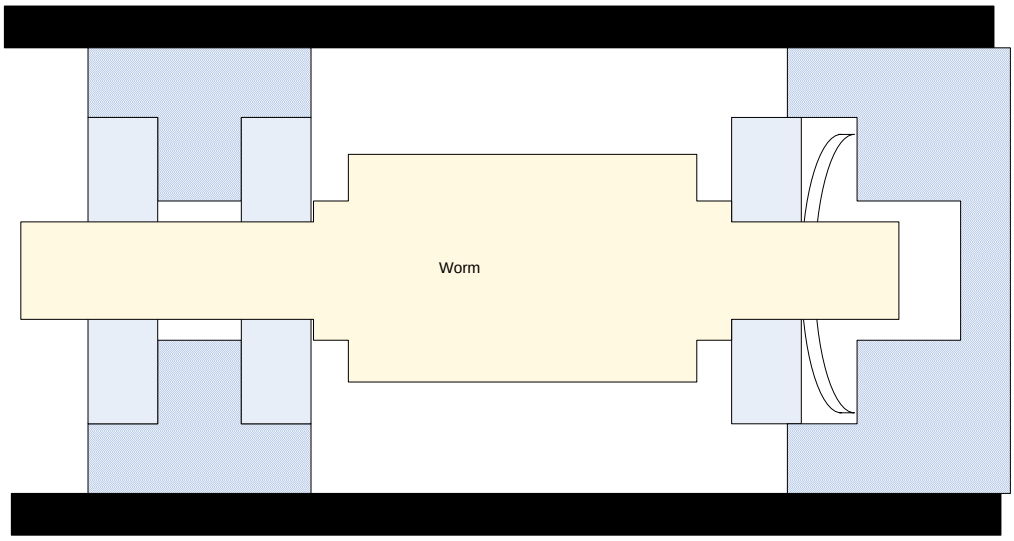
After you put in the washer and compress in the end block, you should see the outer bearing block slightly extend past the end of the OPW:



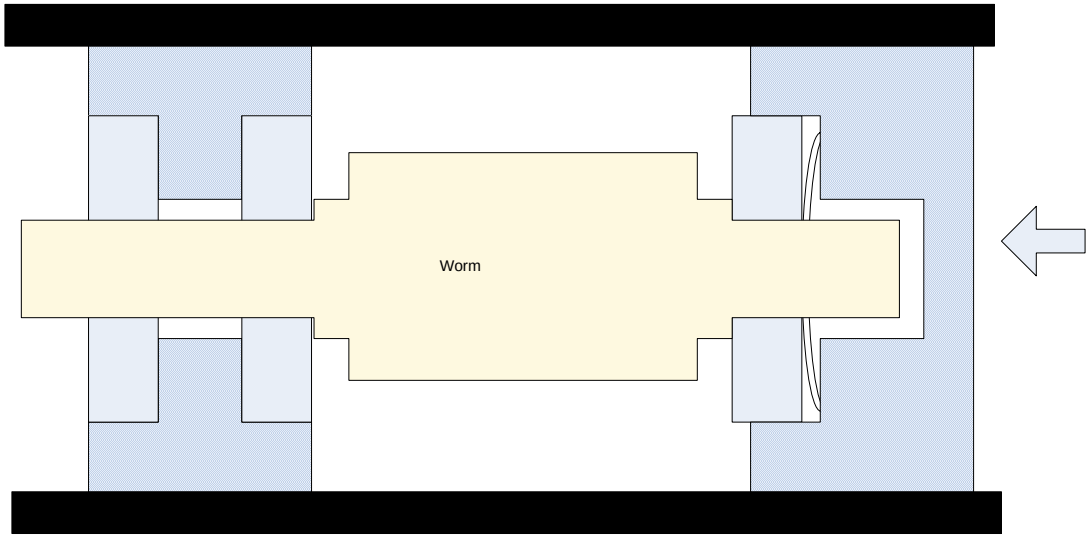
The disks are these, from McMaster-Carr

Here are the sketches of how the spring will go in:

OPW with the Belleville washer installed,
before the rear bearing block is compressed.
Note that when installed with the rear bearing block not force in, the rear block will be either flush or just slightly past the end of the OPW body. (Drawing not to scale)



OPW with the Belleville washer installed,
after the rear bearing block is compressed.
Note that you have to hand-compress the rear bearing block in the direction of the arrow,
while tightening down the bolts that hold it to the OWP frame. (Drawing not to scale)

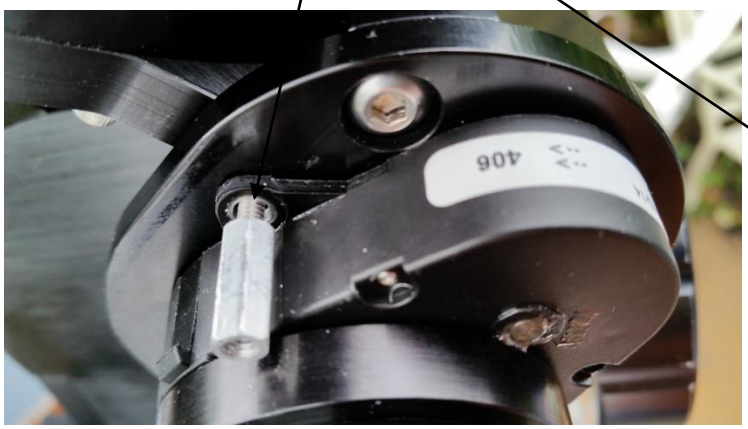


The Belleville washer spec says it compresses fully with 7 pounds pressure... I'd just push the thing together and see how that works. With temperature drops, the aluminum of the G11 will contract slightly faster than the brass of the worm (if your worm is brass). If your worm is stainless, then that contracts even less than brass. In either case, I don't think anything can go very wrong. Could the Belleville washer go in better in the other direction, with the larger edge facing the worm teeth? I am not sure... but my reasoning was that there is less of a lip on the back worm block to hold the inner washer ID edge.

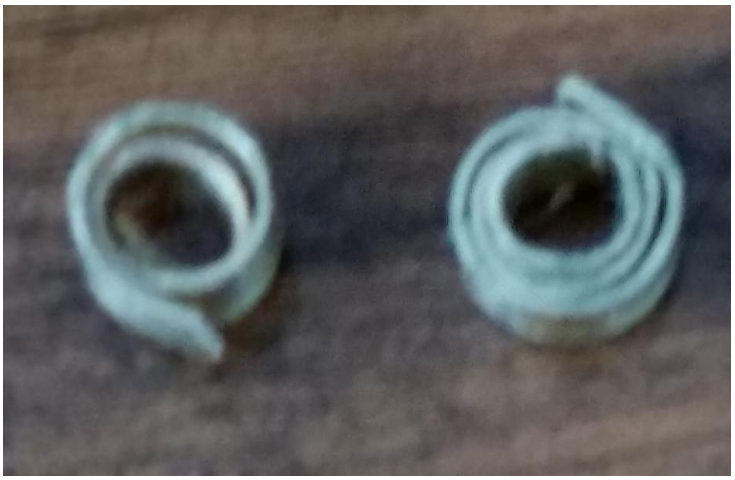
Step C: Reducing gearbox play

There is another part of the puzzle, on the outside of the OPW...the mounting of the Gearbox.

The new gearbox has mounting holes that are larger than the bolt that mounts them. Here is a picture of the problem. To fix this, I made some "tube" that takes up the gap, out of brass shim stock, cut with a scissors, and wound around the bolt. This is not ideal but did work to keep the gearbox from shifting out of alignment with the OPW mounting.



A simple solution: wind some brass shim around the bolt.
In place, the shims keep the gearbox from shifting.



Step D: Measuring the PE (before and after)

Download the free program PECprep from
http://eq-mod.sourceforge.net/pecprep/index.html

When you run the program, you can select the top menu Mount / Losmandy G11 mount... the program then knows the mount and worm parameters.

Download and run the program PHD from Stark (or better, PHD2).

1. Do a drift alignment before you start to gather your PE data. This will help keep your guide star on the imager chip region.
2. Take about 4 or more worm periods. The G11 period is about 240 seconds, so you need about 20 to 30 minutes of tracking.
3. When you run PHD (or PHD2), first allow the program to Calibrate.
4. next tell PHD to make a Log file.

On the Losmandy G11 with Gemini, you MUST be in "G" for Guide mode, else the autoguider signals will not work. Once the PHD is calibrated, go to your Documents top level, and delete or rename the PHD log file.

5. Run the PECprep program. In the File section, import the PHD logfile.

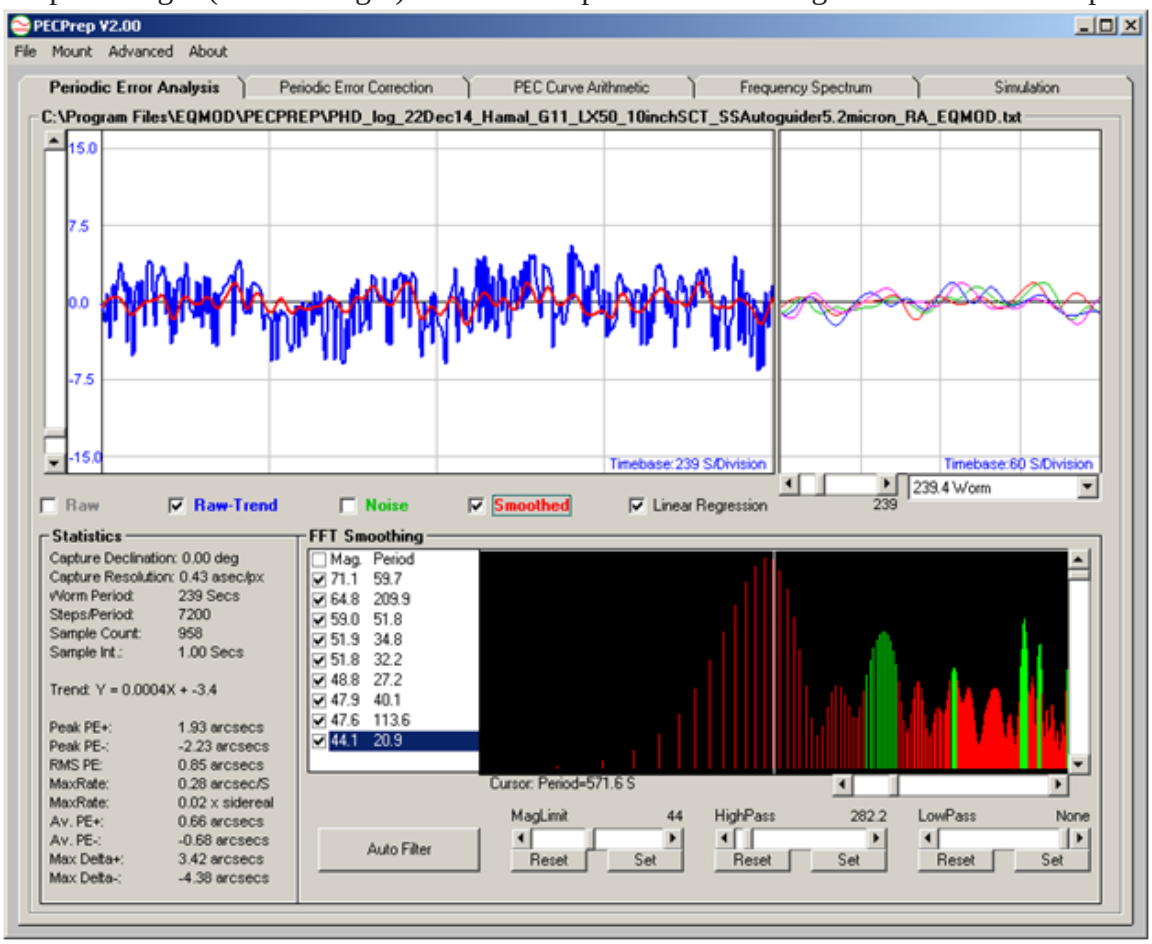
My email to the Losmandy group on Dec23 2014 was:

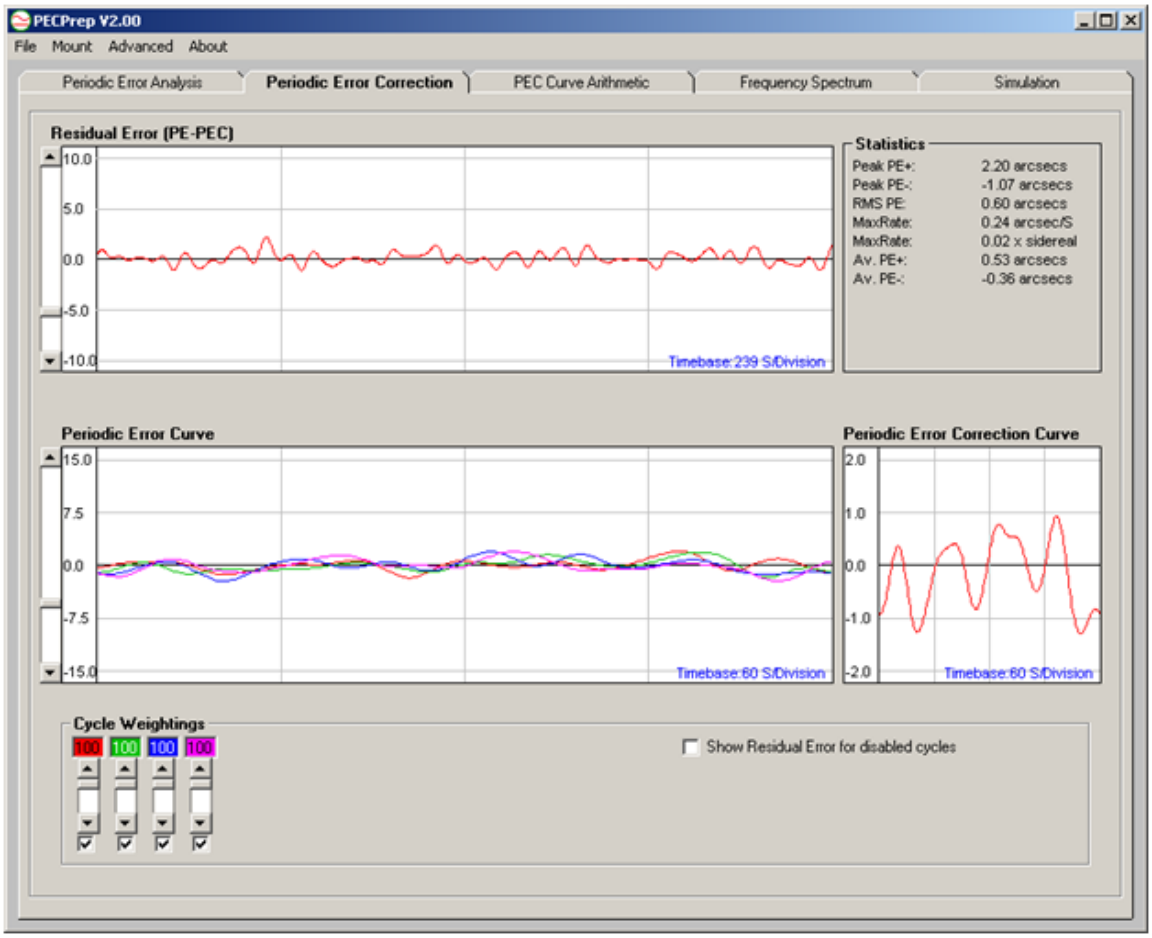
Hi gang,

I just measured the RMS PE measured on the upgraded G11 OPW, and it comes out at under 0.9 arcsecs. That is down from 4.8 arcsecs on the same OPW block from just a few weeks ago, but with a few different components. .

I used the same hardware (Orion Starshoot Autoguider with 5.2um pixels) and software (PECPrep) and scope (Meade LX50 10" SCT FL2500mm) to measure the PE in both cases. (I imaged Hamal for this measurement at about 10PM, at my location near San Francisco, it was starting out pretty close to the meridian and equator).

That PE is below the seeing conditions tonight. The program says that applying a PEC will bring the RMS PE to 0.6 arcsecs. I am running the mount tonight with a heavy 10" SCT, two 20 lb + 7lb counterweights. My camera has a 2" filterwheel and Lumicon giant off-axis guider. I am autoguiding (with no PEC installed) using the ASCOM interface, PHD with 4.5 sec exposures on an Orion Starshoot Autoguider, and getting the best sharpest images (of M1 tonight) at 500 sec exposure that I ever got with this SCT scope.





OK. details if interested:

This G11 is a vintage about 1995, badged as a Celestron G11 made by Losmandy. This is a very old mount; I bought it used a few months ago. It had the original steel worm and original bearing blocks (separate, black color). I bought a used Gemini-1 unit, and new High Torque motors and the new gearboxes for both RA and DEC.

I did not measure the PE of the original equipment, but I learned that they typically run about 8 arcsec PE. Reading that the OPW and new precision worm should deliver about 2 arcsec RMS, and at the urging of another group member, I bought a new OPW (One Piece Worm) retail. It did not come with the worm installed, but instead a worm was sent to me by Losmandy directly. The OPW came with 3 bearings installed, and a new Oldham coupler (2 stainless parts and a plastic coupler for the middle).
It also came with the external aluminum elliptical part that mounts the High Torque gearbox and High Torque motor.

I measured the PE of this set of new OPW and Losmandy precision worm. After drift aligning, I got 4.8 arcsecs RMS. I expected half that, and contacted Losmandy. They sent me another worm to try. This second worm is in the G11 tonight. However, I also upgraded other components... so it is not absolutely clear that only the worm has made the difference.

I also read very well done research by Michael Siniscalchi (http://helixgate.net/) who investigated several aspects of G11 operation. He found that the worm bearings, and their axial preloading, made a difference in his PE. He also investigated the effects of different Oldham and similar couplers.

For those reasons, and other members of our group who pointed out that the worm bearings could be found on line, I purchased new ABEC-7 bearings via eBay from Boca Bearings; they were about $13 each. The OPW takes 3, but I have only used 2: the 2 facing the worm threads. I ordered the 3rd bearing only after reassembling the OPW, and decided to see what the results might be with only 2 high quality bearings around the worm. The other bearing faces the Oldham coupler, and is not present in some other mounts (the Orion Atlas=Synta EQG has only got 2 such bearings).

Other members in emails here also mentioned recently that the Ovision worm block had a Belleville washer and a screw at the end for compressing that. I found the right Belleville washer on McMaster-Carr, and installed one of them at the end of the OPW fartest from the motor. The OPW was able to accommodate the thin washer without difficulty. The washer provides a spring between the worm block and the end bearing outward face, so the bearing is compressed on to the worm. This keeps the worm from side to side movement under any temperature conditions (as Brass contracts faster than either aluminum or stainless steel).

Anyway, I reassembled the system, and ran it in the daytime over the weekend. The RA axis worm gear was set too tightly against the ring gear, and I was getting "RA Lags" error messages on the Gemini-1 handbox. I backed out the worm using the OPW screw adjustment, until the messages went away.

Anyway... I'm surprised this story has a happy ending...maybe an early Xmas present. I really thought I'd have to buy the Ovision worm block...

I'll write up a report with photos of the assembly... but I'm very happy that I did not need to go any further to get to the PE I was seeking.

All the best,
Michael