Jason-2 and Jason-3 GPS Pre-Launch Antenna Calibrations

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The Jason-2 and Jason-3 GPS payload antenna phase patterns were measured in an anechoic chamber between September 5 and 7, 2006. The JPL instrument team analyzed those measurements and provided the JPL precise orbit determination (POD) team with:

1. Models for the respective phase center locations of those antennas.
2. Tables of residuals of the measured phase patterns as a function of antenna elevation (1-degree increments from 0 to 90 degrees) and azimuth (10-degree increments from 0 to 350 degrees).

The JPL POD team typically applies pre-launch GPS antenna phase calibrations as a table of values in antenna elevation and azimuth that represent the total phase patterns with respect to the antenna reference point (ARP), including phase center offset and phase variations with respect to that phase center offset. This approach is adopted to mitigate the impact of differing methodologies to estimate models of phase center offsets (e.g., weighted, unweighted, sampling) and the actual in-flight sampling of the antennas by the GPS constellation.

The Jason-2 and Jason-3 choke ring antennas are built to print in their construction. The distance between the front and back surfaces of the choke ring is 73.8 mm. The distance between the front surface of the choke ring and the reference azimuth axis used for the anechoic chamber measurements is 29 mm. The distance between the back surface of the choke ring and the reference azimuth axis is then 73.8 - 29 mm = 44.8 mm. The back surface of the choke ring mounts directly to the ARP.

For each antenna, the instrument team provides a single data file containing:

1. A model of the phase center offset. The reference for this model is not explicitly stated in the data file but is stated explicitly in a separate spreadsheet as being with respect to the reference azimuth axis. Phase center offsets with respect to the ARP should then be computed by adding 44.8 mm along the boresight (Z-axis) of the antenna. The values of the phase center offsets computed from this model are provided in Table 1 with respect to the ARP, namely after adding 44.8 mm to the provided model.
2. Phase patterns that are described in the data file as being “residuals of phase data with respect to the new model”. Here the reference is somewhat ambiguous given that the phase center offset with respect to the azimuth axis is provided in the same data file, while there is also a comment stating “reposition phase center on beam axis 0.0 mm in front of front surface of choke ring”. Nevertheless, as noted by O. Montenbruck (personal communication), adding 73.8 mm to a phase center offset computed from these “residuals” agrees to within 0.5 mm with those derived from the provided model of the phase center offset with respect to the ARP. This would be consistent with the provided residuals being referenced to the front surface of the choke ring. The values of the phase

center offsets computed from these residuals is provided in Table 2 with respect to the ARP, namely after adding 73.8 mm to the phase center offsets computed from the "residuals".

The following approach is used to generate the values in Tables 1 and 2. The phase center offsets are estimated using equal-area weighting from tabularized (in elevation and azimuth) values of the phase patterns. For Table 1, we applied the model of phase center offsets generated by the instrument team into the elevation and azimuth increments used for the provided residuals. This provides a simple sanity check, and we recovered identical values to the applied model, as expected.

The Jason-3 values from these tables are identical to those provided in the CNES document that summarizes the Jason-3 characteristics for POD processing [TP4-J0-NT-317-CNES]. The source of the values in the CNES document is therefore the model of the phase center offset generated by the JPL instrument team, and with respect to the ARP.

Table 1. Estimated phase center offset with respect to antenna reference point (ARP), at bottom center of choke ring, computed from phase center offset model provided by instrument team. Values are computed by adding 44.8 mm to the Z-offset to account for the difference between the ARP and the reference azimuth axis used for the anechoic chamber measurements. Units are mm.

Antenna	L1			L2		
	X	Y	Z	X	Y	Z
Jason-2 Side A	-1.6	1.4	82.2	-0.7	1.0	104.6
Jason-2 Side B	-1.9	0.5	82.1	-0.9	1.2	104.6
Jason-3 Side A	-1.8	0.4	82.1	-0.9	1.0	104.6
Jason-3 Side B	-2.1	0.3	82.2	-0.8	1.5	104.4

Table 2. Estimated phase center offset with respect to antenna reference point (ARP), at bottom center of choke ring, computed from phase residuals provided by instrument team. Values are computed by adding 73.8 mm to the Z-offset to account for the difference between the ARP and the front surface of the choke ring. Units are mm.

Antenna	L1			L2		
	X	Y	Z	X	Y	Z
Jason-2 Side A	-1.8	1.4	82.1	-1.1	1.0	104.6
Jason-2 Side B	-2.1	0.5	82.0	-1.3	1.2	104.5
Jason-3 Side A	-2.0	0.4	82.0	-1.3	1.0	104.6
Jason-3 Side B	-2.3	0.3	82.2	-1.2	1.5	104.3

We provide the anechoic chamber measurements in data files named j*N*_side*X*_L*M*_*type*.xyz as tables in elevation and azimuth, where:

1. *N* = 2 for Jason-2, and *N* = 3 for Jason-3.
2. *X* = A for the side A antenna, and *X* = B for the side B antenna.
3. *M* = 1 for L1 phase, and *M* = 2 for L2 phase.
4. *type* = *pcomodel* for a representation of the phase center model generated by the JPL instrument team with respect to the reference azimuth axis of the anechoic chamber

measurements; *type* = *residual* for the anechoic chamber measured residuals provided by the instrument team with respect to the front surface of the choke ring antenna.

5. Elevation is the angle between the x-y plane of the antenna (0-degrees elevation) towards the boresight (90-degrees elevation).
6. Azimuth is the angle in the x-y plane of the antenna and referenced to the x-axis of the antenna (0-degree azimuth). Azimuth increases clockwise from the x-axis when looking from the positive boresight direction towards the ARP. The y-axis is at 270-degrees azimuth.

For example, j2_sideA_L1_residual.xyz provides the Jason-2 Side-A GPS antenna anechoic chamber L1 phase residuals with respect to the front surface of the choke ring antenna.

A comment is provided in each of the two types of files "*pcomodel*" and "*residual*" to explicitly indicate the reference point used for the values in each file. The values are intentionally as provided by the instrument team. To reference the provided values to the ARP, at the bottom center of the choke ring, add a Z phase center offset of 44.8 and 73.8 mm to the values in the "*pcomodel*" and "*residual*" files, respectively.

In these files, elevation is the angle between the x-y plane of the antenna (0-degree elevation) towards the boresight (90-degree elevation).

The format of each file is as follows:

1. Comment lines start with "#".
2. A header line starting with "Info" which can be ignored. Provides, in order, satellite name, indicator for satellite (sat), antenna number always set to 1, L1 or L2, azimuth step in degrees for data, elevation step in degrees for data, starting elevation in degrees for data.
3. Data lines with 5 columns:
    a. Column 1: Azimuth angle in degrees (10-degree steps from 0-350^{o})
    b. Column 2: Elevation angle in degrees (1-degree steps from 0-90^{o})
    c. Column 3: Phase variation in mm.
    d. Column 4: Can be ignored, and set to 1.
    e. Column 5: Can be ignored, and set to 100.0.

A full list of the 16 provided data files is shown below.

1. j2_sideA_L1_pcomodel.xyz
2. j2_sideA_L1_residual.xyz
3. j2_sideA_L2_pcomodel.xyz
4. j2_sideA_L2_residual.xyz
5. j2_sideB_L1_pcomodel.xyz
6. j2_sideB_L1_residual.xyz
7. j2_sideB_L2_pcomodel.xyz
8. j2_sideB_L2_residual.xyz
9. j3_sideA_L1_pcomodel.xyz
10. j3_sideA_L1_residual.xyz

11. j3_sideA_L2_pcomodel.xyz
12. j3_sideA_L2_residual.xyz
13. j3_sideB_L1_pcomodel.xyz
14. j3_sideB_L1_residual.xyz
15. j3_sideB_L2_pcomodel.xyz
16. j3_sideB_L2_residual.xyz

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