Tallysman

When precision matters.™

VeraPhase Antenna for Survey Use

1. INTRODUCTION

The reliance on GNSS within the Surveying Industry is well known. There is continual improvement in available GNSS technology to increase the accuracy and reduce the complexity of use. This document introduces the VeraPhase antenna for use as a rover in surveying activity.

As will be seen, the VeraPhase technology introduces a new level of accuracy and a new level of simplicity to surveying. Using a VeraPhase antenna as a rover in an RTK or PPP surveying application effectively eliminates the worry about the orientation of the antenna (with respect to compass directions) and eliminates the need to use calibration data files. As will be seen, the reason for this is because of the high stability of the PCV over the L1/L2 and G1/G2 frequencies over all azimuths and from all elevation angles above 10 degrees (above horizon).

2. ANALYSIS

The data relied upon in this analysis is publicly available from NGS at this website: https://www.ngs.noaa.gov/ANTCAL/ .

There are two methods of calculating calibration data: relative calibration; and absolute calibration. As the intent of this analysis is to understand the stability of Phase Centre Variation (PCV) in absolute terms, only absolute calibration data were used.

Antennas compared

Tallysman VP6000	NovAtel 750
NovAtel 702GG	Trimble Zephyr 3
Javad Choke Ring DM	Topcon PG-A1
Leica 1230	AOA DM_TA
NavXperience 3G+C	

1. Standard Deviation of the PCV
   The quickest measure of the variability of the PCV is calculating the standard deviation of all the observations (all azimuth and all elevation angles). Table A shows the results of these calculations for each of the above antennas. The elevation selection of 5 to 85 degrees was used because the calibration methodology defines zenith (90 degrees) as being zero and the use of signals below five (5) degrees is fraught with numerous issues (and thus is impractical for use).

TABLE A - Standard Deviations of PCV across Elevations (5 - 85 degrees) and all Azimuths

	Tallysman VP6000	NovAtel 750	NovAtel 702GG	Trimble Zephyr 3	Javad Choke Ring DM	TopCon PG-A1	Leica 1230	AOA DM_TA	NavX 3G+C	Best Antenna
GPS L1	**0.6253**	1.8867	0.6906	0.6277	4.8476	1.5845	0.6851	4.6453	0.7283	Tallysman VP6000
GPS L2	0.5307	2.6523	**0.4534**	1.2089	3.2358	1.0463	0.6203	2.9078	1.1330	NovAtel 702GG
GL G1	**0.6118**	1.8483	0.7972	0.7931	4.7464	1.6901	0.8222	4.4827	0.8919	Tallysman VP6000
GL G2	**0.4454**	2.5693	0.5290	1.1738	3.0447	1.0061	0.5505	2.8733	1.0347	Tallysman VP6000

Table A shows that the Tallysman VeraPhase 6000 antenna provides the lowest overall PCV. It also shows that the 99% confidence level (3x standard deviation) of the PCV is no worse than 1.9mm for the VP6000 antenna. This supports the conclusion that a surveyor, using the VP6000, doesn't have to worry about the orientation of the antenna nor about using PCV correction data to get sub 2mm accuracy regardless of which signal(s) is/are being used.

2. <u>Useable Mask Angle</u>
   Another meaningful way to examine the utility of an antenna for use as a rover in an RTK system is to determine the lowest mask angle one can set in the receiver to achieve the desired level of PCV. For example, what is the lowest elevation mask setting one can use to achieve less than a Xmm PCV across all azimuth and all elevation angles? Tables B, C &D provide answers to this question for 1mm, 1.5mm, and 2.0mm respectively.

TABLE B - LOWEST ELEVATION MASK TO ACHIEVE LESS THAN +/- 1MM PCV VARIATION OVER ALL AZIMUTH ANGLES

	Tallysman VP6000	NovAtel 750	NovAtel 702GG	Trimble Zephyr 3	Javad Choke Ring DM	TopCon PG-A1	Leica 1230	AOA DM_TA	NavX 3G+C	**Best Antenna**
GPS L1	55	80	50	55	80	75	60	80	35	NavX 3G+C
GPS L2	50	80	70	60	80	70	55	80	75	Tallysman VP6000
GL G1	50	80	60	60	85	80	65	85	55	Tallysman VP6000
GL G2	45	80	60	65	80	70	50	85	80	Tallysman VP6000
WORST CASE	55	80	70	65	85	80	65	85	80	**Tallysman VP6000**

TABLE C - LOWEST ELEVATION MASK TO ACHIEVE LESS THAN +/- 1.5MM PCV VARIATION OVER ALL AZIMUTH ANGLES

	Tallysman VP6000	NovAtel 750	NovAtel 702GG	Trimble Zephyr 3	Javad Choke Ring DM	TopCon PG-A1	Leica 1230	AOA DM_TA	NavX 3G+C	**Best Antenna**
GPS L1	0	80	30	40	80	75	55	80	30	Tallysman VP6000
GPS L2	0	75	5	45	75	65	50	75	70	Tallysman VP6000
GL G1	10	75	45	40	80	70	60	80	30	Tallysman VP6000
GLG2	0	75	20	40	75	65	25	80	75	Tallysman VP6000
WORST CASE	**10**	80	45	45	80	75	60	80	75	**Tallysman VP6000**

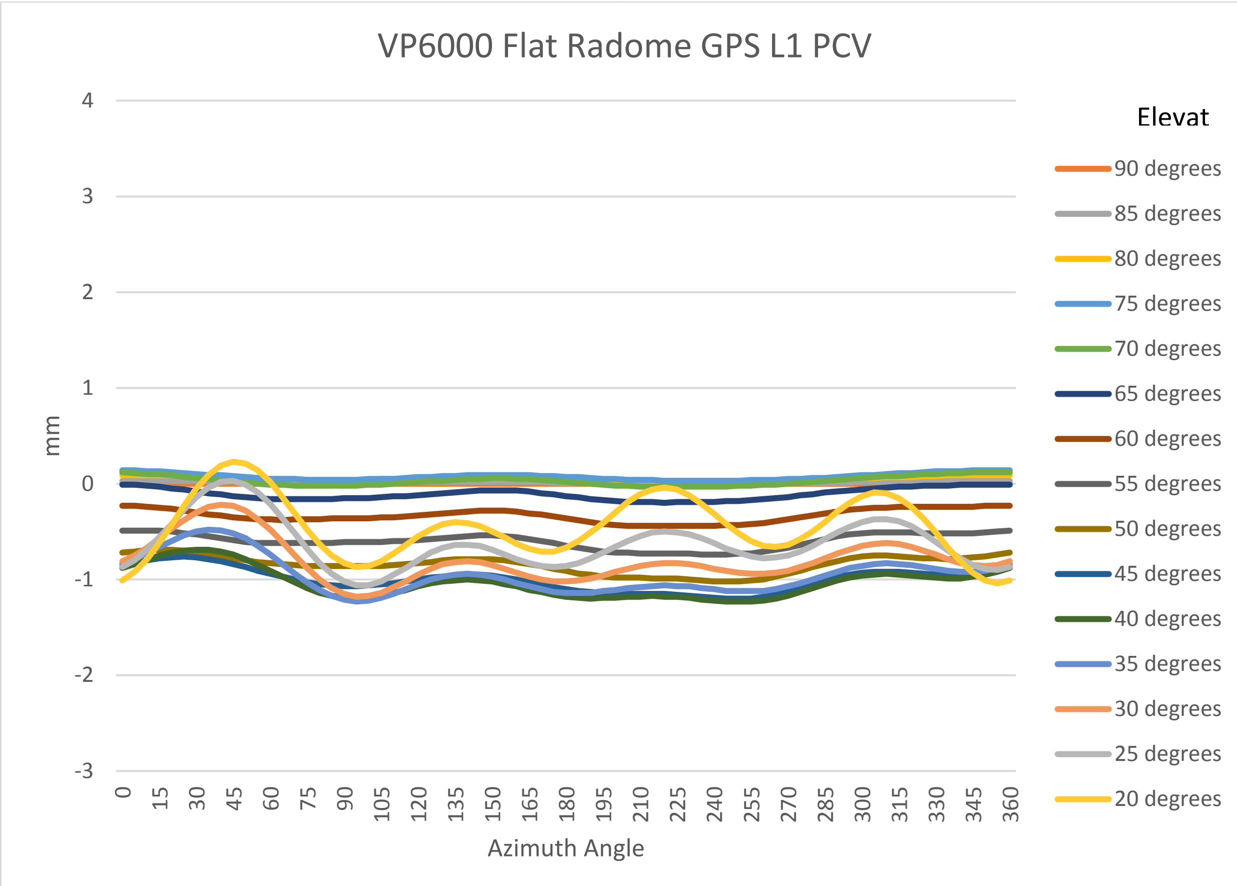
TABLE D - LOWEST ELEVATION MASK TO ACHIEVE LESS THAN +/- 2MM PCV VARIATION OVER ALL AZIMUTH ANGLES

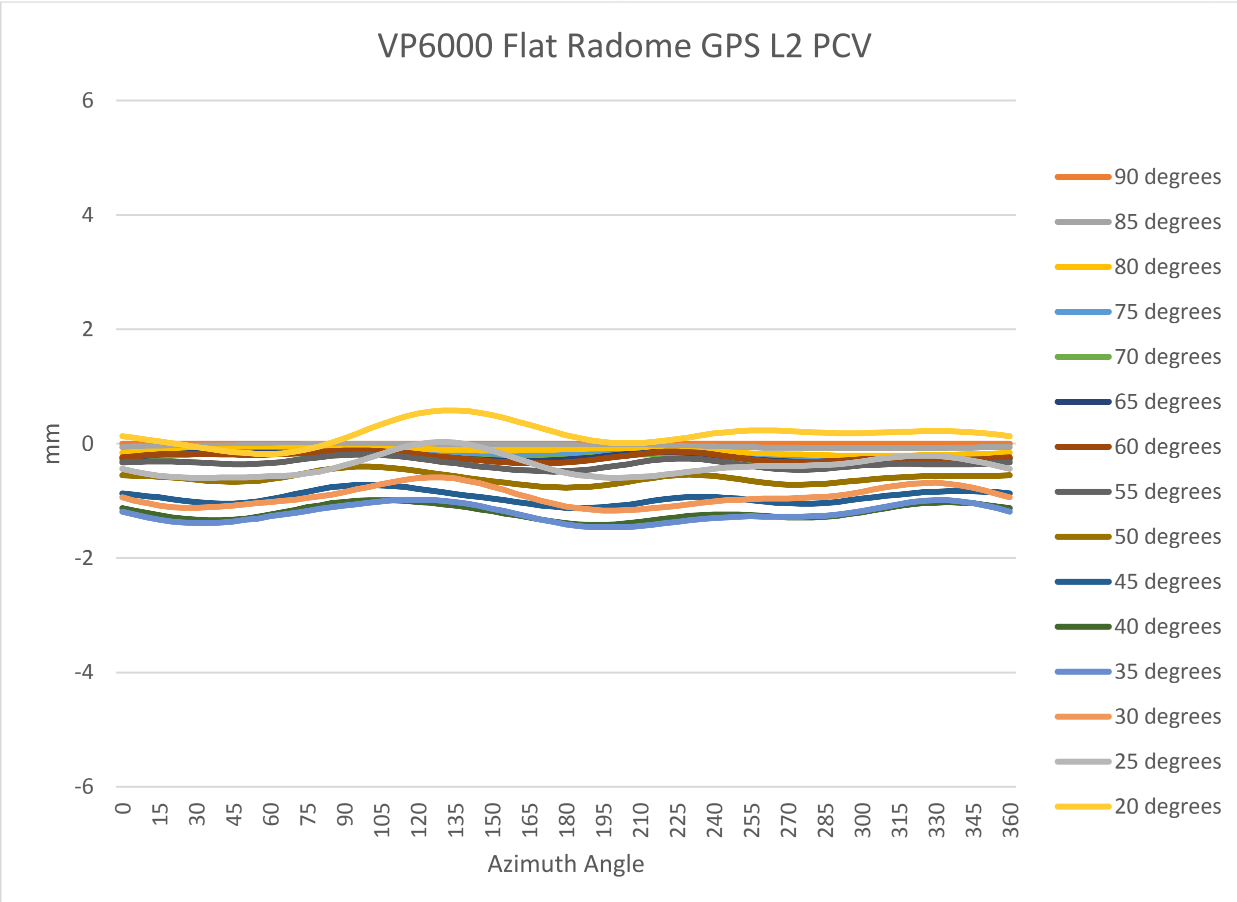
	Tallysman VP6000	NovAtel 750	NovAtel 702GG	Trimble Zephyr 3	Javad Choke Ring DM	TopCon PG-A1	Leica 1230	AOA DM_TA	NavX 3G+C	**Best Antenna**
GPS L1	0	75	15	10	80	65	10	80	15	Tallysman VP6000
GPS L2	0	70	0	40	70	60	0	70	65	Tallysman VP6000
GL G1	10	75	10	35	80	70	55	80	25	Tallysman VP6000
GL G2	0	75	10	40	75	60	0	75	65	Tallysman VP6000
WORST CASE	**10**	75	15	40	80	70	55	80	65	**Tallysman VP6000**

3. CONCLUSION

The above analysis has shown that if a person were to set the elevation angle mask of the RTK receiver to 10 degrees above horizon, the results achieved from the VeraPhase 6000 antenna would be plus/minus 2mm regardless of the azimuth or the elevation angle of the received satellite signals (L1/L2/G1/G2). Furthermore, overall the VeraPhase 6000 antenna outperforms choke ring antennas and other high end survey grade antennas when using un-corrected PCV information.

The receiving element of the VeraPhase 6000 antenna is used in all VeraPhase antennas, so the same results will be achieved regardless which model of VeraPhase antenna is used.


VP6000 Flat Radome GPS L1 PCV
4
3
2
1
0
-1
-2
-3
mm
0 15 30 45 60 75 90 105 120 135 150 165 180 195 210 225 240 255 270 285 300 315 330 345 360
Azimuth Angle
Elevat
90 degrees
85 degrees
80 degrees
75 degrees
70 degrees
65 degrees
60 degrees
55 degrees
50 degrees
45 degrees
40 degrees
35 degrees
30 degrees
25 degrees
20 degrees


VP6000 Flat Radome GPS L2 PCV
mm
6
4
2
0
-2
-4
-6
0
15
30
45
60
75
90
105
120
135
150
165
180
195
210
225
240
255
270
285
300
315
330
345
360
Azimuth Angle
90 degrees
85 degrees
80 degrees
75 degrees
70 degrees
65 degrees
60 degrees
55 degrees
50 degrees
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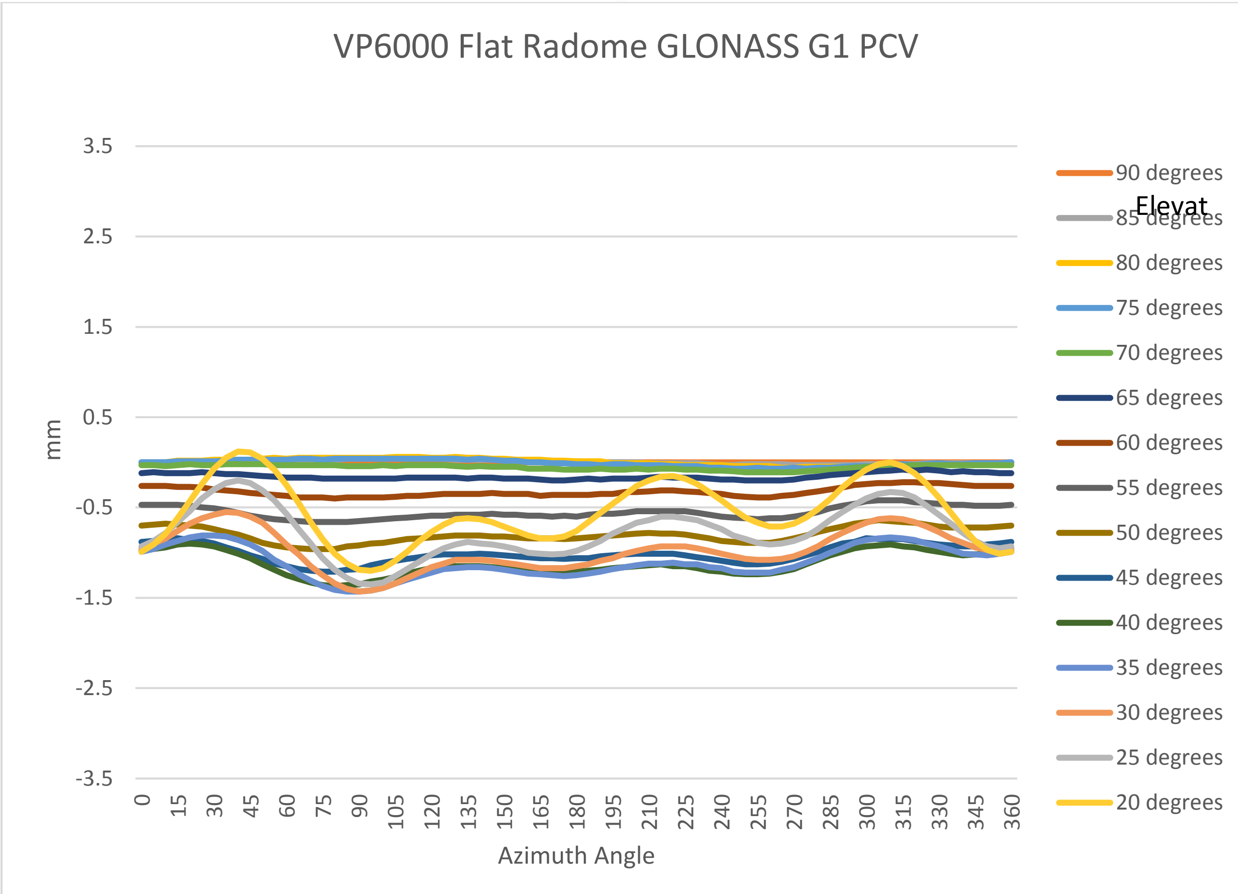
20 degrees


VP6000 Flat Radome GLONASS G1 PCV
3.5
2.5
1.5
0.5
-0.5
-1.5
-2.5
-3.5
mm
0
15
30
45
60
75
90
105
120
135
150
165
180
195
210
225
240
255
270
285
300
315
330
345
360
Azimuth Angle
90 degrees
Elevat
85 degrees
80 degrees
75 degrees
70 degrees
65 degrees
60 degrees
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50 degrees
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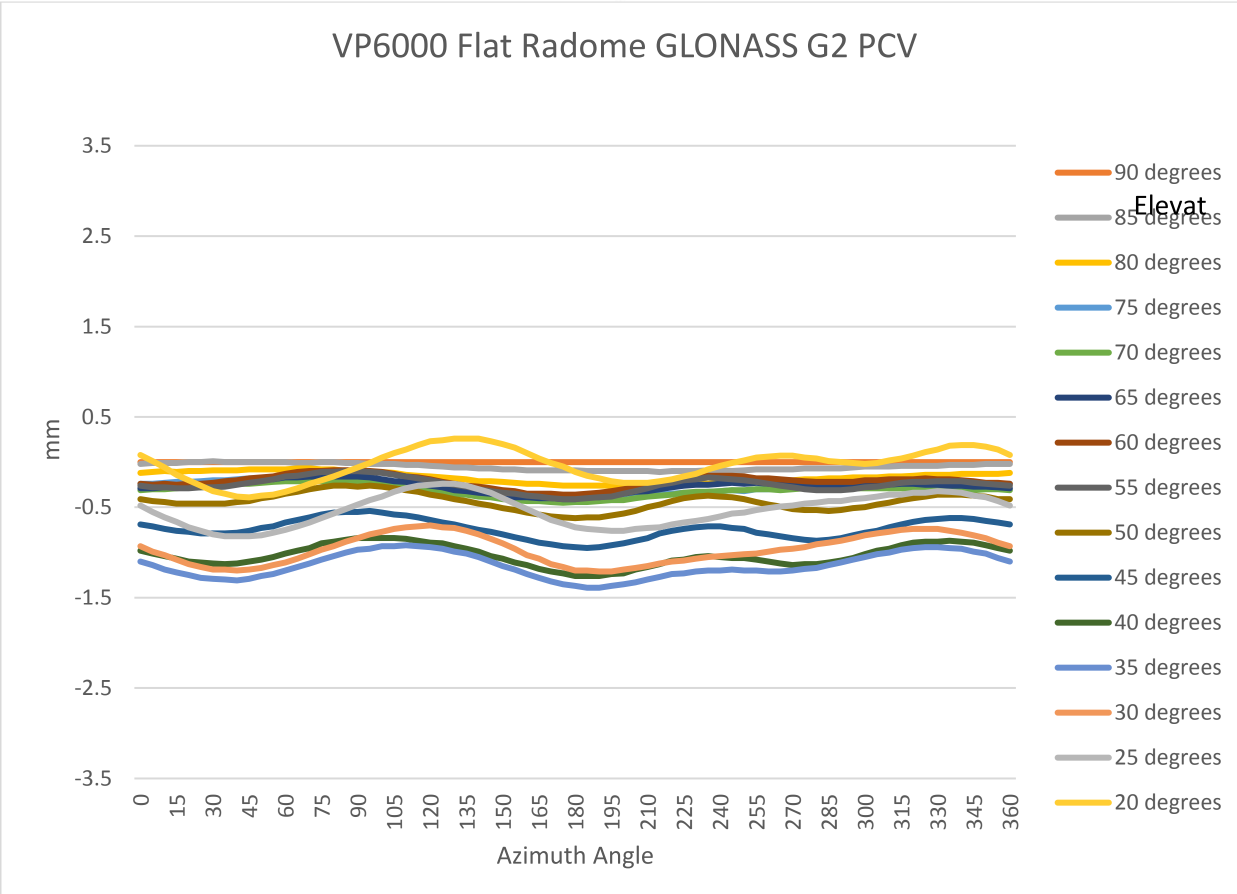
35 degrees
30 degrees
25 degrees
20 degrees


VP6000 Flat Radome GLONASS G2 PCV
mm
3.5
2.5
1.5
0.5
-0.5
-1.5
-2.5
-3.5
0 15 30 45 60 75 90 105 120 135 150 165 180 195 210 225 240 255 270 285 300 315 330 345 360
Azimuth Angle
Elevat
90 degrees
85 degrees
80 degrees
75 degrees
70 degrees
65 degrees
60 degrees
55 degrees
50 degrees
45 degrees
40 degrees
35 degrees
30 degrees
25 degrees
20 degrees