Ashtech and Trimble Choke Ring SNR Analysis

Introduction

The Trimble 4000 receiver is obsolete and the Ashtech Z12 is nearing the end of its product lifespan. With this in mind, we tested Ashtech Choke Ring antennas on Trimble 4700 receivers and Trimble Choke Ring Antennas on Ashtech µZ receivers. This will allow users to use the less expensive Ashtech antenna on a Trimble receiver or allow users to replace 4000 receivers with Trimble Choke Rings with µZ receivers. Also, users can replace Z12 receivers with Ashtech Choke Rings with Trimble receivers. This study was intended to be a first-order look at the compatibility of Ashtech Choke Rings on Trimble receivers and Trimble Choke Rings on Ashtech receivers.

Conclusions

1. Using a different receiver to power the antenna splitter has no effect on SNR ratio. On a µZ and 4700 zero-baseline with Trimble and Ashtech Choke Ring Antennas, it makes no difference which receiver powers the antenna splitter.
2. For both L1 and L2 frequencies, the Trimble Choke Ring antenna provides slightly higher SNR ratio compared to the Ashtech antenna on similar receivers. For L1, using the Ashtech Choke Ring antenna results in SNR values ~1 dB Hz lower than the corresponding Trimble antenna. For L2 there is a 1-2.5 dB Hz improvement in SNR when using the Trimble Choke Ring. Control tests were not performed during this study so it is difficult to gauge the significance of SNR improvement when using the Trimble Choke Ring.
3. The Trimble and Ashtech antennas can interchanged. It is a trade off between the slightly increased SNR's with the Trimble relative to the Ashtech antenna and the ~ 40% cost reduction in the Ashtech Choke ring as compared to the Trimble antenna.
4. Other studies, which could benefit this work, are to investigate any effects of on station position in response to changing antennas. Another issue that could be addressed is the antenna-to-antenna variability in SNR from within a pool of the same manufacturers antennas.

Antenna/Receiver compatibility

Table 1 shows the antenna port voltage output of various GPS receivers. The receiver output voltages were measured directly from the receiver. The antenna input voltages (Table 2) were provided from the manufactures. These values are the nominal operating values and there is a safety factor built into them. This means the antenna will operate slightly outside the published range but it is not recommended. Example: The Ashtech choke ring requiring 5-15V will work with the Ashtech Micro-Z receiver that outputs 4.85V with the antenna as a load.

Table 1. GPS receiver antenna port output voltage.

Receiver	w/o antenna (V)	w/ antenna (V)
4000SSE	8.35	6.8
4000Ssi	11.84	10.4
4700	7.62	7.4
5700	5.05	4.97
Z-12	9.71	9.64
μ-Z	4.94	4.85
Turbo Rouge	11.95	11.93

Table 2. GPS antenna voltage input range.

Antenna	Voltage Range
Trimble fixed ground plane L1/L2	7-28V
Trimble removable ground plane L1/L2	7-28V
Trimble microcenter	7-28V
Trimble choke ring	7-28V
Trimble Zephyr	4.8-22V
Ashtech all	5-15V

Both the Trimble and Ashtech Choke ring antennas are voltage compatible with the other manufacturers receiver. We performed antenna compatibility tests over the course of three days (Table 3).

Table 3. Antenna and splitter configuration for tests.

Day	Antenna Power	Receivers	Antenna
290	Ashtech μZ	4700/Ashtech μZ	Ashtech Choke
291	4700	4700/Ashtech μZ	Ashtech Choke
292	4700	4700/Ashtech μZ	Trimble Choke

We logged a ~24 hour data files with a Trimble 4700 and an Ashtech μZ connected to an antenna splitter which powered a Trimble or Ashtech Choke Ring antenna. For each data file the Signal to Noise (SNR) values for all epochs were extracted and binned into 2-degree elevation increments. The 4700 and μZ receivers were chosen for this test because they both report SNR as C/N_0 or Carrier to Noise Power expressed as a ratio in units of dB-Hz. The SNR values are not directly comparable from different manufacturers due to different noise characteristics the way each manufacturer defines the ratio. SNR values are consistent, however, when using the same receiver but different antennas. For all of our tests we used 2 receivers connected to a single antenna (Figure 1).

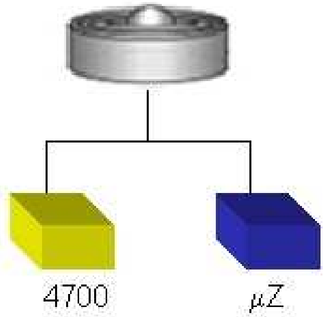

Figure 1. Zero baseline configuration used during this tests. The antenna was powered on day 290 with the μZ and days 291-292 with the 4700. Using a different receiver to power the antenna had no effect on SNR values.

Between days 290 and 291 we tested to see if powering the antenna splitter with a different receiver caused a change in the recorded SNR values. In Figures 2 & 3 we show an overlay of SNR values vs. elevation angle that indicate the receiver powering the antenna has no effect on SNR.

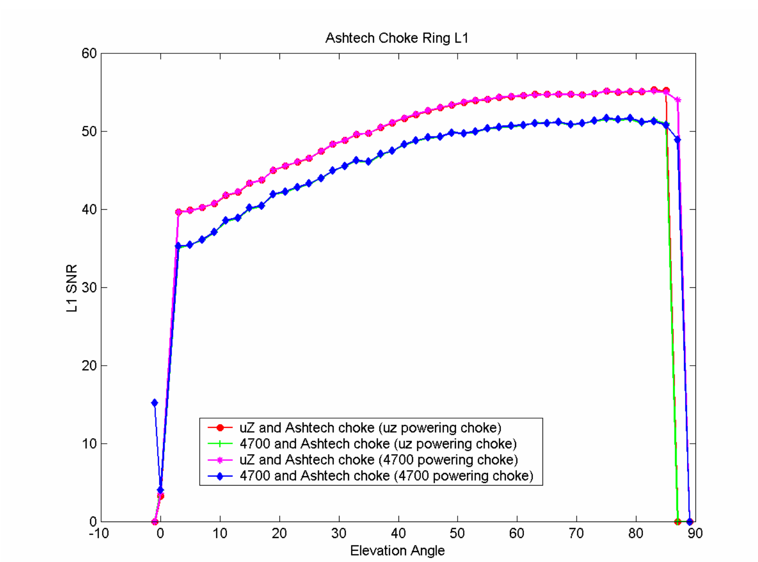

Figure 2. Upper data sets show L1 SNR values for μZ with the antenna being powered by the μZ (red dots) and the 4700 (magenta dots). There is no statistical difference between the two data sets. Lower data sets show L1 SNR values for 4700 with the antenna being powered by the μZ (green dots) and the 4700 (blue dots). There is no statistical difference between the two data sets.

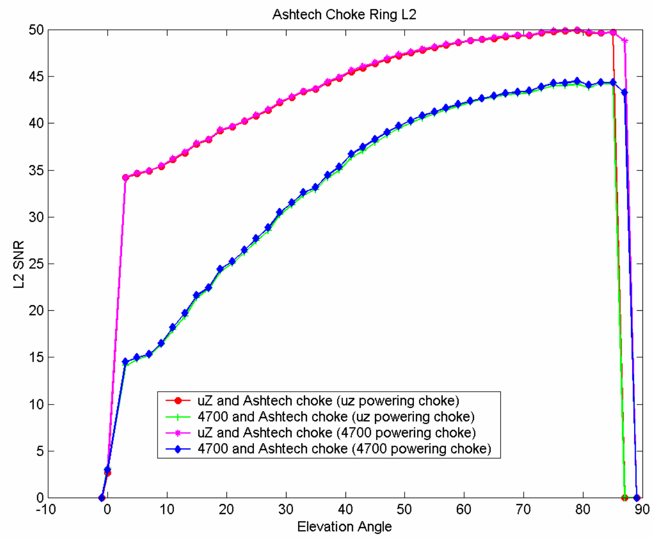

Figure 3. Same as Figure 2 but showing L2 SNR values.

On days 291 and 292 we tested to see if there was a measurable change in SNR with receivers using different choke ring antennas (Figure 4). To do this we acquired data on day 291 using an Ashtech Choke Ring and on day 292 with a Trimble Choke Ring.

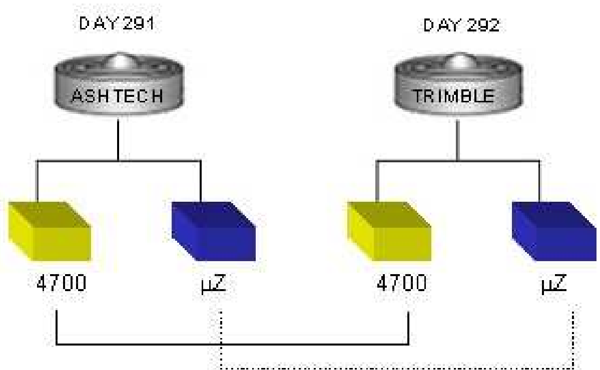

Figure 4. Testing configuration for days 291 and 292. The connecting lines indicate SNR differences displayed in Figures 7 & 8.

Figures 5 & 6 show L1 and L2 SNR values for the Trimble 4700 and Ashtech µZ receivers tracking with the Ashtech and Trimble Choke Ring antennas. Both figures indicate that there is a slight loss of SNR when using an Ashtech compared to a Trimble Choke Ring (for example blue circles compared to yellow circles).

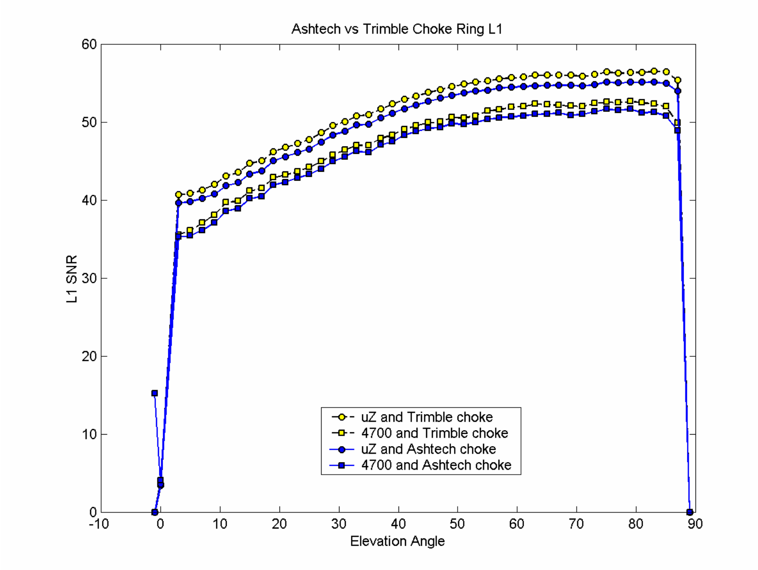

Figure 5. Upper data sets show L1 SNR values for μZ with an Ashtech Choke Ring (blue circles) and a Trimble Choke Ring (yellow circles). The lower graph shows L1 SNR values for a Trimble 4700 receiver with a Trimble Choke Ring antenna (yellow squares) and an Ashtech antenna (blue squares).

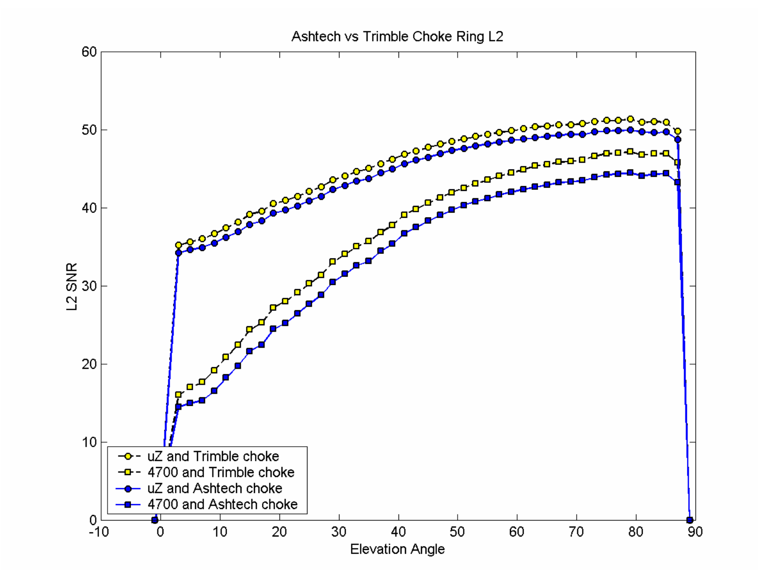

Figure 6. Same analysis as figure 4 but for L2.

In Figure 7 and 8 we plot the difference of the SNR values from data sets with the same receiver and different antennas (see Figure 4). Figure 7 shows that for an Ashtech μZ receiver the differences in L1 SNR are on the order of 1 dB Hz lower when using an Ashtech rather than a Trimble Choke Ring antenna. For a Trimble 4700 receiver the

SNR values are ~0.8 dB Hz lower when using an Ashtech vs. a Trimble Choke Ring antenna. Neither configuration shows any appreciable elevation dependence in the SNR differences. In other words both receivers perform slightly better (at the 1 dB Hz) when using a Trimble Choke Ring antenna.

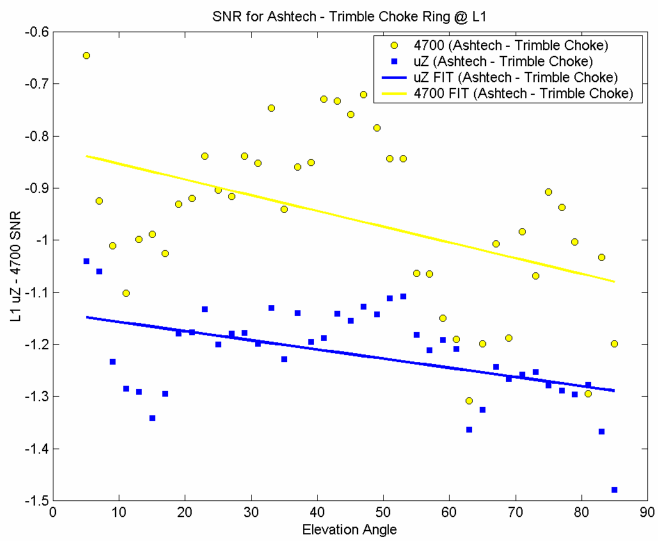

Figure 7. Upper data sets show difference between L1 SNR values for a 4700 with a tracking with a Ashtech and Trimble Choke Ring (linear fit: `dS=-0.003 (E)-0.823 r = 0.91)`. *The lower graph shows the difference between L1 SNR values for a μZ with an Ashtech and Trimble Choke Ring (linear fit:* `dS=-0.002(E)-1.139 r = 0.50)`. *E is elevation angle and dS represents delta SNR.*

Figure 8 shows that for an Ashtech μZ receiver the difference in L2 SNR are on the order of 1 dB Hz lower when using an Ashtech rather than a Trimble Choke Ring antenna. For a Trimble 4700 receiver, the SNR values are 2.5 dB Hz lower when using an Ashtech vs. a Trimble Choke Ring antenna. Neither configuration shows any appreciable elevation dependence in the SNR differences. Again, both receivers perform slightly better when using a Trimble Choke Ring antenna.

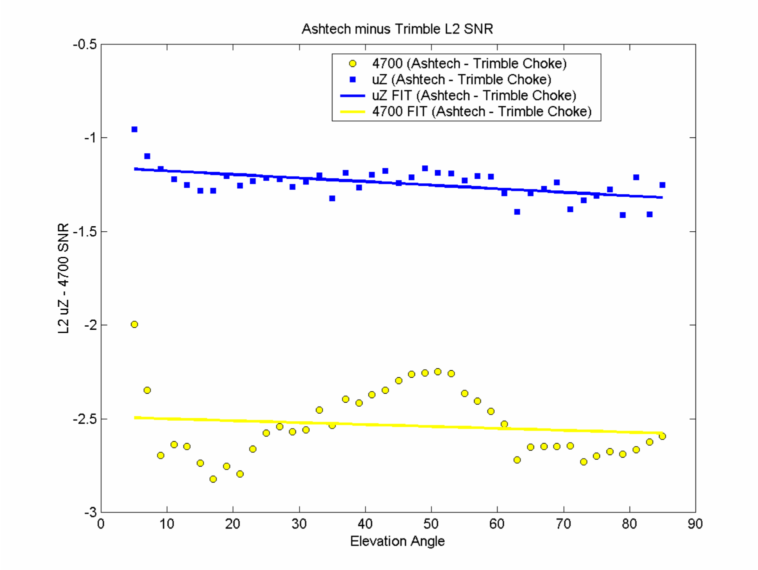

Figure 8. Upper data sets show difference between L2 SNR values for a μZ with an Ashtech and Trimble Choke Ring (linear fit: `dS = -0.002(E)-1.156 r = 0.44)`*. The lower graph shows the difference between L2 SNR values for a 4700 with a tracking with a Ashtech and Trimble Choke Ring (linear fit:* `dS = -0.001(E)-2.489 r = 1.16)`*. E is elevation angle and dS represents delta SNR.*

Table 4 presents a summary of the number of expected and actual observations, MP1 and MP2 values (Estey & Meertens, 1999) and the number of observations per cycle slip for day 291 and 292 data sets. Irrespective of the antenna, the 4700 has more observations per slip and lower MP1 and MP2 values for these data sets than the Ashtech. Note that this is inconsistent with the findings of Jackson et al (2000), which showed similar values of observations per slip between the μZ and the 4700.

Table 4. QC output for day 291 and 292 data files.

Test	Day	# Expected Observations	# Observations Actual	%	Mp1	Mp2	obs/slip
μZ and Ashtech choke	291	45257	44763	98.9	0.69	0.63	3443
μZ and Trimble choke	292	45254	45230	99.9	0.67	0.56	9046
4700 and Ashtech choke	291	45257	43473	96	0.26	0.38	43473
4700 and Trimble choke	292	45254	45254	100	0.25	0.38	45254

References

Estey, L., & Meertens, C., (1999). TEQC: The multipurpose toolkit for GPS/GLONASS data. GPS Solutions Vol. 3, No. 1 pp. 44-49.

Jackson, M.E, Meertens, C., Andreatta, V., and Van Hove, T. GPS Receiver and Antenna Testing Report for SuomiNet. Unpublished UNAVCO Report, 2000. http://www.unavco.ucar.edu/science_tech/dev_test/publications/suominetreportv_4.pdf

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