4.7 Design of Truncated Corner GPS Element – Cylindrical Surface

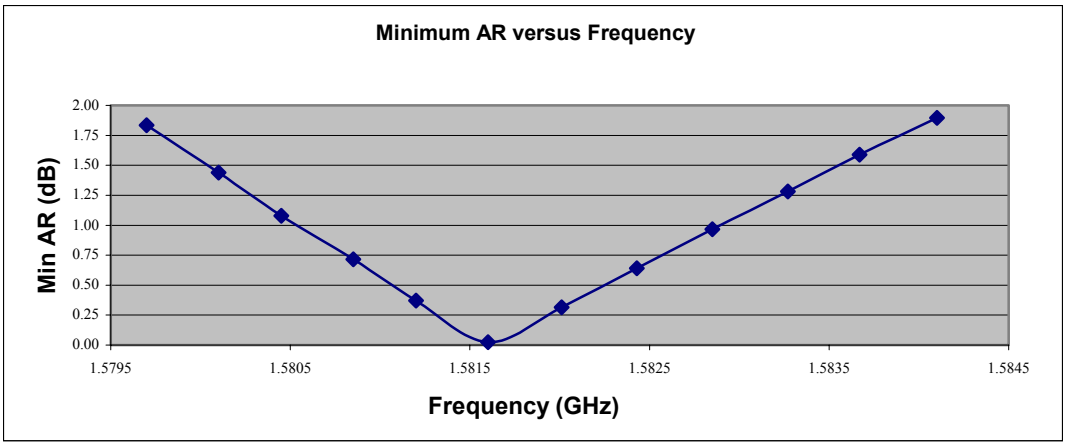
In this section, truncated corner GPS elements for 6, 8, and 14-inch diameter cylinders are designed. The nearly square patch design for the GPS antenna will not be investigated because the truncated corner patch provides more control in the tuning process. As in the case with the telemetry designs, the GPS truncated corner patch designs were accomplished using Clementine simulations.

4.7.1 Effects of Varying Truncated Corner Patch Dimensions

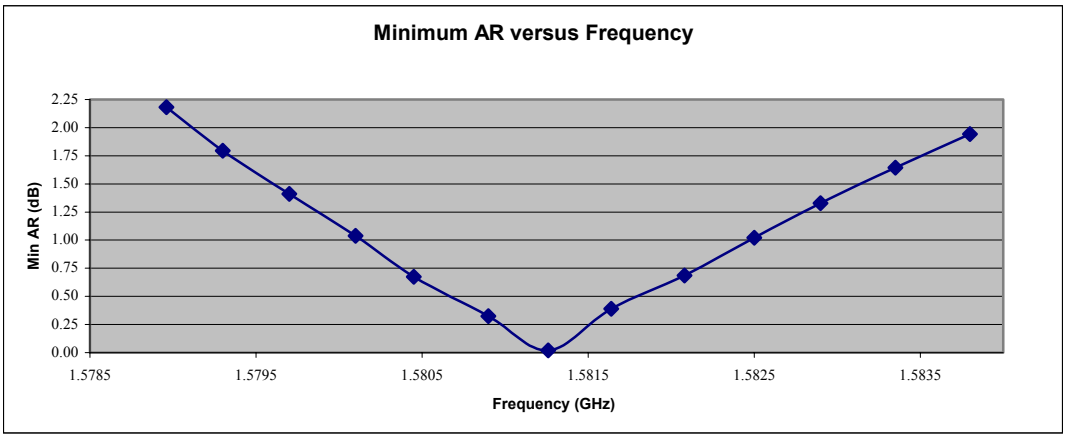
The axial ratio of the truncated corner patch is tuned by adjusting the sides of the truncated corner perturbation segment. The frequency tuning is accomplished by modifying the patch's length and width equally, while keeping the truncated corner dimensions constant. In order to observe the effect changing the triangular segment and the patch's dimensions have on the patch's axial ratio, several patches with different dimensions were analyzed using Clementine. The minimum axial ratios of these simulations and the dependence of frequency on patch dimensions are plotted in figures 4.28 and 4.29, respectively. These results are summarized in tables 4.18 and 4.19.

Table 4.18. Axial ratio tuning information for truncated corner GPS patch. 'Left' and 'Right' refer to the end points in figure 4.28.

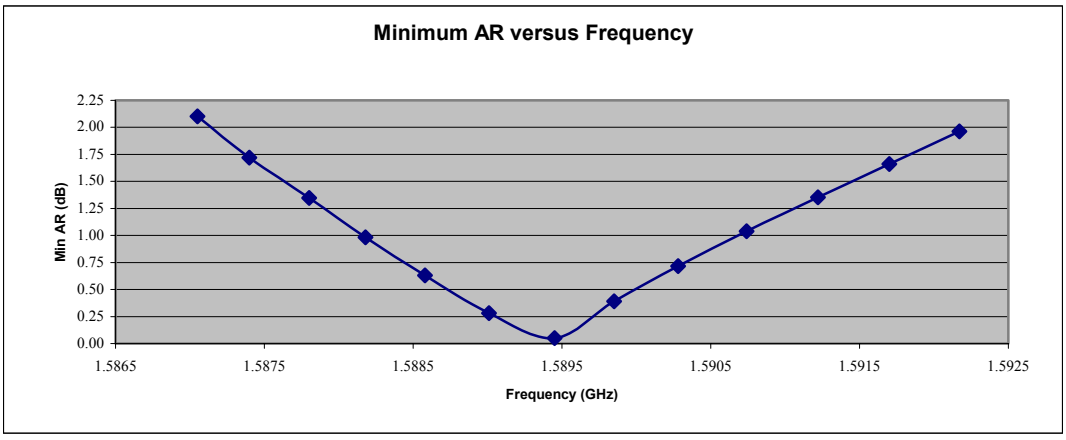
AR versus Frequency								Rate of Change	
	Left AR		Middle AR		Right AR			AR Factor	
Diameter	AR	Frequency	AR	Frequency	AR	Frequency		Left of Minimum AR	Right of Minimum AR
(inches)	(dB)	(GHz)	(dB)	(GHz)	(dB)	(GHz)		(mm/dB)	(mm/dB)
14	1.840	1.57970	0.030	1.58160	1.900	1.58410		-0.27624	0.32086
8	2.180	1.57900	0.020	1.58130	1.940	1.58380		-0.27778	0.31250
6	2.103	1.58705	0.050	1.58945	1.960	1.59217		-0.29233	0.31414



a. patch on 14-inch diameter cylinder.

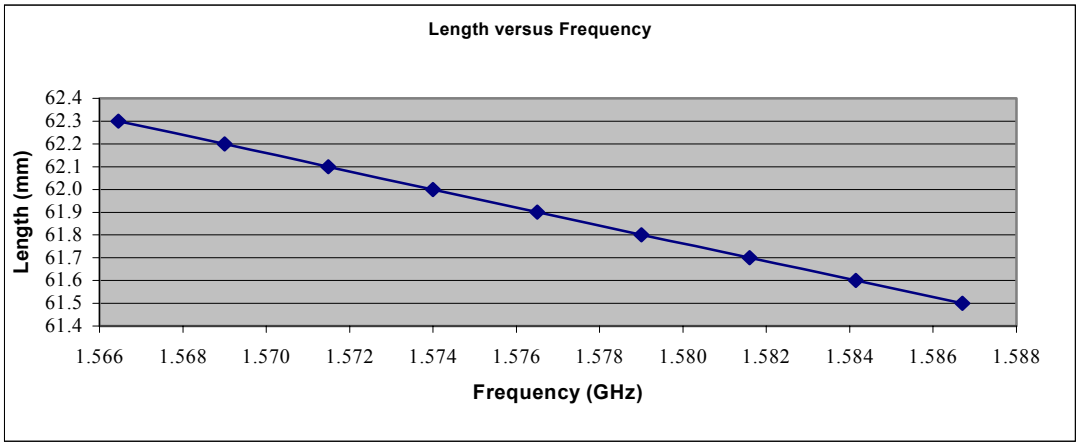


b. patch on 8-inch diameter cylinder.

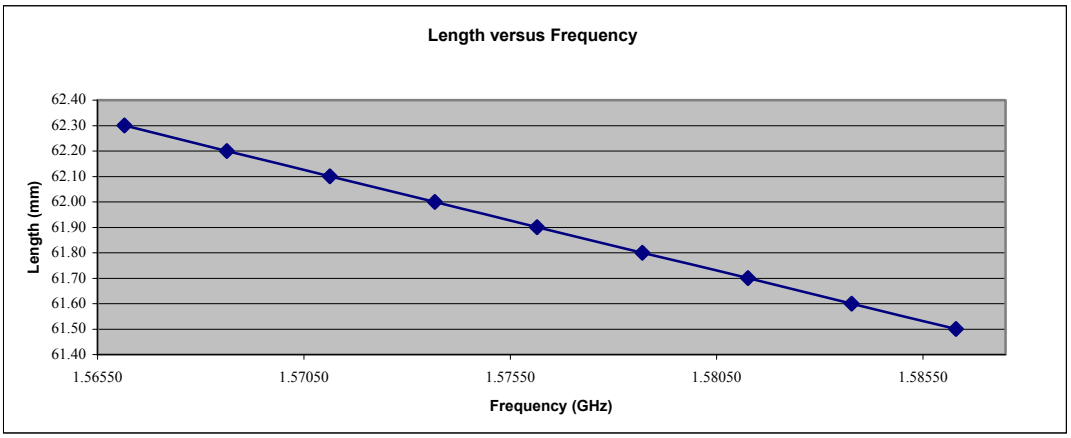


c. patch on 6-inch diameter cylinder.

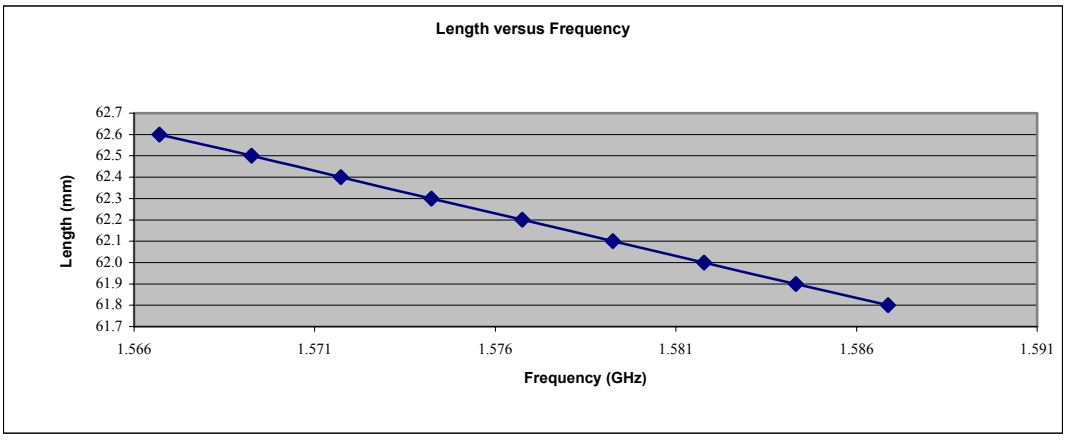
Figure 4.28. Minimum AR versus frequency for the truncated corner patch as the triangular segment length of the patch is varied in 0.1 mm steps while the length and width of the patch are held constant.



a. patch on 14-inch diameter cylinder.



b. patch on 8-inch diameter cylinder.



c. patch on 6-inch diameter cylinder.

Figure 4.29. Length versus frequency for the truncated corner GPS patch as its length and width are reduced in 0.1 mm steps. Note that axial ratio remains nearly constant at ≈ 0.0 dB.

Table 4.19. Frequency tuning information for truncated corner GPS patch. 'Left' and 'Right' refer to end points in figure 4.29.

AR versus Frequency						Rate of Change
	Left Data Point		Right Data Point			Frequency Factor
Diameter	Length	Frequency	Length	Frequency		
(inches)	(mm)	(GHz)	(mm)	(GHz)		(mm/MHz)
14	62.30	1.56645	61.50	1.58670		-0.03951
8	62.30	1.56615	61.50	1.58630		-0.03970
6	62.60	1.56670	61.80	1.58687		-0.03966

4.7.2 Performance of Truncated Corner GPS Patch

GPS corner telemetry patches were tuned for axial ratios of 0 dB at 1.57542 GHz, for 6, 8, and 14-inch diameter cylinders using Clementine, as shown in table 20. The performance of these patches is shown in figures 4.30 – 4.35 and tabulated in table 4.21. The patches were matched to 50 ohm lines using L-section matching networks.

Table 4.20. GPS truncated corner patch dimensions.

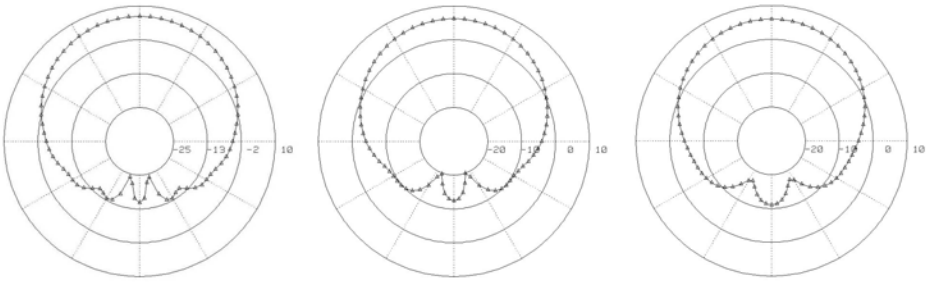
Diameter (in)	6	8	14
Frequency (GHz)	1.57542	1.57542	1.57542
Height (mm)	1.524	1.524	1.524
Permittivity	2.33	2.33	2.33
Loss Tangent	0.001	0.001	0.001
Length (mm)	62.2525	61.93	61.944
c (mm)	4.777	4.657	4.697
Zin (Ohms)	106.5 - j 29.2	124.2 - j 15.7	136.2 - j 3.93

Table 4.21. GPS truncated corner patch dimensions and performance data.

Diameter	Azimuth Plane		Elevation Plane		Broadside		
	3 dB Beamwidth	6 dB AR Beamwidth	3 dB Beamwidth	6 dB AR Beamwidth	Gain	Impedance Bandwidth	6 dB AR Bandwidth
(inches)	(degrees)	(degrees)	(degrees)	(degrees)	(dB)	(MHz)	(MHz)
14	90	180	90	145	6.5	63	12.7
8	90	180	90	135	6.3	68	12.1
6	100	185	90	140	6.1	72	11.8

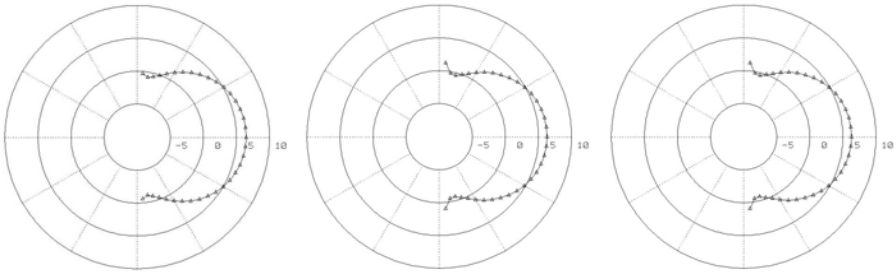
4.7.3 Comparison of the Truncated Corner Telemetry and GPS Patch Elements

The GPS element and perturbation dimensions are larger than that of the telemetry element because the operating frequency of the GPS element is approximately 640 MHz lower than the telemetry frequency. Additionally, the GPS element's input



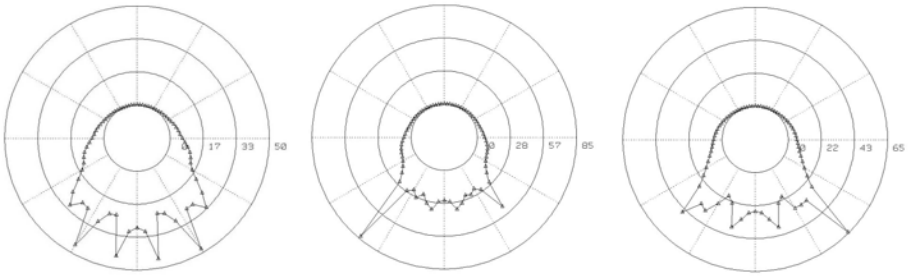
a. 14-inch diameter **b.** 8-inch diameter **c.** 6-inch diameter

Figure 4.30. Gain for truncated corner GPS element in the azimuth plane.



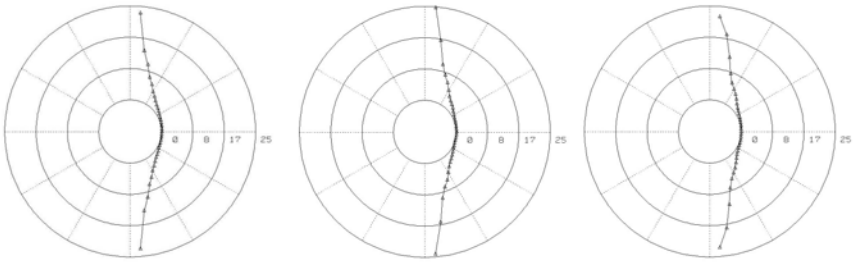
a. 14-inch diameter **b.** 8-inch diameter **c.** 6-inch diameter

Figure 4.31. Gain for truncated corner GPS element in the elevation plane.



a. 14-inch diameter **b.** 8-inch diameter **c.** 6-inch diameter

Figure 4.32. Axial ratio for truncated corner GPS element in the azimuth plane.



a. 14-inch diameter **b.** 8-inch diameter **c.** 6-inch diameter

Figure 4.33. Axial ratio for truncated GPS element in the elevation plane.

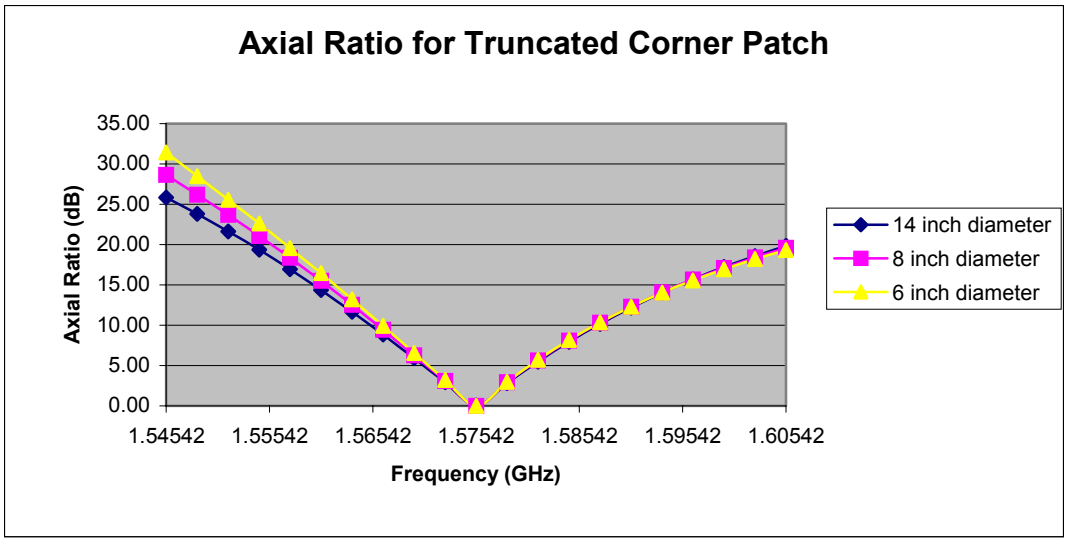


Figure 4.34. Truncated corner GPS patch axial ratio versus frequency.

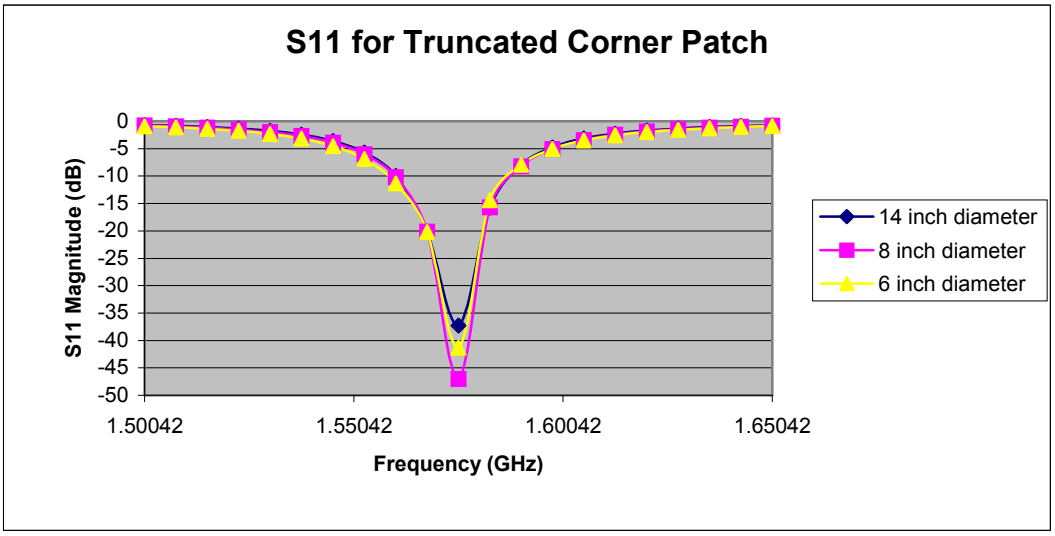


Figure 4.35. S_{11} versus frequency for truncated corner GPS patch.

impedance is less than that of the telemetry patch. Again, this is expected since the patch is larger in size. As with the telemetry element, the GPS element's input reactance is relatively small. The GPS and telemetry elements' gain and beamwidth performance are essentially the same. However, the broadside impedance and axial ratio of the GPS element is roughly half that of the telemetry patch.