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Test Report
Low Cost Land Vehicular Antenna
AT1595-90 "Tear Drop"
Serial Number 3002

Rev History

Rev	Author	Changes
1	Bill Eaton	• First version. Based on “Performance of Low Cost Land Vehicular Antenna Prototypes”, Rev 2, dated 17 Nov 2011

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1 Introduction

After an evaluation process, Inmarsat has selected an antenna offered by AeroAntenna: the AT1595-90 “teardrop” (Figure 1). This antenna is meant to be a low cost, magnetic mount, vehicular antenna for the IsatPhone Pro product line. Prototype antennas have been built and delivered to Inmarsat. This report focuses on measurements taken on Serial Number 3002.

Figure 1. AT1595-90 Antenna prototype, SN3002.

2 Differences Between Prototype and Production Configuration

From an antenna performance point of view, the prototype is expected to be nearly identical to the production configuration. A detailed comparison of construction is detailed in Table 1.

Table 1. Comparison of prototype and production configurations

Item	SN3002 Prototype	Production Configuration
Inmarsat antenna element	identical	
GPS antenna element	identical	
circuit board	nearly identical	
radome material	polyurethane based polymer	polycarbonate/ polyester injection molded plastic
base material		
radome finish	smooth paint. light gray	smooth, unpainted plastic. agate gray (RAL 7038)
base finish	textured paint, black	textured, unpainted plastic. black.
magnet placement	outside of base (exposed to environment)	inside of base (not exposed to environment)

3 Results

All antenna measurements presented in this report were performed with the antenna mounted on a 4 foot diameter, flat, round aluminum ground plane. The purpose of this ground plane was to simulate the metal roof of a ground vehicle.

3.1 Axial Ratio

Measuring axial ratio was done in an anechoic chamber using a spinning linear transmit antenna and receiving the signal with the AT1595-90, SN3002. Example raw data measured at 1518 MHz is shown in Figure 2. The axial ratio is calculated by taking the difference of the max envelope and min envelope and graphed in Figures 3 and 4. The original requirement was 4 dB to angles ±70° from zenith, with a relaxation to 6 dB for the extended band. However, the selected antenna demonstrates 4 dB down to only ±60° with no relaxation necessary for extended band. In the contract it was agreed that a waiver would be allowed for axial ratio. The numbers are summarized in Table 2.

Table 2. Axial ratio requirement

Parameter	Requirement		
	Statement of Work		Contract
Axial ratio	Operational Band	4 dB, Zenith ± 70°	All bands 4 dB, Zenith ± 60°
	Extended Band	6 dB, Zenith ± 70°	

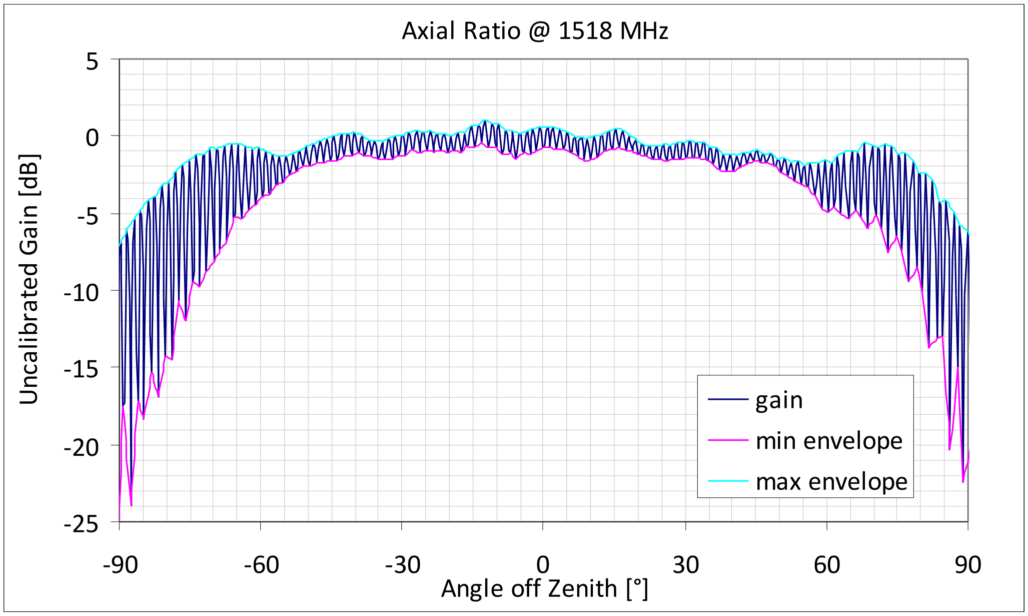

Figure 2. Raw data for axial ratio measurement at 1518 MHz. The difference in the max and min envelopes is the axial ratio.

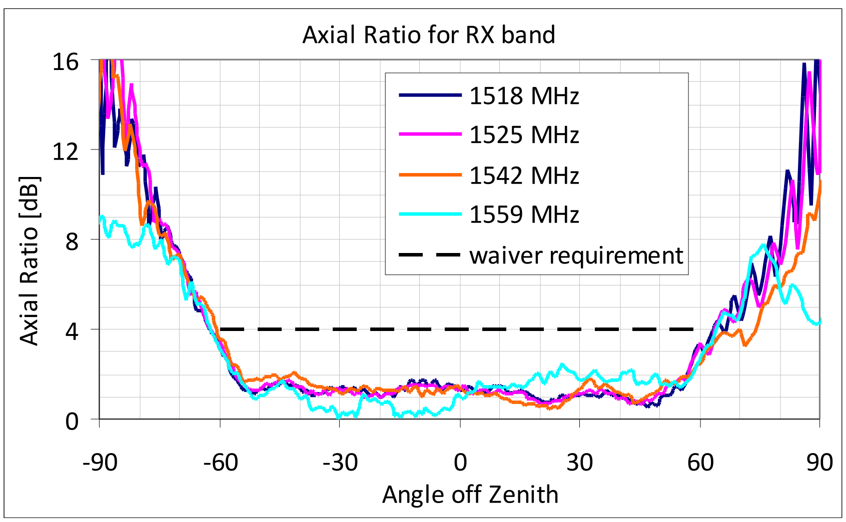

Figure 3. Axial ratio for receive band.

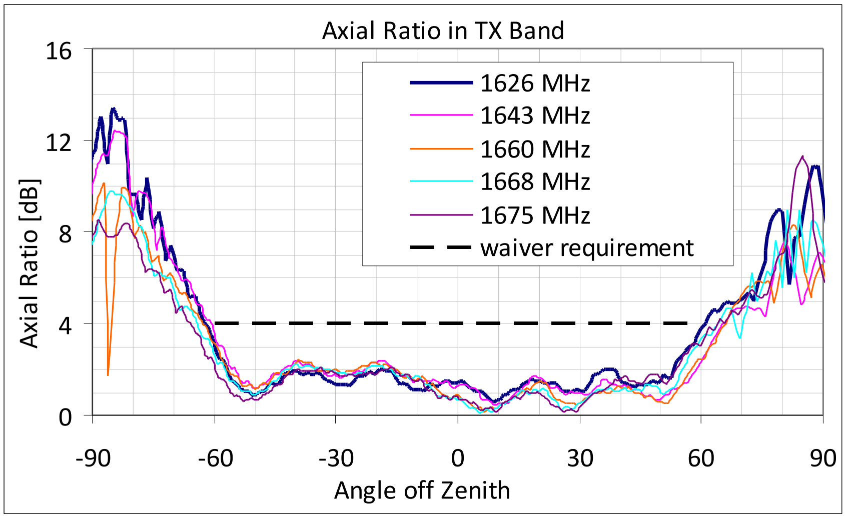

Figure 4. Axial ratio for transmit band.

3.2 Gain vs Elevation

Gain was measured in one of AeroAntenna's anechoic chambers. Measurements were performed at every 45° in azimuth (i.e. 0°, 45°, 90 °. . . 315°) and then averaged To make the graphs of Figure 5 and Figure 6.

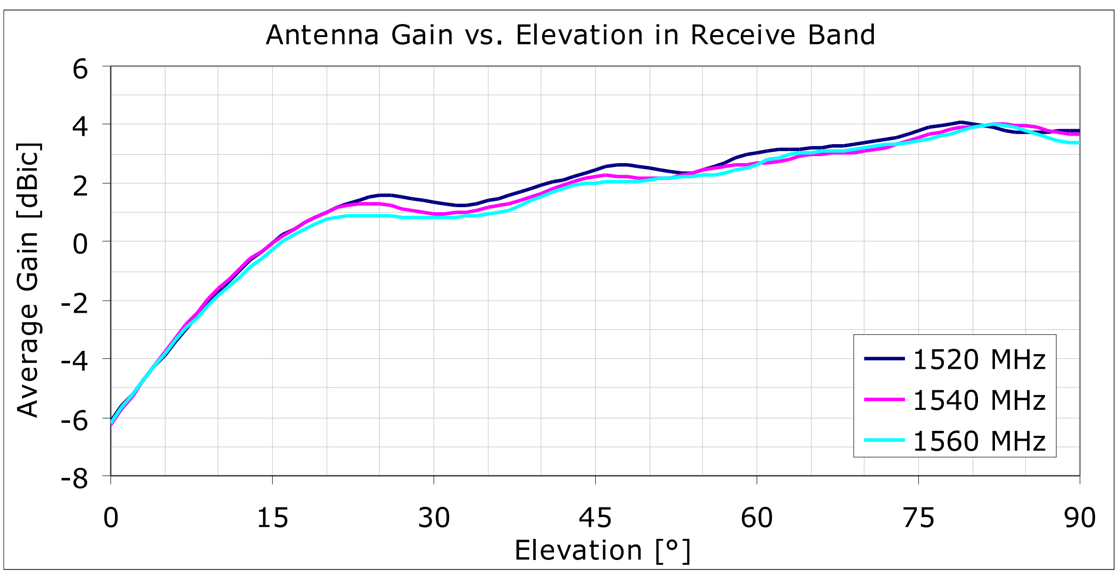

Figure 5. Gain vs Elevation for AT1595-90, SN3002 antenna for Inmarsat receive band. 0° and 90° elevations correspond to antenna horizon and zenith, respectively.

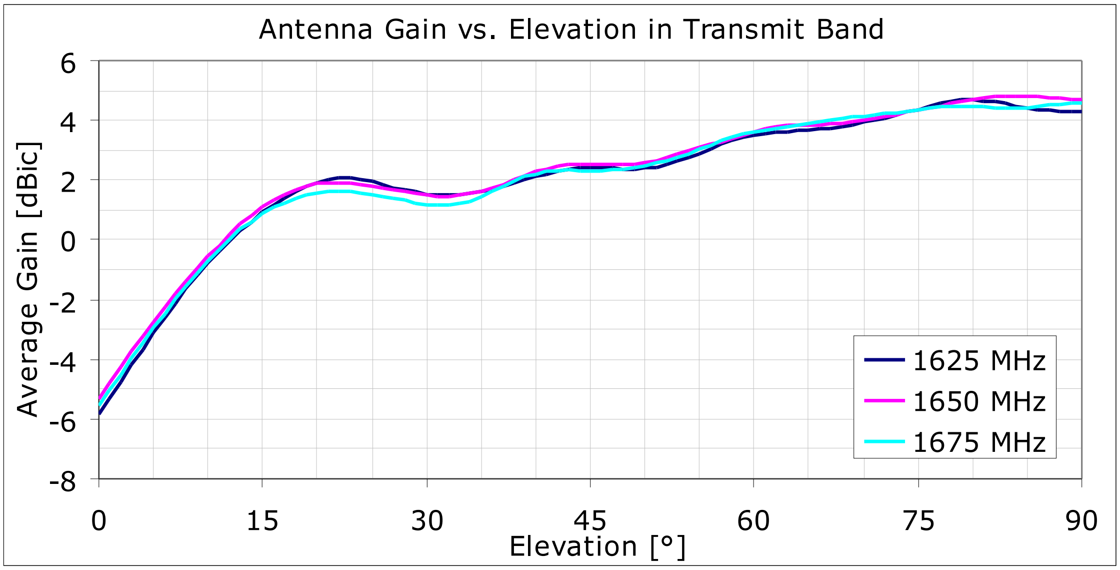

Figure 6. Gain vs Elevation for AT1595-90, SN3002 antenna for Inmarsat transmit band. 0° and 90° elevations correspond to antenna horizon and zenith, respectively.

3.3 G/T

Based on the Equation 1 of **Section 4.2** and measured gain data of **Section 3.1**, predicted G/T performance is plotted in Figure 7 for three frequencies across the receive band. Regrettably at higher frequencies, the G/T falls short of the requirement, making more discussion necessary.

The trickiest part about G/T measurement/calculation is the noise temperature of the antenna (T_{ant}). Among other things it is a property of the galactic temperature, and is generally a function of elevation. In this report, we have used a conservative number of 100K. A more liberal value of T_{ant} would yield more favorable results (as much as 1.5 dB).

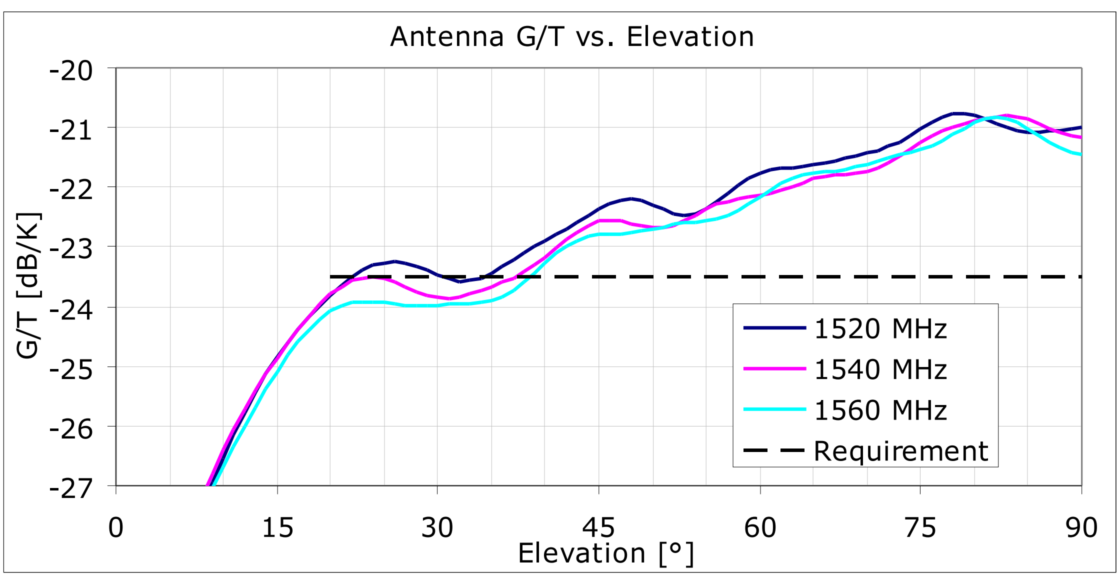

Figure 7. G/T for AT1595-90, SN3002.

3.4 EIRP

Based on the Equation 8 of **Section 4.3** and measured gain data, EIRP performance is plotted in Figure 8 for three frequencies across the transmit band. As shown in the figure, the antenna meets the requirement.

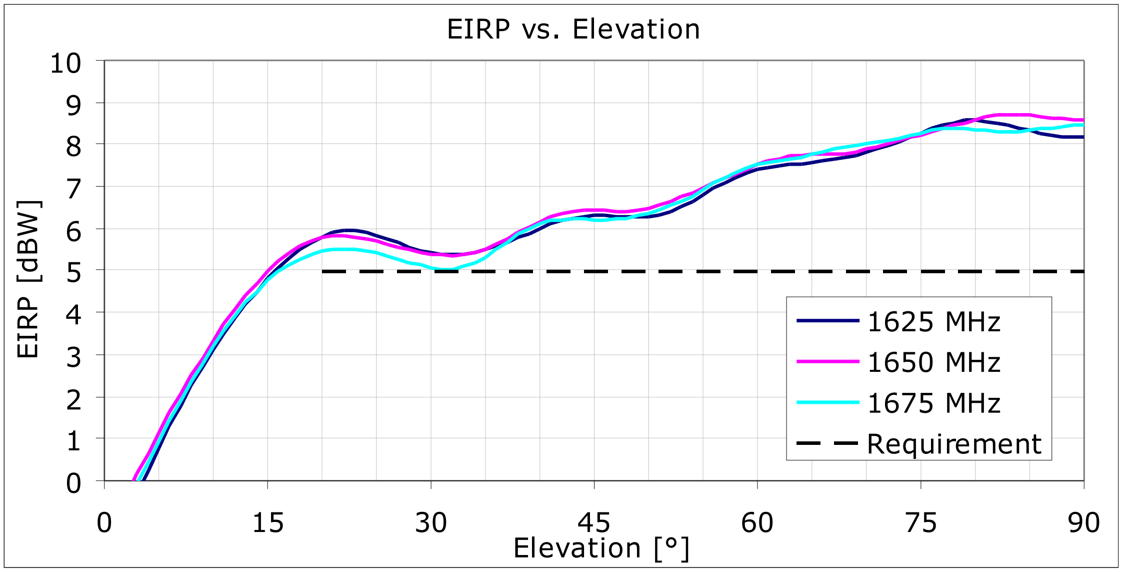

Figure 8. EIRP for AT1595-90, SN3002.

4 Appendix - Analysis

4.1 Requirements and Assumptions

Table 3.

Requirements		
Parameter	Value/Variable Assignment	Units
$\frac{G}{T}$	$\frac{G}{T} := -23.5$	[dB/K]
$EIRP$	$EIRP := 5$	[dBW]
Assumptions		
Cable Type	LMR 240 Ultra Flex	
Cable Length	$L_{cable} := 1.5$	[m]
Cable Loss	$Loss_{cable} := \left(\frac{40.48}{100}\right) L_{cable} = 0.6072$	[dB]
Handset Noise Figure	$NF_{handset} := 1.7$	[dB]
Handset Power	$P_{handset} := 34.5$ $P_{handset} := 4.5$	[dBm] [dBW]

4.2 G/T

G/T is one of the more important figures of merit for a receive antenna. It gives an idea of the signal to noise ratio that can be achieved from a given antenna. A block diagram of losses and noise sources for a passive antenna is shown in Figure 9.

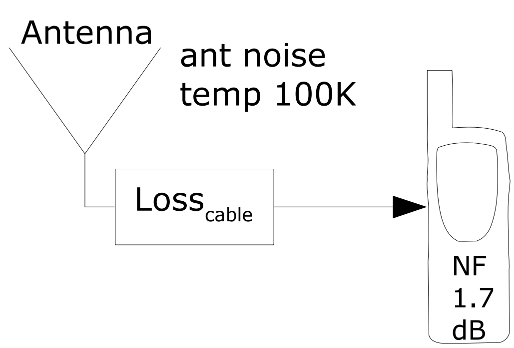

Figure 9. G/T block diagram for passive antenna.

G/T can be expressed as

$$\frac{G}{T} = 10\log\left(\frac{G_{dB}}{T_{sys}}\right) = G_{\text{ant dB}} - 10\log\left(T_{sys}\right) \quad [dB] \tag{1}$$

where $G_{ant\,linear}$, G_{dB}, and T_{sys} are the linear gain of the antenna element, the gain in dBic of the antenna element, and the noise temperature of the system (i.e. antenna plus cables and other losses) in Kelvin (K), respectively.

Our strategy is to calculate 10 log(T_{sys}) and solve for G_{ant}.

$$T_{sys} = T_{ant} + T_{loss} \tag{2}$$

where T_{ant} and T_{Loss}, are the noise temperatures of the antenna and losses, respectively. T_{ant} is presumed to be (conservatively)

$$T_{sky} := 100\,K \tag{3}$$

Losses account for all losses between the output of the antenna element and the input of the handset. The general equation to convert from loss or noise figure in dB, to noise T temperature in K, is

$$T = (290\,K)\left[10^{\frac{Loss_{dB} \text{ or } NF_{dB}}{10}} - 1\right] \tag{4}$$

In our case, we will add the noise figure of the handset to the cable loss. T_{loss} becomes

$$T_{loss} := (290\,K)\left[10^{\frac{Loss_{cable} + NF_{handset}}{10}} - 1\right] = 203.3\ K \tag{5}$$

And Equation 2 becomes

$$T_{sys} := T_{sky} + T_{loss} = 303.3\ K \tag{6}$$

Finally, Equation 1 can be rewritten as

$$G_{dB} := \frac{G}{T} + 10\log_{10}\left(\frac{T_{sys}}{K}\right) = 1.319 \quad \text{[dBic]} \tag{7}$$

4.3 EIRP

The Equivalent Isotropically Radiated Power (EIRP) is used to characterize how much power can be transmitted from an antenna.

A block diagram for a passive antenna is shown in Figure 10.

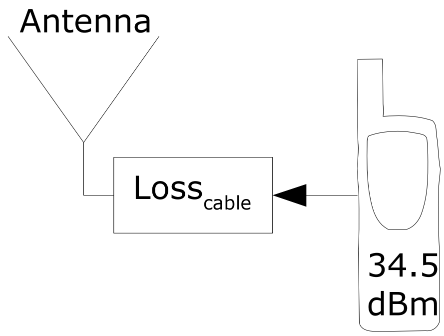

Figure 10. EIRP block diagram for passive antenna.

EIRP is given by

$$EIRP = P_{handset} - Loss_{cable} + G_{ant} \quad [dB] \tag{8}$$

Rearrange Equation 8 to solve for G_{ant}

$$G_{ant} := EIRP - (P_{handset} - Loss_{cable}) = 1.107 \quad [dB] \tag{9}$$

So G/T narrowly dominates over EIRP as the important parameter to meet in this system. Since TX and RX bands are separated in frequency, it is better to skew more antenna gain towards the RX band than the TX band.