EML-0001-QUL
Rev. Basic
29 August 2013

EMC TEST REPORT

StangSat

CubeSat Program

ENGINEERING SERVICE CENTER ELECTROMAGNETIC LABORATORY
Kennedy Space Center, FL 32815-0233

JOHN F. KENNEDY SPACE CENTER, NASA

EMC TEST REPORT

StangSat

CubeSat Program

Originator:

Lynne M. Carmody
Electromagnetic Lab
EMI Engineer

Reviewers:

James E. Stanley
Electromagnetic Lab Supervisor

Gerard P. Floyd
ENG Integration

Peter S. Aragona
NASA Electromagnetic Lab
Manager

Revision History

Revision	Date	Author(s)	Changes
Original	August 29, 2013	Lynne M. Carmody	Document Release

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

Abstract

This report documents the Electromagnetic Interference E M I testing performed on the StangSat; the unit under test (UUT). Testing was per the requirements of MIL STD-461F. The UUT was characterized and passed the radiated emissions (RE102 limit for Spacecraft) testing.

1 Introduction

The following tests (See Table 1) were requested for the StangSat. The testing was performed to MIL-STD-461F.

Table 1: StangSat MIL-STD-461F Requirements

Test Method	Test Description	Frequency Range
RE102	Radiated Emissions, Electric Field, Space System, Fixed Wing Internal Limit, ≥ 25m Nose to Tail	2 MHz to 18 GHz

MIL-STD-461 was established to determine the requirements for the control of electromagnetic interference characteristics of subsystems and equipment for applicable Military and Aerospace Divisions. MIL-STD-461 deals with two basic areas, electromagnetic effects that are conducted and radiated. Each of these areas has two different categories, emissions and susceptibility. MIL-STD-461 Rev F establishes specific requirements and test methods for each set and subset: Conducted Emissions, Conducted Susceptibility, Radiated Emissions and Radiated Susceptibility.
MIL-STD-461 Rev. F EMI Testing is performed to determine compliance of the StangSat to the requirements listed in Table 1. The EMI testing confirms there is a high level of confidence the StangSat will function properly and not interfere with other systems and equipment.

1.1 Unit under Test (UUT) Description

Merritt Island High School in collaboration with NASA engineers under the Launch Space Program at Kennedy Space Center designed a small satellite known as a CubeSat; and named it StangSat. The StangSat is a 1U payload (10cmX10cmX10cm) with a wifi module transmitting at 2.4 GHz as shown in Figures 1 and 2. A Wifi module was enclosed in a shielded box and supported on the chamber wall to receive the 2.4 GHz signal. A camera was set-up to monitor the LED on the CubeSat during test (See Figure 3). LED's were built into the CubeSat and blinking when the CubeSat was recording and transferring data to the Customer Laptop via the 2.4 GHz Wifi module. A diagram of the test set-up is shown in Figure 4. The objective of this CubeSat is to measure, record and transmit (by wifi) the vibration and shock data from a rocket launch.

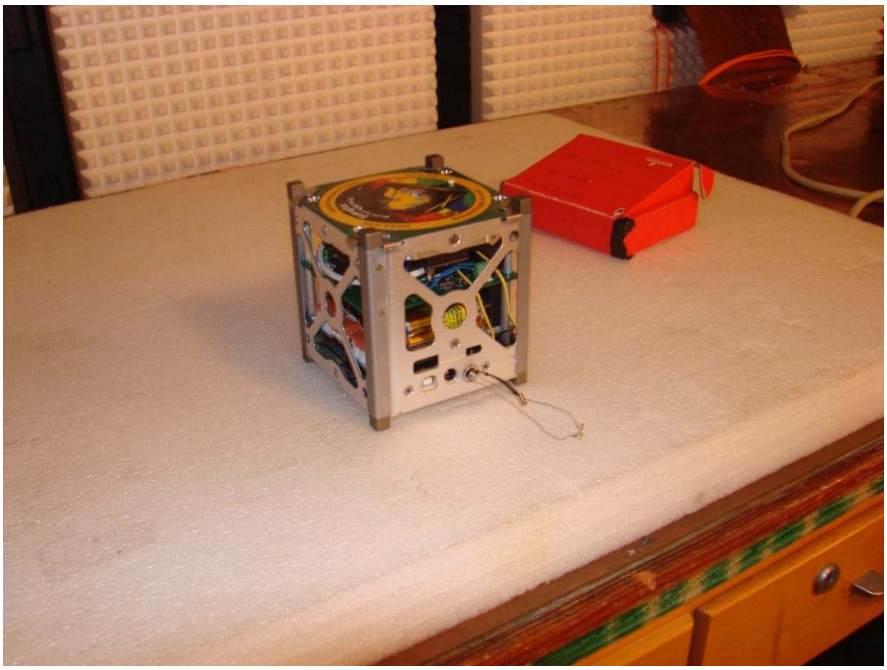

Figure 1: StangSat Test Setup

Figure 2: StangSat Test Setup "Top View"

Figure 3: Camera View of StangSat During Test

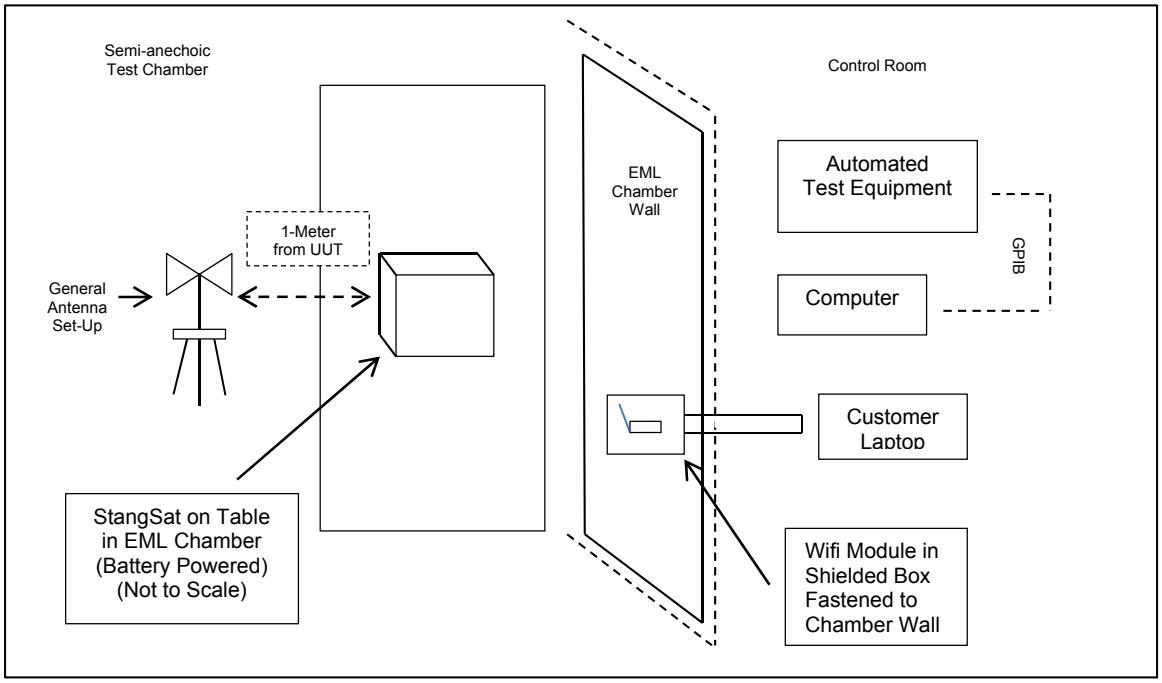

Figure 4: Diagram of Test Set-Up

2 Purpose

The purpose of this report is to collect all information needed to reproduce the testing performed on the StangSat, document data gathered during testing, and present the results. This report may also be used to assist in the qualification of the StangSat to the EMI requirements herein.

3 Scope

This document presents information unique to the measurements performed on the StangSat, using test methods prepared to meet MIL-STD-461F requirements. It includes the information necessary to satisfy the needs of the customer per work order number 1031118. The information presented herein should only be used to meet the requirements for which it was prepared.

4 Test Method

Current test requirements and test methods are specified in MIL-STD-461F. The UUT (StangSat) was designed as a payload to mount on a Falcon 9 Launch Vehicle. Therefore, the RE102 limit selected was the RE102 Limit for spacecraft, Fixed Wing ≥ 25 meters. See Figure RE102-3 from MIL-STD-461F as shown below as Figure 5.

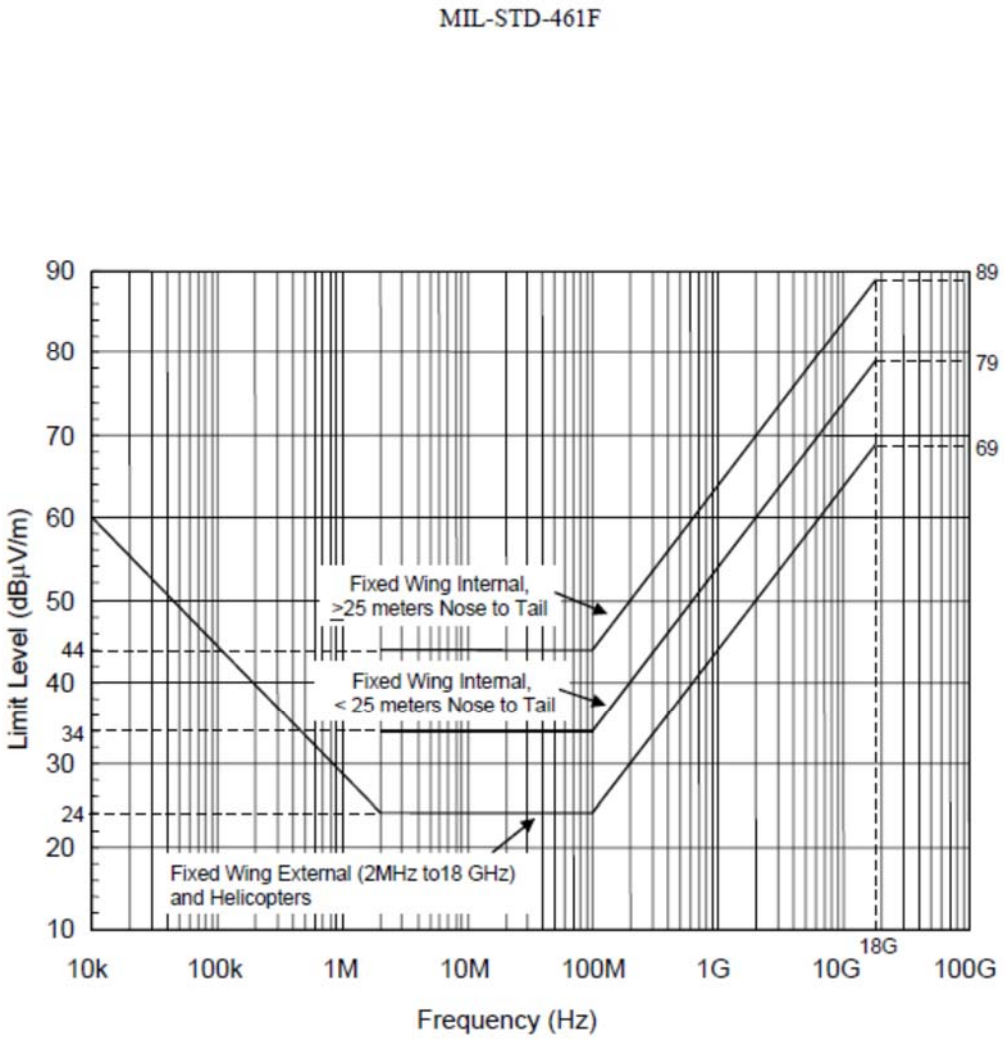

Figure 5: RE102 Limit for Aircraft and Space Systems Applications

5 Results

5.1 Bonding

There were no bonding requirements for the StangSat.

5.2 Testing Results

The results of the EMI evaluation contained within this report were obtained over 9 August 2013 through 12 August 2013. The device passed the tests specified by the customer's requirements as shown in Table 5.2. Detailed results are presented in Appendix A.

Table 5.2: Testing Results

Test	Result	Test Completion Date
RE102	Complied	12 AUG13

6 References

[1] *MIL-STD-461F, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment*, Department of Defense, ASC/ENOI, 2530 Loop Road W, Wright-Patterson AFB, OH, 5433-7101, December 2007.

A RE102 Radiated Emissions, Electric Field

A.1 RE102 Equipment

Table A.1: RE102 Equipment List

Nomenclature	Manufacturer	Model Number	Serial Number	Calibration Due
TDK Emissions Lab Software	TDK	VER. 6.97	NA	NA
Spectrum Analyzer	Agilent	E446A	SG46180307	04DEC13
RF Preselector	Agilent	N9039A	CSC412031	30NOV13
Analog Signal Generator	Agilent	N5181A	CSC41204	30NOV13
LISN	Solar	9233-50-TS-50-N	088650	NCR
LISN	Solar	9233-50-TS-50-N	088651	NCR
Preamplifier	Agilent	8449B	3008A00475	NCR
Active Rod Antenna	EMCO	3301B	3443	25JAN16
Biconical Antenna	EMCO	3104C	4656	03JAN16
Big Horn Antenna	ETS Lindgren	3106	75838	22DEC15
Small Horn Antenna	EMCO	3115	2316	08JAN16

Note: The equipment is also catalogued in the Maximo System.

A.2 Bandwidths and Dwell Times

Table A.2: RE102 Bandwidths and Dwell Times

Frequency Range	Bandwidth Used	Dwell Time Used
2 MHz to 30 MHz	10 kHz	15 milliseconds
30 MHz to 1 GHz	100 kHz	15 milliseconds
1 GHz to 18 GHz	1 MHz	15 milliseconds

A.3 RE102 Data

A.3.1 RE102 Verification

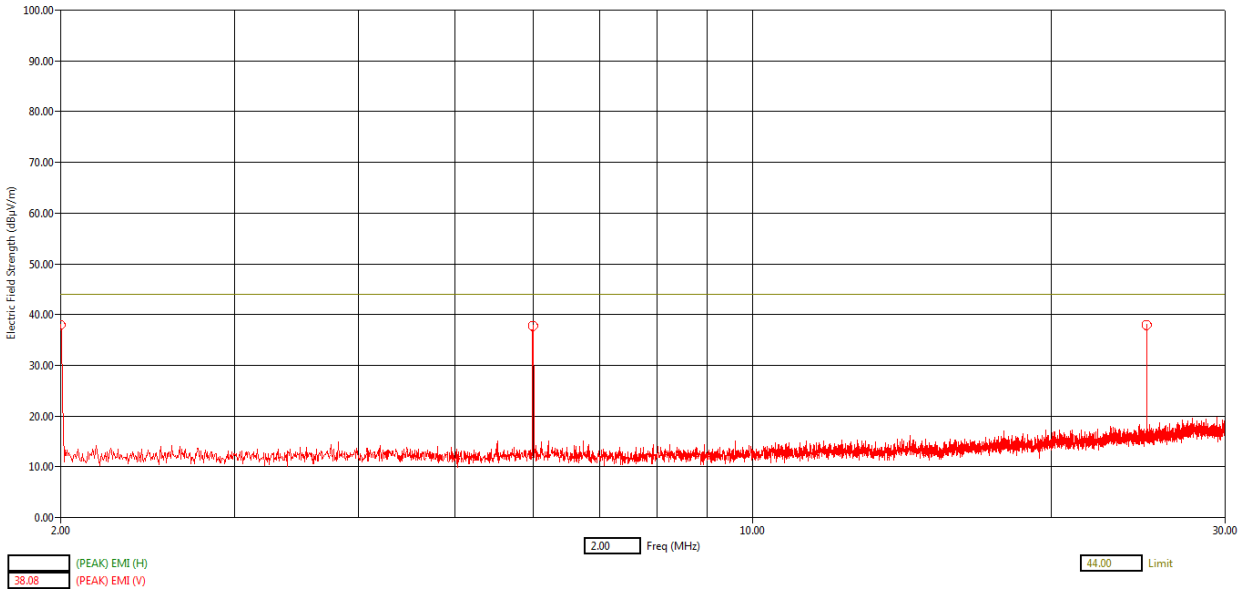

Figure A.3-1: RE102 Active Rod Verification

Table A.3-1: RE102 Active Rod Verification, Peaks

Measured Frequency (MHz)	Peak ($dB\,\mu V\,m^{-1}$)	Limit ($dB\,\mu V\,m^{-1}$)
2.5000	38.08	44.0
6.000	37.97	44.0
24.000	38.01	44.0

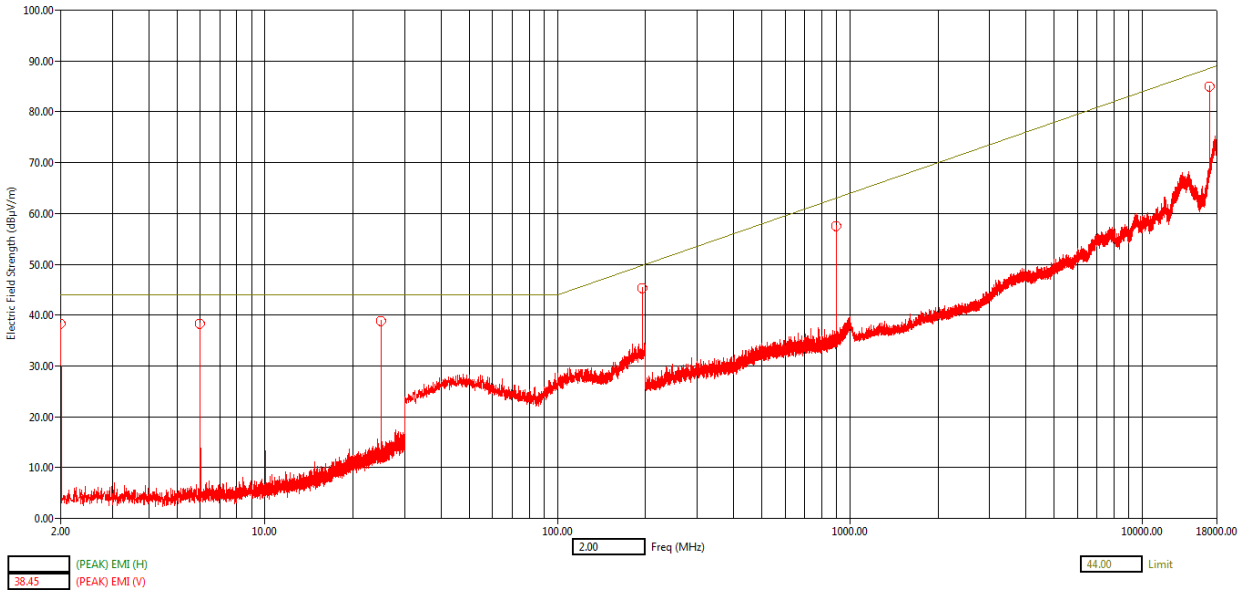

Figure B.3-2: RE102 System Verification

Table A.3-2: RE102 Verification 2MHz to18000MHz, Peaks

Measured Frequency (MHz)	Peak ($dB\,\mu V\,m^{-1}$)	Limit ($dB\,\mu V\,m^{-1}$)
2.5000	38.45	44.0
6.000	38.39	44.0
24.000	38.90	44.0
195.00	45.49	50.0
900.00	57.56	63.0
17000.00	85.06	88.5

A.3.2 Test Data

The Wifi Transmit Frequency is at 2.4 GHz and exempt from the test. *See MIL-STD-461F paragraph 5.17.1 RE102 applicability - The requirement does not apply at the transmitter fundamental frequencies and the necessary occupied bandwidth of the signal.*

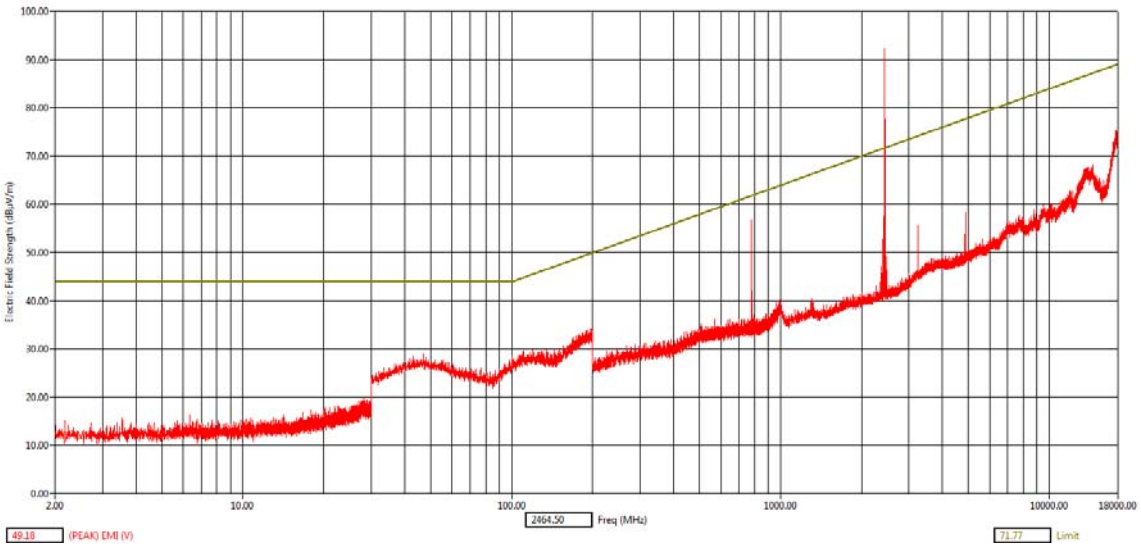

Figure A.3-3: RE102 Test Data 2 MHz to 8000 MHz Vertical Polarization

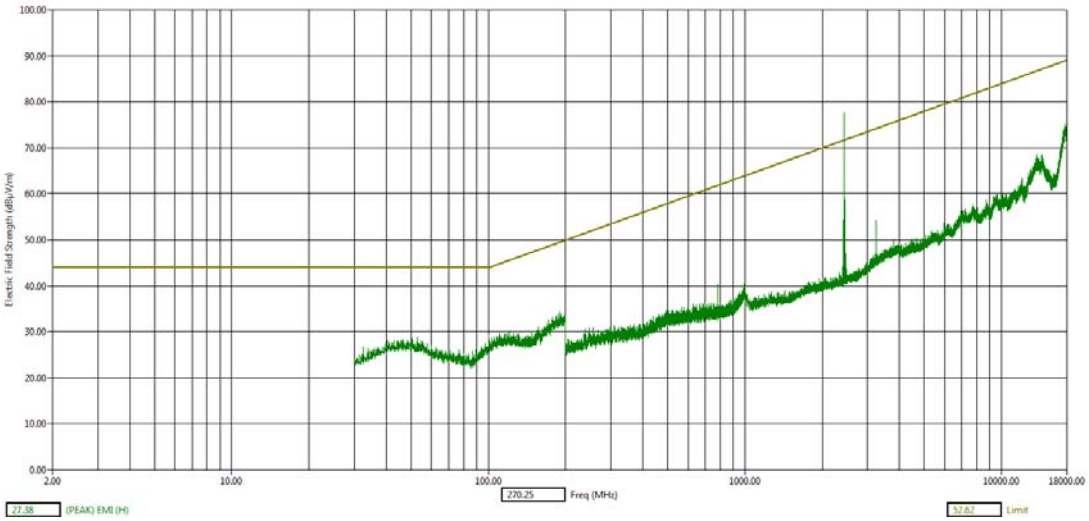

Figure A.3-4: RE102 Test Data 30 MHz to 18000 MHz Horizontal Polarization

A.3.3 Photos

Figure A.3-5: RE102 Active Rod Antenna Setup

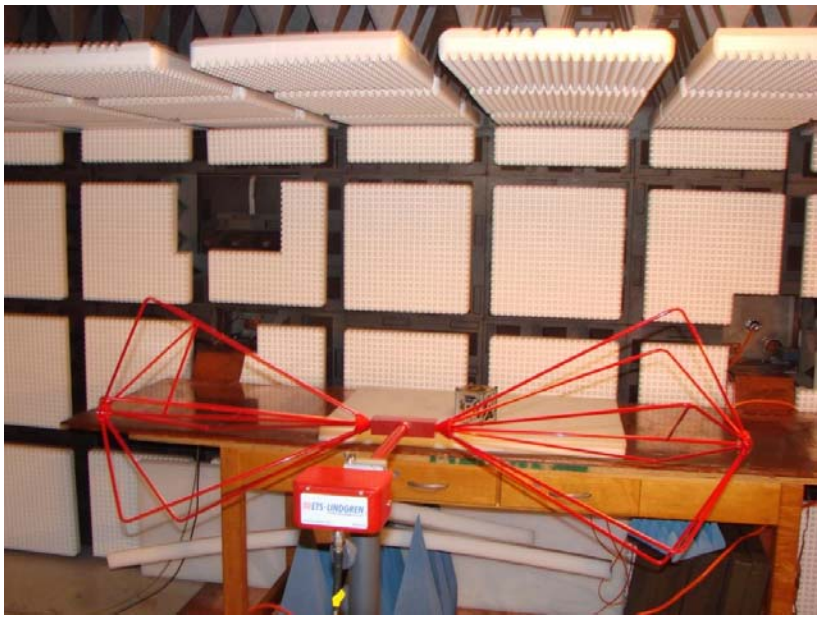

Figure A.3-7: RE102 Biconical Antenna Setup, Horizontal

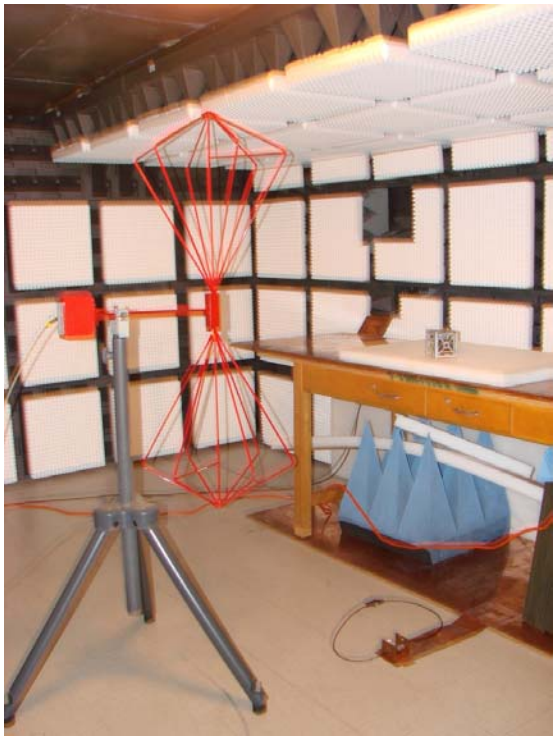

Figure A.3-8: RE102 Biconical Antenna Setup, Vertical

Figure A.3-9: RE102 Big Horn Antenna Setup, Horizontal

Figure A.3-10: RE102 Big Horn Antenna Setup, Vertical

Figure A.311: RE102 Small Horn Antenna Setup, Horizontal

Figure A.3-12: RE102 Small Horn Antenna Setup, Vertical

Electronic:

Shaun Daly	shaun.m.daly@nasa.gov
Peter S. Aragona	peter.s.aragona@nasa.gov
Lynne Carmody	lynne.m.carmody@nasa.gov
Electromagnetics Laboratory	EML document server