Additional Information for File Number: 0670-EX-CN-2018
Applied Research Associates, Inc. – FRN 0027803881
Application for Experimental License to Perform MIL-STD-188-125 Continuous Wave Immersion Testing

1. PURPOSE OF LICENSE APPLICATION

This license application is for the purpose of conducting MIL-STD-188-125 Volume 1 and Volume 2 Continuous Wave Illumination Testing (CWI) on to be determined facilities throughout the Continental United States (CONUS). The CWI testing system will be based in San Antonio, TX at Applied Research Associates, Inc. facilities at 11220 W. Loop 1604 N. Building 2. Testing may also take place at the ARA San Antonio facility.

Testing at any given facility will be limited to less than 2 months in duration, and may typically take only 1-3 weeks. Testing may be conducted during extended normal working hours from about 7:00 AM to 7:00 PM local time. However, hours may be adjusted to accommodate facility or spectrum management operational requirements.

ARA envisions a maximum of 6 tests per year, with a more likely number of tests being in the range of 2-3 per year. Because of the uncertainty in the number and locations of the testing, ARA is requesting a 5 year Experimental License.

This testing will be conducted under a U.S. Government Contract with the Defense Threat Reduction Agency. The following are the contractual details:

Contract Number: HDTRA1-14-D-0003-0009 and 0011

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2. CWI TEST OVERVIEW

Continuous Wave Immersion (CWI) testing is a component of MIL-STD-188-125 Volume 1 and Volume 2 Verification Testing. CWI measures the attenuation of external electromagnetic fields by the facility's electromagnetic shield and/or its construction materials. CWI characterizes both the free field electromagnetic environment inside the facility and the currents coupled on facility cabling from that environment. It also provides a transfer function of the facility shielding for use in performing threat level extrapolations and other analysis.

The MIL-STD-188-125 Appendix C CWI test method shown in Figure 1 is essentially an insertion loss or attenuation measurement technique. A list of typical equipment used is shown in Table 1. An initial measurement is made of the signal level from a receive sensor (B-dot or D-dot) positioned at a known distance in free space (over ground) from a transmitting antenna. This measurement of free field path loss becomes the "Reference" or "Calibration" measurement. The receive sensor is then placed within the facility under test and the measurement is repeated, keeping the same equipment configuration, transmit power, and transmit/receive antenna/sensor orientation and spacing as with the "Reference" measurement. The quotient of the "Reference" signal power over the measured facility internal signal power represents the attenuation or transfer function of the facility.

Testing is conducted in both the horizontal and vertical polarizations of the transmitting antenna. Table 2 describes the basic CWI testing requirements from MIL-STD-188-125 Volume 1 or Volume 2 Appendix C. For the readers convenience, a full copy of MIL-STD-188-125-1 can be found here. MIL-STD-!88-125-2 is very similar, and applies to transportable systems.

The transmitting antennas will mounted to a telehandler that will be rented onsite. A photograph of this concept is shown in Figure 2.

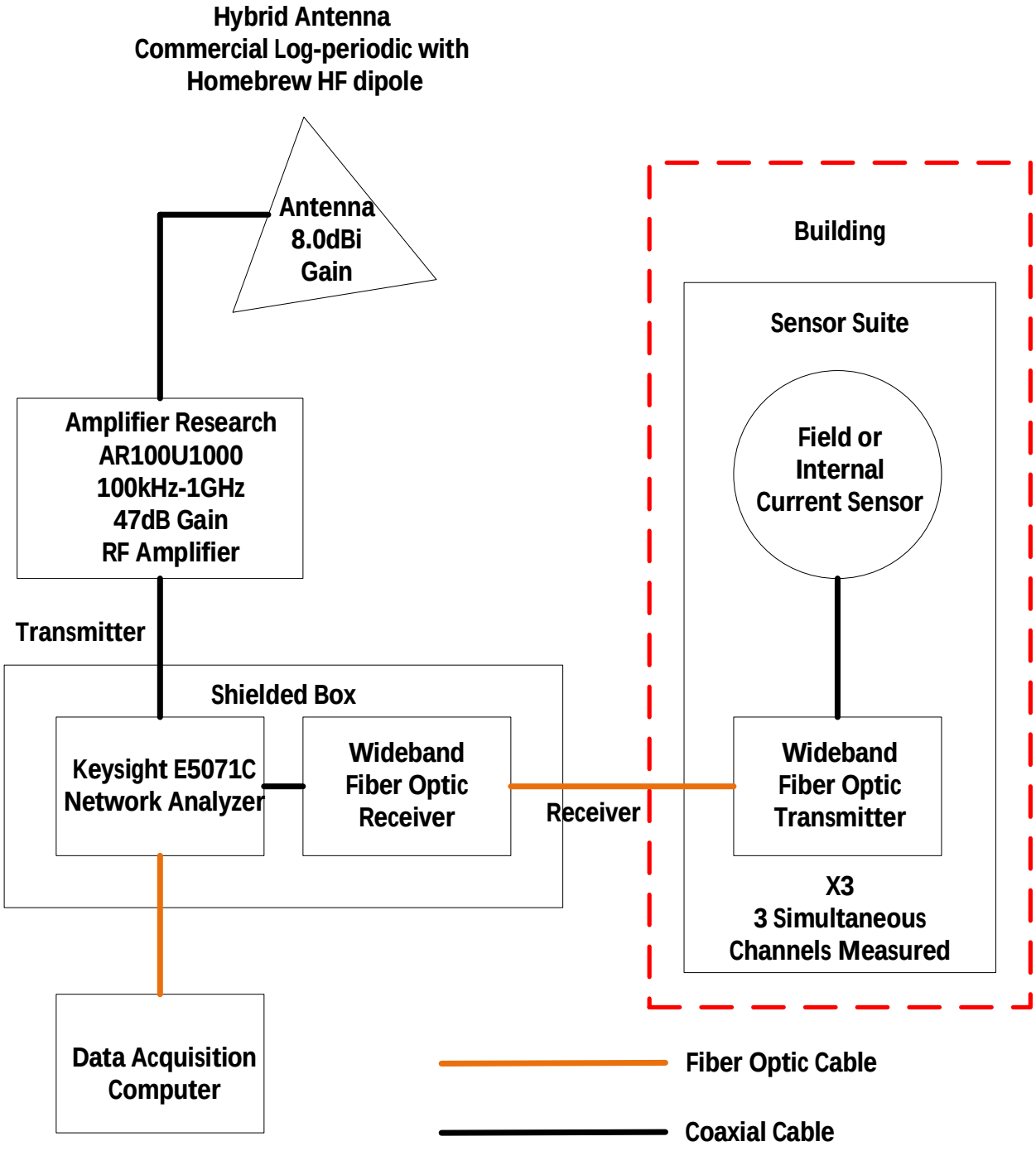

Figure 1 Functional Diagram of MIL-STD-188-125-1 or -2 Continuous Wave Immersion (CWI) Test Setup (Network Analyzer Measures S21, S31, S41 Simultaneously)

Figure 2 Proposed CWI Antenna System Mounting Scheme (Telehandler Height Maximum 55ft.)

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Table 1 Equipment List For MIL-STD-188-125-1 or 2 CWI Testing (Transmitting Equipment Highlighted in Yellow)

Equipment	Description	Calibration Status
Laptop Computer (w/ GPIB or Ethernet)	Data Acquisition Computer: Transfers data from the network analyzer and saves in ASCII format. Also used for data reduction.	NOT APPLICABLE
Log-periodic High Frequency Antenna	30MHz-1.1GHz, 8dBi gain – United States Antenna Products Model LP-1018BA or equivalent/	NOT APPLICABLE
Low Frequency Dipole Antenna	7MHz , 2.15 dBi gain – Cushcraft Model D40 or equivalent 40 m homebrew folded dipole	NOT APPLICABLE
RF Network Analyzer	Agilent E5071C Network Analyzer or equivalent Used for the 10kHz to 1GHz SE test frequencies and measurements from sensors	CURRENT
Wideband Analog Fiber Optic Data Link	EG&G ODS1500 Fiber Optic Transmitter/Receiver System or equivalent Provides an analog (10 kHz – 1 GHz) RF link with gain (max = 50 dB) between the receive antenna and network analyzer.	MEASURED WITH NETWORK ANALYZER BEFORE TEST
Wideband RF Power Amplifier	Amplifier Research AR100U1000 or equivalent DC 1 GHz, 100 W, 50 dB RF amplifier, or Amplifier Research 10W1000 DC -1 GHz 10 W 50dB RF amplifier.	MEASURED WITH NETWORK ANALYZER BEFORE TEST
Prodyn Technologies	Model B-20 B-dot Sensor or equivalent $A_{EQ}=0.01m^2$ >300MHz	NOT APPLICABLE
Prodyn Technologies	Model B-60 B-dot Sensor or equivalent $A_{EQ}=0.001m^2$ > 840MHz	NOT APPLICABLE
Prodyn Technologies	Model AD-40 D-dot Sensor or equivalent $A_{EQ}=0.01m^2$ >1GHz	NOT APPLICABLE
Prodyn Technologies	Model B-50 J-dot Sensor $A_{EQ}=0.001m^2$ >700MHz	NOT APPLICABLE
Prodyn Technologies	Model B-40 J-dot Sensor $A_{EQ}=0.01m^2$ >230MHz	NOT APPLICABLE
Prodyn Technologies	Model I-125-1HF Clamp-on Current Probe 50kHz – 1GHz $Z_T=5$ Ohms	NOT APPLICABLE
Fiber Optic Talk Set	Optical Wavelength Labs Model LH-1310 or equivalent – Voice communications	NOT APPLICABLE

3. MIL-STD-188-125 REQUIREMENTS

Table 2 Basic MIL-STD-188-125 CWI Test Requirements

Requirement	Type	Comment
Transmit Antenna Locations	Radiated field region chosen to Illuminate entire facility	3 or 4 locations normally required
Transmit Antenna Distance From Facility	As far from the facility as possible but within site physical and instrumentation measurement sensitivity constraints	Illumination from radiated field excitation Typical distances that have been used by others in the past are approximately 30-40m which while practical does not satisfy the radiated (far) field requirement at the low frequencies
Incident Fields	Electric field on facility surface closest to transmitting antenna Horizontal and Vertical Polarity	100kHz - 1MHz = 0.1V/m 1MHz - 50MHz = 1V/m 50MHz – 100MHz = 0.1V/m 100MHz – 1GHz = 0.01V/m
Frequency Range	100kHz – 1GHz	May require several sweeps in different bands using different antennas
Free-field Reference Measurement	Low and High Frequency B-dot or D-Dot	For each transmit antenna location: 1- three axis using low frequency sensor and 1- three axis using high frequency sensor
Internal Fields Measurement	Low and High Frequency B-dot or D-dot	For each transmit antenna location: 5- three axis using low frequency sensor and 5- three axis using high frequency sensor
Internal Surface Current Measurement	Low and High Frequency J-dot	For each transmit antenna location: 3- two axis using low frequency sensor and 3- two axis using high frequency sensor
Internal Cable Current Measurement	Wideband current probe	For each transmit antenna location: 20 –representative of the classes of cables within the facility internal cable plant

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MIL-STD-188-125 requires that testing be over the frequency range from 100kHz to 1GHz. This is accomplished by using a Keysight Technologies Vector Network Analyzer (VNA) as both the transmitter and receiver. The VNA is configured to measure S21, S31, and S41 simultaneously in one "sweep" so that three measurements can be taken at once to reduce the number of "sweeps" required. The VNA outputs discrete frequencies at frequencies that are either determined by the VNA settings or the operator. Thus the term "sweep" in quotations.

It is necessary to conduct test in several bands because of the frequency response limitations of some of the receiver sensing hardware (B-dot and D-dot probes). Table 3 shows the proposed bands and number of frequencies in each band. It is possible that this may be reduced to two bands, with Band 1 covering 100kHz to 100MHz and Band 2 covering 100MHz to 1GHz. If two bands are used, there will still only be 1601 frequency points maximum in each band.

The frequencies may be spaced linearly of logarithmically in each band and are unmodulated. The actual frequencies used will be automatically determined by the VNA settings used or may be input by the operator to exclude frequencies requested by local spectrum management, so it is possible that the actual frequencies from test tot test may vary. However, the dwell time at each frequency will be minimal. For example, if a "sweep" of 1601 discrete frequencies takes 2 minutes or 120 seconds, then the dwell time will be 120 seconds/1601 or 75 milliseconds per frequency. This should be considered typical, and is not expected to cause any interference to other services due to the short duration on frequency.

Table 3 Proposed Frequency Bands for CWI Testing and Maximum Number of Frequencies in Each Band

Frequency Range		ARA CWI System Maximum Number of Test Frequencies in Each Band
100kHz	1MHz	1601
1MHz	10MHz	1601
10MHz	100MHz	1601
100MHz	1GHz	1601
Total Number of Test Frequencies		**6404**

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4. APPENDIX- MANUFACTURER'S DATA SHEETS FOR TRANSMITTER COMPONENTS

Please click on hyperlink "here" to link to the manufacturer's web page for specification on the individual equipment that comprises the transmitter.

The manufacturer's data sheet for the Keysight E5071 VNA can be found here.

The manufacturer's data sheet for the Amplifier Research 100U1000 power amplifier can be found here.

The manufacturer's data sheet for the Amplifier Research 10W1000 power amplifier can be found here.

The manufacturer's data sheet for the United States Antenna Products LP1018BA Log Periodic antenna can be found here.

The low frequency dipole which attempts to extend the range of the Log Periodic to the 100kHz to 30MHz range will either be a Cushcraft D40 loaded dipole or a homebrew folded terminated dipole. The manufacturer's data sheet for the Cushcraft D40 dipole can be found here.