1. PURPOSE OF SPECIAL TEMPORARY AUTHORIZATION APPLICATION

This Special Temporary Authorization application is for the purpose of conducting MIL-STD-188-125 Volume 1 and Volume 2 Continuous Wave Illumination Testing (CWI). The proposed CWI testing will be at the AFEMPS and VEMPS facilities at White Sands Missile Range (WSMR). A map of the test location is shown below in Figure 1.

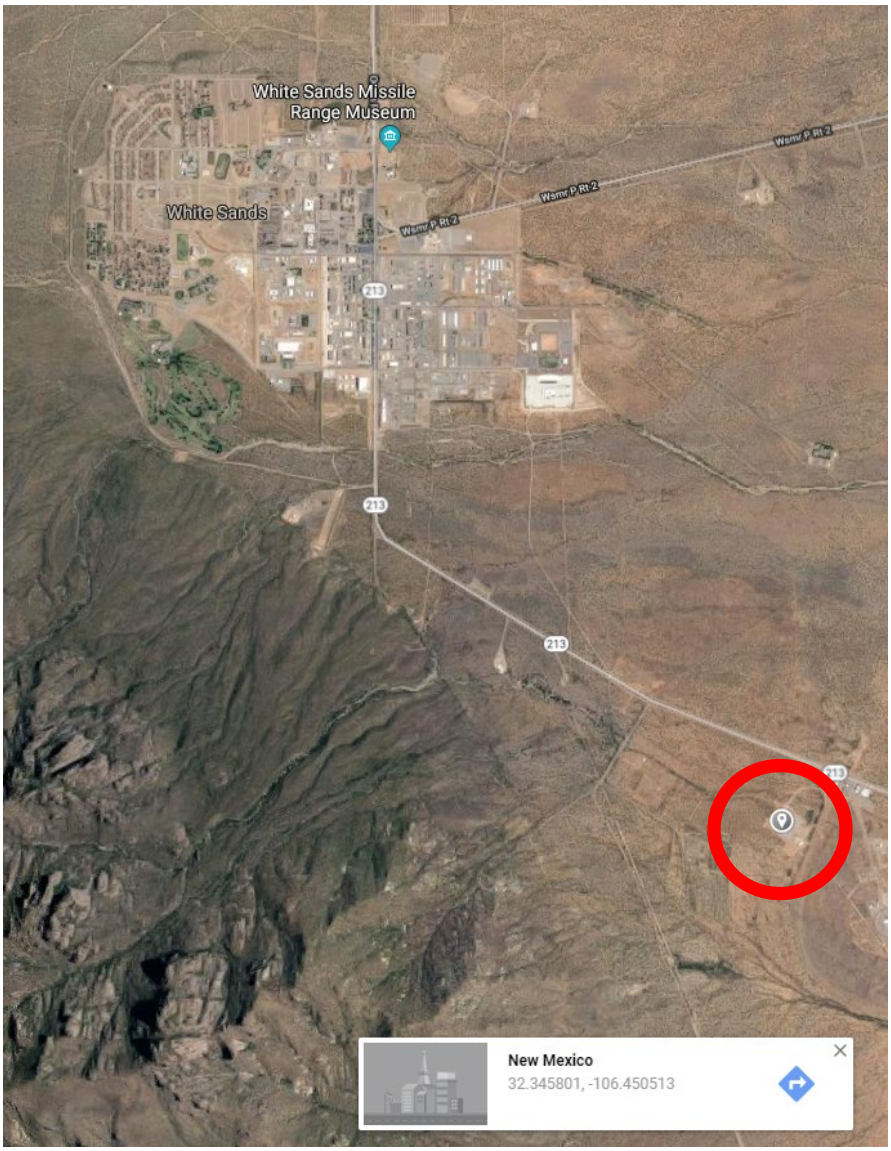

Figure 1. Map showing location of temporary WSMR transmitter

Condron AAF lies 3.5 km east of the test site but it has been marked as “Closed Permanently” and “Unattended” so we have concluded Las Cruces International Airport is the nearest active air traffic.

https://skyvector.com/airport/WSD/Condron-AAF-Airport

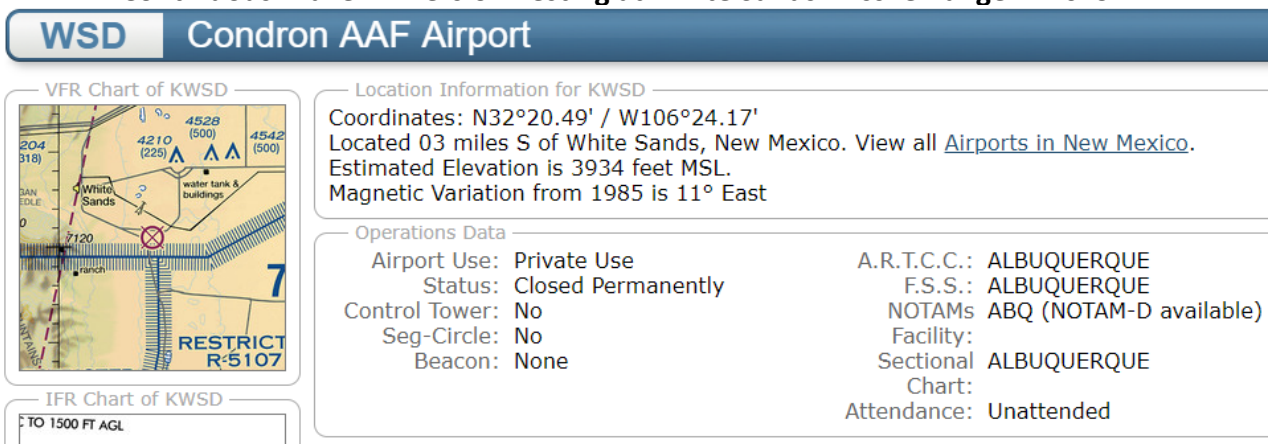

Figure 2. Screen capture of skyvector.com listing for Condron AAF showing that it is "Closed Permanently" and "Unattended".

Testing at any given facility will be limited to 2 months in duration. 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.

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-0003-0028

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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 2 is essentially an insertion loss or attenuation measurement technique. A list of typical equipment used is shown in Table 1, and links to the manufacturers data sheets can be found in Section 4 Appendix A.

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.

MIL-STD-188-125 Requirements

Table 2 describes the basic CWI testing requirements from MIL-STD-188-125 Volume 1 or Volume 2 Appendix C. For the reader's convenience, a full copy of MIL-STD-188-125-1 can be found here. MIL- STD-188-125-2 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 3.

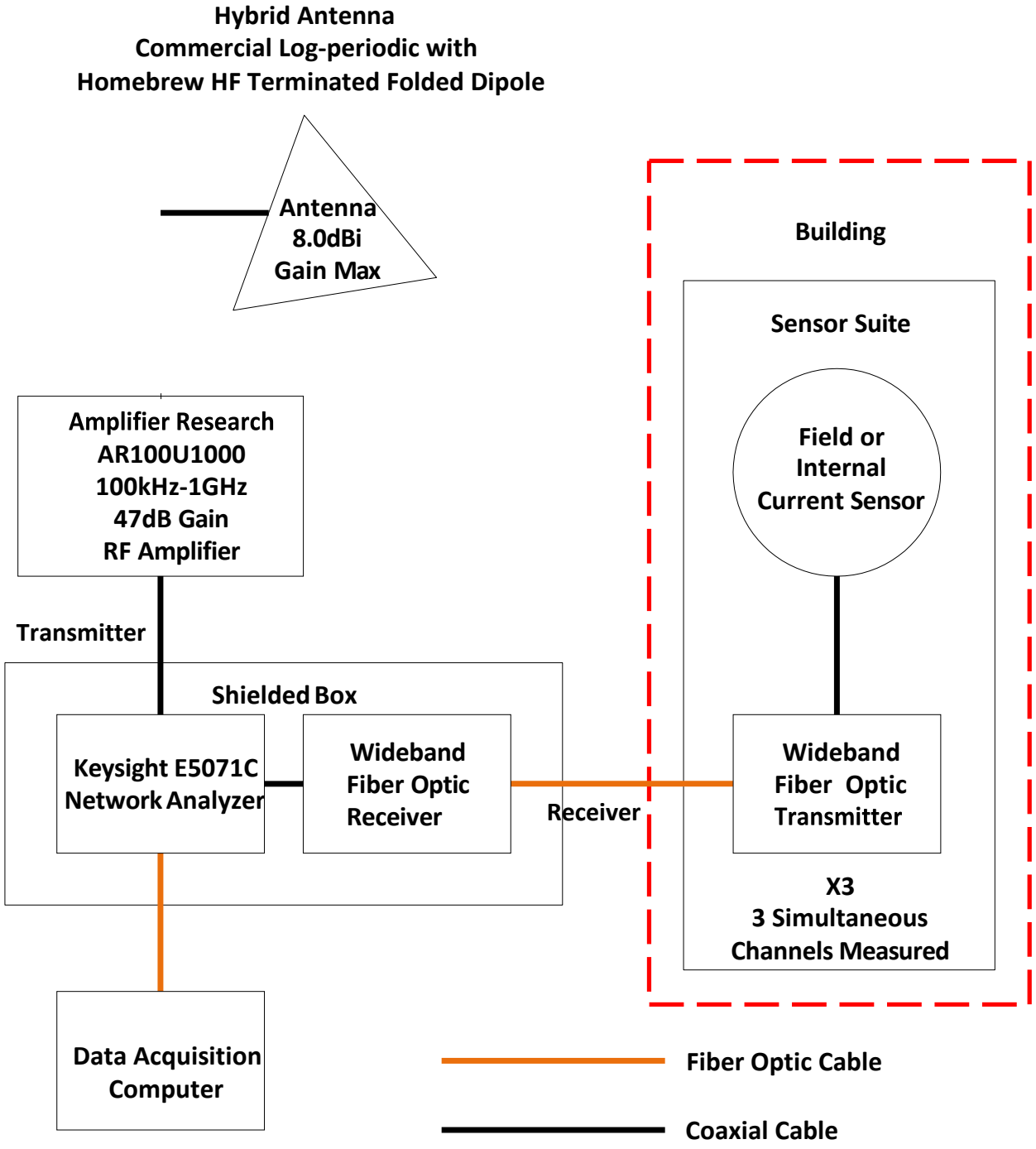

Figure 3. Functional Diagram of MIL-STD-188-125-1 or -2 Continuous Wave Immersion (CWI) Test Setup (Network Analyzer Measures S21, S31, S41 Simultaneously)

Figure 4. Proposed CWI Antenna System Mounting Scheme (Telehandler Height Maximum 55ft.)

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 Terminated Folded Dipole Antenna	7MHz , 0 dBi gain – Terminated Folded Dipole Resonant at about 10 MHz	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

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 stepped 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 some example bands, number of frequencies in each band, the total sweep time for 1601 frequencies and the calculated dwell time per frequency. It is possible that this may be reduced to two bands, with Band 1 covering 100kHz to 30MHz and Band 2 covering 30MHz to 1GHz. If two bands are used, there will still only be 1601 frequency points maximum in each band.

IMPORTANT INFORMATION ABOUT EXCLUSION FREQUENCIES:

The frequencies may be spaced linearly or logarithmically in each band and are unmodulated. ARA is able to exclude specific frequencies or bands from its 'sweeps', and proposes to 'notch out' or not transmit on any of the AFTRCC, AAG or MAG frequencies within the 100kHz to 1GHz range. Section 5 Appendix B of this paper contains a table of the AFTRCC, AAG and MAG frequencies that we will avoid. We can help to ensure that there will be no interference by using guard bands before and after each band of exclusion frequencies or each individual exclusion frequency. A reasonable guard band seems to be 5kHz for frequencies less than 100MHz and 25kHz for frequencies above 100MHz. These guard bands are about a factor of two greater than the AFTRCC requirements. Upon advice from others, we can increase or decrease the size of the guard bands.

In addition, our dwell time at each frequency will be minimal. For example, if a "sweep" of 1601 discrete frequencies takes about 52 seconds, then the dwell time will be 52 seconds/1601 or 32.5 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 and lack of modulation.

Table 3 Example Frequency Bands for CWI Testing and Maximum Number of Frequencies in Each Band (4 Band Case)

Frequency Range		ARA CWI System Maximum Number of Test Frequencies in Each Band	Sweep Time Linear Sweep[1]	Dwell Time per Frequency	Sweep Time Log Sweep[1]	Dwell Time per Frequency
100kHz	1MHz	1601	52 seconds	32.5 ms	52 seconds	32.5 ms
1MHz	10MHz	1601	52 seconds	32.5 ms	52 seconds	32.5 ms
10MHz	100MHz	1601	52 seconds	32.5 ms	52 seconds	32.5 ms
100MHz	1GHz	1601	52 seconds	32.5 ms	52 seconds	32.5 ms
Total Number of Test Frequencies		**6404**				

[1] Measured "sweep" times using Keysight Model E5071C Vector Network Analyzer using 1601 stepped frequency points, 30 Hz IF bandwidth and automatic sweep time (based on IF bandwidth).

Table 4 Example Frequency Bands for CWI Testing and Maximum Number of Frequencies in Each Band (2 Band Case)

Frequency Range		ARA CWI System Maximum Number of Test Frequencies in Each Band	Sweep Time Linear Sweep[1]	Dwell Time per Frequency	Sweep Time Log Sweep[1]	Dwell Time per Frequency
100kHz	30MHz	1601	52 seconds	32.5 ms	52 seconds	32.5 ms
30MHz	1GHz	1601	52 seconds	32.5 ms	52 seconds	32.5 ms
Total Number of Test Frequencies		**3202**				

[1] Measured "sweep" times using Keysight Model E5071C Vector Network Analyzer using 1601 stepped frequency points, 30 Hz IF bandwidth and automatic sweep time (based on IF bandwidth).

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4. APPENDIX A 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.

5. APPENDIX B EXCLUSION FREQUENCIES

AFTRCC, AAG and MAG Exclusion Frequencies		
AFTRCC Individual Frequencies (±2.8kHz required, ±5kHz proposed guard band)		
2.851MHz		
3.004MHz		
3.281MHz		
3.443MHz		
5.451MHz		
5.469MHz		
5.571MHz		
6.550MHz		
8.822MHz		
10.045MHz		
11.288MHz		
11.306MHz		
13.312MHz		
17.964MHz		
21.931MHz		
AFTRCC Frequency Bands (±12.5kHz required, ±25kHz proposed guard band)		
From	**To**	
123.1125MHz	123.2875MHz	
123.3125MHz	123.5875MHz	
MAG Frequency Bands (±25kHz proposed guard band)		
From	**To**	
225.000MHz	328.600MHz	
335.400MHz	399.900MHz	
AAG Frequency Bands (+ 25kHz proposed guard band)		
From	**To**	
190kHz	285kHz	Inclusive
285kHz	435kHz	
510kHz	535kHz	Inclusive
74.800MHz	75.200MHz	
108.000MHz	121.9375MHz	Inclusive
123.5875MHz	128.8125MHz	Inclusive
132.0125MHz	137.000MHz	Inclusive
328.600MHz	335.400MHz	
978MHz	1020MHz	ARA will not transmit above 975MHz