MITRE

TECHNICAL EXHIBIT
AMENDMENT TO PENDING EXPERIMENTAL FCC Special Temporary Authority (STA) APPLICATION
The MITRE Corporation

The MITRE Corporation seeks an FCC Special Temporary Authority License to transmit data within the High Frequency (HF) band between 2.505 MHz and 16 MHz from several locations in Alaska, Massachusetts, and New York from 19 June – 08 September 2017. There are four primary locations from which the test will be executed: 1) Joint Base Elmendorf (JBER), Anchorage AK; 2) Barrow, AK; 3) Bedford, MA; 4) Stockbridge, NY. The JBER primary location has three local sites, only one will be used at any given time/date. Each site will likely be used during the eleven and a half-week test period, just not simultaneously. The Barrow primary site has four local sites, only one of which will be used at any given time/date as with the JBER locations. As with JBER, each of the local Barrow sites may be used, just not simultaneously. Bedford and Stockbridge are each a single location. USNORTHCOM and NLCC/NC3 is conducting a test between these locations and have asked the MITRE team conducting advanced beyond line of sight (BLOS) High Frequency (HF) communications to be part of the test. As such, we will need transmit authority for those 81 days in those locations.

This Exhibit describes the program of research and experimentation proposed, including: description of equipment and theory of operation; the specific objectives sought to be accomplished; and how the program of experimentation has a reasonable promise of contribution to the development, extension, expansion or utilization of the radio art and/or is along lines not already investigated.

Research and Experimentation Program Description

Assured beyond line-of-sight (BLOS) communications is a challenging problem yet essential for our warfighters. Military and civilian systems rely on a combination of high data rate satellite connectivity as well as low data rate HF Sky Wave communications. While satellite communication provides high data rate connectivity, there are vulnerabilities that include degradation and disruption of service. HF radio communication generally are limited to narrower bandwidths and lower data rates than satellite communications. To ensure critical communications are maintained, we are investigating the capability of commercial off-the shelf equipment and their implementation of MIL-STD-188-110C (inclusive of Appendix D Wideband waveforms), MIL-STD-188-141C, and STANAG 4538 FLSU.

Long distance HF communication is accomplished via reflection of HF radio waves off the ionosphere, a variable medium. This introduces challenges that must be overcome to make HF communications more reliable. These include multipath propagation and polarization rotation; both contribute to signal fades.

We will demonstrate reliable BLOS HF communications with both robust voice communications and high data rates; characterize the ionosphere; and deterministically evaluate various frequency selection protocols – VOACAP predictive models, sounding, 2G ALE, and 3G ALE.

Objectives

The goal is to communicate reliably in both the mid-latitudes and Arctic Region; evaluating and the performance of COTS equipment, and the impact of ionospheric channel conditions unique to their geographical locations. Multiple waveforms will be tested; MIL-STD-188-110C (inclusive of Appendix D Wideband waveforms), MIL-STD-188-141C, and STANAG 4538 FLSU.

The research program is planned to include a series of over-the-air (OTA) demonstrations, each testing new waveforms. We will attempt to test the capabilities, trade-offs, and performance of these waveforms over varying channel conditions to evaluate the impact on the sponsor mission space. We will also perform ionospheric sounding for channel characterization and waveform calibration.

The requested frequencies and transmission operational parameters are those permitted under Section 90.266 of the Commission's Rules, *Long Distance Communications on Frequencies below 25 MHz* and are identified specifically in the FCC's Electronic Code of Federal Regulations, Title 47 (Telecommunication), Volume 1, Chapter 1, Part 2.106 Table of Frequency Allocations. These frequencies bands requested are designed to avoid the Restricted Bands of Operation outlines in the Electronic Code of Federal Regulations, Title 47 (Telecommunication), Part 15 (Radio Frequency Devices), Subpart C Intentional Radiators.

Listed in the following Table 1 are the requested proposed technical parameters for the experimental research program.

Crossed Dipole (Signal) Transmit Antenna	
Transmitter Site Locations	**Transmitter Site #1**
	Joint Base Elmendorf, Anchorage AK (National Guard Building)
	61.180316 N, 149.423848 W
	Crossed Dipole Antenna Radiation Center: 5.9 m AGL
	Crossed Dipole (signal) Transmit Antenna Azimuth Orientation: omnidirectional
	Crossed Dipole (signal) Transmit Antenna Vertical Plane Orientation: 90 degrees (120 Deg beamwidth)
	Transmitter Site #2
	Joint Base Elmendorf, Anchorage AK (JBER MRC Location)
	61.256995 N, 149.750704 W
	Antenna Configuration same as Transmitter Site # 1
	Transmitter Site #3
	Joint Base Elmendorf, Anchorage AK (ALCOM J6 Alternate Facility)
	61.247025 N, 149.811503 W
	Antenna Configuration same as Transmitter Site # 1
	Transmitter Site #4
	Barrow , AK (Top of the World Inn)
	71.175100 N, 156.461830 W
	Antenna Configuration same as Transmitter Site # 1
	Transmitter Site #5
	Barrow , AK (High School Football Field)
	71.105458 N, 156.394730 W
	Antenna Configuration same as Transmitter Site # 1
	Transmitter Site #6
	Barrow , AK (East Barrow Location)
	71.200530 N, 156.383467 W
	Antenna Configuration same as Transmitter Site # 1
	Transmitter Site #7
	Barrow , AK (Barrow Airport)
	71.164436 N, 156.471237 W
	Antenna Configuration same as Transmitter Site # 1
	Transmitter Site #8
	Bedford, MA (MITRE Corp)
	42.50361111 N, 71.23638889 W
	Antenna Configuration same as Transmitter Site # 1
	Transmitter Site #9
	Stockbridge, NY (Peterboro Road)
	43.02972222 N, 75.65138889 W
	Antenna Configuration same as Transmitter Site # 1
Requested Frequency ranges (kHz)	2505.0 - 4100.0, 4210.0 - 4650.0, 4700.0 - 4995.0, 5005.0 - 6210.0, 6400.0 - 8250.0, 8970.0 - 9995.0, 10005.0 - 11275.0, 11400.0 - 12200.0, 13500.0 - 14990.0, 15010.0 -
Maximum Transmit Power	200 Watts (average varies between 20 and 200 Watts)
Transmitter	Harris RF-7800H Wideband HF Manpack Radio
Transmitting Antenna	**MITRE-built Crossed-Dipole** (see Figure 1)
	Broadband bow-tie shaped, inverted vee-dipoles with resistive loading
	Small Footprint (< 20 meter diameter)
	Dipoles are arranged orthogonally on mast to produce x-,y- polarizations
Maximum Occupied Bandwidth	24 kHz
Maximum Transmit Time Duration (Duty)	Most of the experiment will be conducted during the daylight hours, some portion may run up to 24 hours. Duty cycle will be up to 100% during the 81 day period.

Table 1. Proposed Experimental Crossed-Dipole Transmission Parameters

The MITRE-developed Crossed-Dipole antenna configuration and dimensions are shown in Figure 1 below.

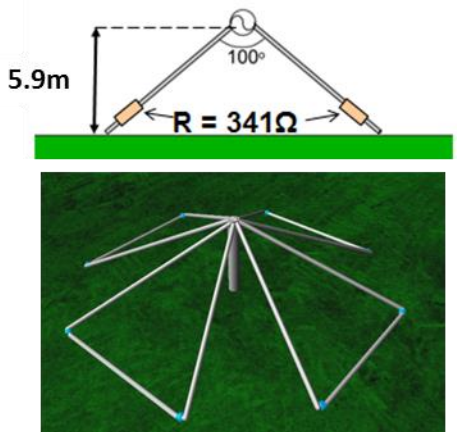

Figure 1. Model Crossed Dipole Antenna (< 20m diameter)

The system supports two orthogonal polarizations: two inverted vee-dipoles (x-, y-polarized). The antenna elements are well matched over 2.505-16 MHz to 50 ohms and offset to avoid mutual coupling effects. The antennas exhibit omnidirectional antenna patterns with an antenna gain of 2 dBi between 2.505 and 16 MHz. The system is simple, low-cost and MITRE-fabricated, -assembled, and –setup.

Crossed Dipole (Signal) Transmit Antenna	
Transmitter Site Locations	**Transmitter Site #1**
	Joint Base Elmendorf, Anchorage AK (National Guard Building)
	61.180316 N, 149.423848 W
	Crossed Dipole Antenna Radiation Center: 5.5 m AGL
	Crossed Dipole (signal) Transmit Antenna Azimuth Orientation: omnidirectional
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	Transmitter Site #2
	Joint Base Elmendorf, Anchorage AK (JBER MRC Location)
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Maximum Transmit Power	200 Watts (average varies between 20 and 200 Watts)
Transmitter	Harris RF-7800H Wideband HF Manpack Radio
Transmitting Antenna	**Wideband HF Antenna** (see Figure 1)
Maximum Occupied Bandwidth	24 kHz
Maximum Transmit Time Duration (Duty)	Most of the experiment will be conducted during the daylight hours, some portion may run up to 24 hours. Duty cycle will be up to 100% during the 81 day period.

Table 2. White Wolf Systems Crossed-Dipole Transmission Parameters

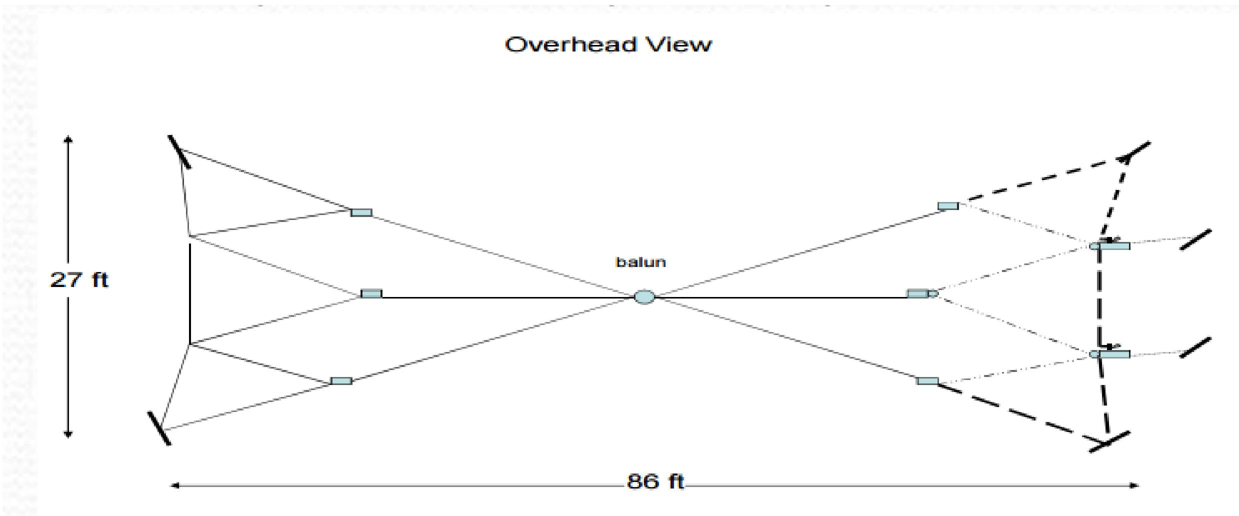

Figure 2. White Wolf Systems Antenna Overhead View

Some of the equipment was purchased from commercial vendors. Table 2 shows a list of the commercially purchased equipment that will be used during the experiment(s).

Table 2. Commercially purchased transmission equipment list.

Transmitting Equipment			
Manufacturer	**Model Number**	**No. of Units**	**Experimental (Y/N)**
Harris	RF-7800H	2 (Rotated between sites)	N
Harris	RF-5832H	2 (Rotated between sites)	N

Research and Experimentation Contribution to the Development of the Radio Art

Assured beyond line-of-sight communications is a challenging problem yet essential for certain types of communication. Fortunately, HF technology is uniquely suited to address this problem, applying new techniques and understanding of the ionosphere. With HF, BLOS communications is achievable without the use of satellites or pseudo-lites. The traditionally low data rates can be improved upon as well. In today's economic climate, HF is very affordable, with a well-established commercial market.

MITRE's work will demonstrate the performance of multiple waveforms, record ionospheric conditions

If there are any technical questions with the proposed application, please contact one of the undersigned.

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