Technical Exhibit
Special Temporary Authority Application
Virginia Tech Eclipse Experiment

The electrical engineering department at Virginia Tech is seeking an FCC experimental license to perform fundamental ionospheric research that will require transmitting low-power pulses within a carrier frequency band spanning 2-25 MHz (excluding prohibited bands, e.g., standard frequency and timing signal). This exhibit describes the experimental program objectives, as well as the methods and instrumentation to be used. The research project for which this license is sought has been funded by the National Science Foundation under grant number AGS-1552188.

Project Description

The experiment involves fundamental ionospheric research related to the total solar eclipse that will be visible over most of the United States on 21 August 2017. The total duration over which eclipse effects on the ionosphere will be measureable over the USA is approximately two hours, spanning the midday range from 16:00-18:00 UT. The ionosphere is a variable medium that exerts strong control over radio propagation in the high-frequency (HF) band, so data and vertical soundings obtained in this band are useful for characterizing temporal changes in the medium during the eclipse. Findings from the study are relevant to HF communications reliability, and to space-weather effects in the ionosphere at mid-latitudes. Results from the experiment will be published in the refereed scientific literature.

Facilities and Specific Operational Information

Table 1 shows the locations of the HF transceivers to be deployed for the experiment, and for prior testing at the Blacksburg, VA site. Throughout the eclipse interval we will operate these stations so that they periodically measure vertical-incidence backscatter from the ionosphere over the frequency range of interest. For one week prior to the eclipse date we will operate the sites in the same way over the same time period (midday) in order to obtain baseline data for later comparison.

Table 1 *– Transceiver field station data (note "AFB" = Air Force Base).*

Site ID	Location	Antenna	Power	Usage Note
OR	Bend 44.362° N 121.560° W	Crossed Dipole (< 30 m dia.)	<100 W Non-interference basis	Site operational only between 14-23 August, 2017.
KS	Holton 39.474° N 95.771° W	Crossed Dipole (< 30 m dia.)	<100 W Non-interference basis	Site operational only between 14-23 August, 2017.
SC	Shaw AFB 33.833° N 80.488° W	Crossed Dipole (< 30 m dia.)	<100 W Non-interference basis	Site operational only between 14-23 August, 2017.

The sites will operate only in the 14-23 August period in 2017, coincident with the eclipse event, and prior to it by ~1 week. All field sites listed in the table will utilize lower

power pulsed transmissions coded to minimize interference with other radio sources. All sites will be operated on a non-interference basis.

The transceivers will be computer controlled, but a licensed amateur radio operator will monitor the operations and data flow at each field site to assure compliance with all federal and local regulations. The antennas and transceivers will be identical at each location in order to ensure that the performance of each field site will be as similar as possible. Aside from the VA location the transceivers will be set up approximately one week prior to the eclipse. They will be tested periodically during the week, and will run continuously during the eclipse and for about 12 hours after it ends. This will provide baseline data for comparison with existing models, as well as independent datasets that can be compared to each other.

Applicable Regulations

The requested frequencies and operational transmission parameters are those permitted under Section 90.266 of the FCC rules: Long Distance Communications on Frequencies below 25 MHz. The permitted operational parameters 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. The frequency bands requested are designed to avoid the Restricted Bands of Operation stipulations described in the Electronic Code of Federal Regulations, Title 47 (Telecommunications), Part 15 (Radio Frequency Devices), Subpart C (Intentional Radiators).

Antenna and Transceiver Specifications

Table 2 lists the specific parameters of our antenna and transceiver systems.

Table 2

System or Parameter	Specifications and Relevant Parameters
Transceiver (Tx)	Ettus USRP N210 Software Defined Radio (SDR) Red Pitaya SDR System FlexRadio 6500 (SDR)
Requested Frequency Range	2-25 MHz carrier with 600 kHz modulation bandwidth, operated on a non-interference basis
Maximum Tx Power	100 W maximum – systems will be operated at the lowest power level possible to ensure adequate signal to noise ratios.
Maximum Bandwidth	100 kHz modulation on short carrier wave pulses
Maximum Transmit Duration (duty cycle)	Testing Phase: Intermittent at 100%, Effective duty cycle < 10% During Eclipse: 100% over 5 hour interval centered on eclipse
Emission Description	500 μs fixed frequency pulses at 250 Hz pulse repetition frequency
Transmitting Antenna	MITRE-developed Crossed Dipole (inverted-V dipoles with resistive loading)

The inverted V dipole is comprised of two sets of wires arranged in a triangular shape to form a classical bow-tie antenna, as shown in Figures 1-3. This triangle provides more radiating surface area which increases the radiation resistance, allowing for easier impedance matching. It increases the bandwidth as compared to a simple straight wire dipole. Each inverted V dipole provides horizontal polarization, and the two dipoles are orthogonal to each other.

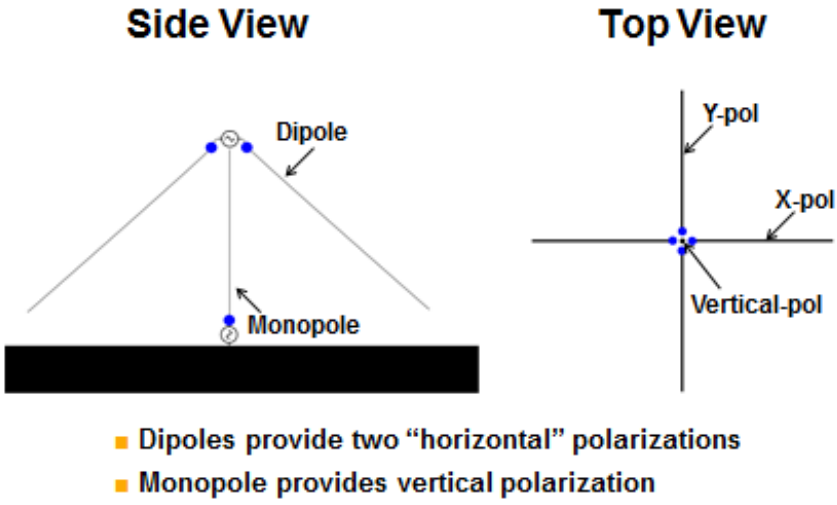

Figure 1 – Side view (left) and top view (right) of the interted-V antenna elements.

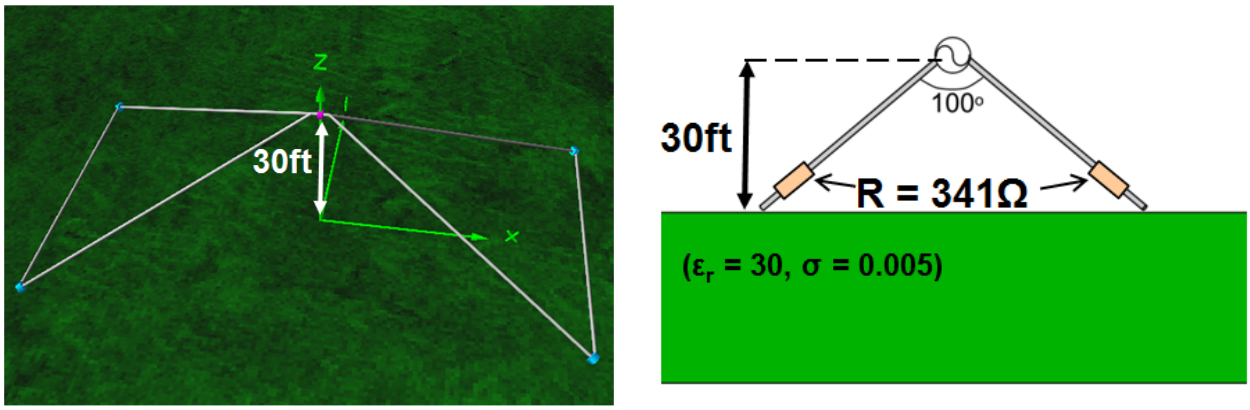

Figure 2 – Model rendering of the inverted-V dipole mounted on a 30-foot vertical center mast (left). The right panel shows the location and size of the in-line resistive loads, which improve the impedance matching over the low frequency side of our operating range.

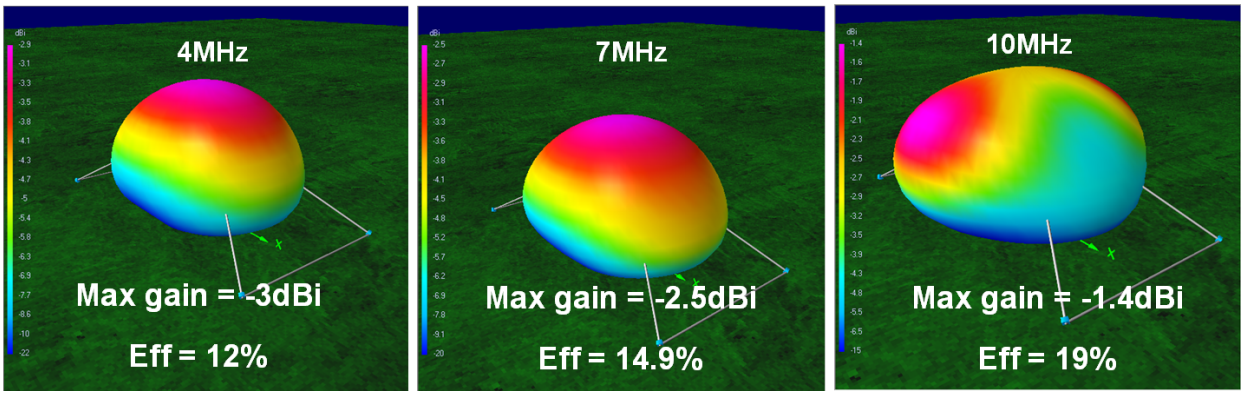

Figure 3 - Radiation patterns of the inverted-V bow-tie dipole at f = 4, 7, and 10MHz, showing the maximum gain and radiation efficiency values at each frequency.

Contact Information

The principal points of contact for the research project for which we seek licensing may be contacted at any time for questions relating to this license application.

Professor Gregory D. Earle
Virginia Tech – Space Sytems Bldg.
1901 Innovation Drive
Blacksburg, VA 24061

earle@vt.edu
Cell: 972-809-6479
Office: 540-231-2294

Lee Kordella
Virginia Tech – Space Systems Bldg.
1901 Innovation Drive
Blacksburg, VA 24061

lee8@vt.edu
Cell: 703-477-2306