Atmospheric and Space Technology Research Associates
Experimental STA Application
File Number: 2135-EX-ST-2024

Explanation of Experiment

Atmospheric and Space Technology Research Associates d/b/a Orion Space Solutions ("Orion") is filing this application to request authorization for the testing and demonstration of HF radio transmitters, centered at Wallops Island, VA, as part of an HF Doppler sounder system to measure traveling ionospheric disturbances (TIDs) in the F-region of the ionosphere. This technology is of significant interest to the Missile Defense Agency because it would allow MDA to understand the impacts of human made activities on the ionosphere.

Need for an STA

The Missile Defense Agency has requested a demonstration of this technology in January 2025. Orion is seeking an STA to install and test the TIDs system starting on January 6, 2025, so that it is prepared for the demonstrations required by the DoD customer later in January and beyond.

Technical Synopsis

Spectrum Needed: 4.442995-4.443025 MHz
4.646995-4.647025 MHz
6.768995-6.769025 MHz
6.992995-6.993025 MHz
Emission designator: 30H0N0N
Output Power and ERP: 30 W, ERP: 50 W
Federal Contract #: W9124-P-19-9-0001

Description of Operations

TIDs are wave-like corrugations in the ionosphere that propagate from various sources including the aurora (northern lights), thunderstorms, and even ocean waves. The TID Detector Built in Texas (TIDDBIT) sounder system provides crucial measurements of TIDs. Orion's TIDDBIT sounder is able to map the TIDs as they propagate, as depicted in Figure 1 below.

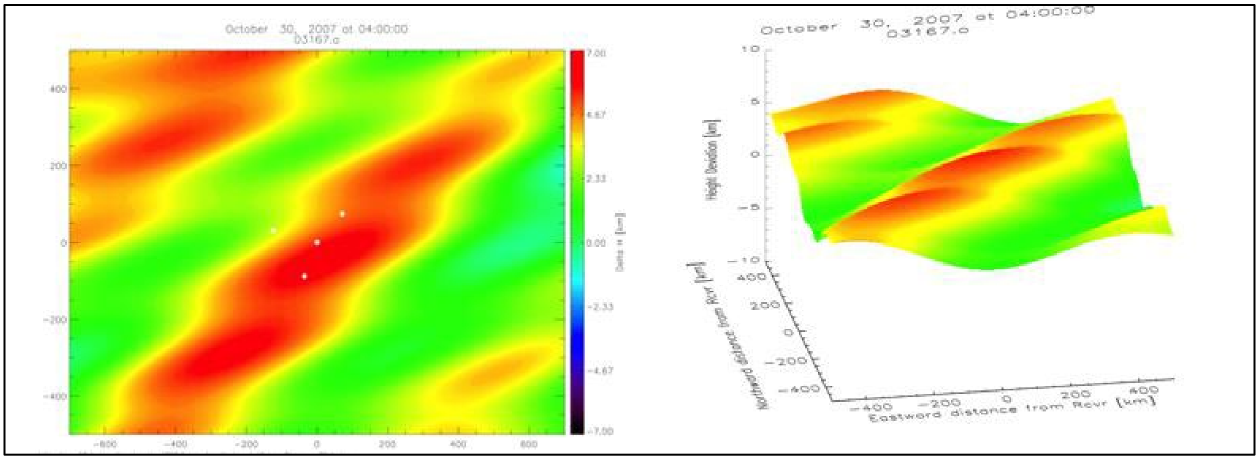

Figure 1. Reconstruction of isoionic contours perturbed by various TID components measured by the TIDDBIT TID Mapping System. Color scale represents height perturbation from – 7km to + 7 km. Left panel: horizontal distribution centered on TIDDBIT array (white dots) and extrapolated out to several hundred kilometers. Right panel: 3-D representation of left panel. Consecutive frames can be viewed as a movie showing TIDs propagating with time.

Previously, Orion deployed and tested the radar in San Antonio, TX (at higher frequencies in the HF band), and also at Wallops Island, VA (at lower frequencies in the HF band). It worked reliably and collected good data. The radar was interfaced with a data-logging computer, and a real-time display capability was developed and tested. Web-access to the real time displays was also developed. Those earlier operations have prompted DoD to request additional demonstrations around the Wallops Island area from a series of transmitters that will show the customer how the system can perform to address some new challenges.

Brief Description of the Radar:

One of the most sensitive methods for detecting transient changes in the ionosphere is the HF Doppler sounder technique (Georges, 1967). A simple Doppler system consists of a continuous wave (CW) radio transmitter and receiver, which are highly frequency-stable (1 part in 10^7), together with some kind of recording device (e.g., Crowley, 1985). The CW signals are typically transmitted in the HF band between 2-10 MHz. When a HF radio wave is reflected from the ionosphere, movement of the reflection point during the passage of a TID produces a change in phase path and a Doppler shift proportional to the time rate of change of the phase path. Although the frequency shift is small (typically 1 part in 10^7), it can easily be measured by comparison with a standard reference oscillator. A sensitive communications receiver with a narrow bandwidth (~100 Hz) receives the sky-wave signal at a site about 50-100 km from the transmitter and down-converts the signal to a frequency of several Hertz. The Doppler shift of the received signal is thus measured from variations of the receiver output frequency. If three transmitters are used, the spatially separated propagation paths can be monitored, and the time difference between the wave signatures from the three reflection points yields the speed and direction of the TIDs by triangulation.

Transmitter:

Each of the HF transmitter systems consists of a signal generator feeding a CW signal into a HF amplifier. The amplifier output then feeds a simple dipole antenna, which is installed in an inverted-

V configuration. Thus, the major lobe of the antenna radiation pattern is in the vertical direction. Because we need to recognize the three transmitted signals at the receiver, frequency offsets of 10 and 20 Hz are applied in two of the transmitted CW signal frequencies. For illustrative purposes, we explain using simpler frequencies than those requested in this application: if one transmitter operates at a frequency of 4.64 MHz, the second would operate at 4.640010 MHz, and the third would operate at 4.640020 MHz.

The technical details include Antenna Height is less than 6 meters. RF output power at the transmitter terminals is 30 Watts. Mean Max Effective Radiated Power is ~50 Watts. FCC Emission type is N0N. The transmitted signal only occupies 30 Hz of spectrum.

Receiver:

The receiver system consists of 4 Ten-Tec 331 receivers. The radar will operate on two frequencies, and both O- and X-modes will be differentiated, so four distinct channels will be analyzed in the system. The baseband audio (with BFO of 1 kHz) outputs from the receivers into an 8-channel A/D converter (only 4 channels are used) and is processed on a PC. The processed data is logged on a large hard drive for Doppler-data processing. The antenna feeding the receivers is a crossed inverted V dipole (less than 6 m tall) with a quadrature hybrid to separate O- and X-mode components. A highly stable 10 MHz oscillator is used to stabilize the receiver system.

A typical data set is shown in Figure 2, which shows the Doppler shifts caused by well-correlated TIDs perturbing the radio reflection points on three different transmission paths at different times for October 15th, 2006. Time delays between the perturbations on different Doppler paths have traditionally been estimated by the cross-correlation technique, however Orion developed a cross-spectral analysis technique, which has the advantage of separately examining the time (i.e., phase) component of a signal (Crowley et al. 1984; Crowley 1985).

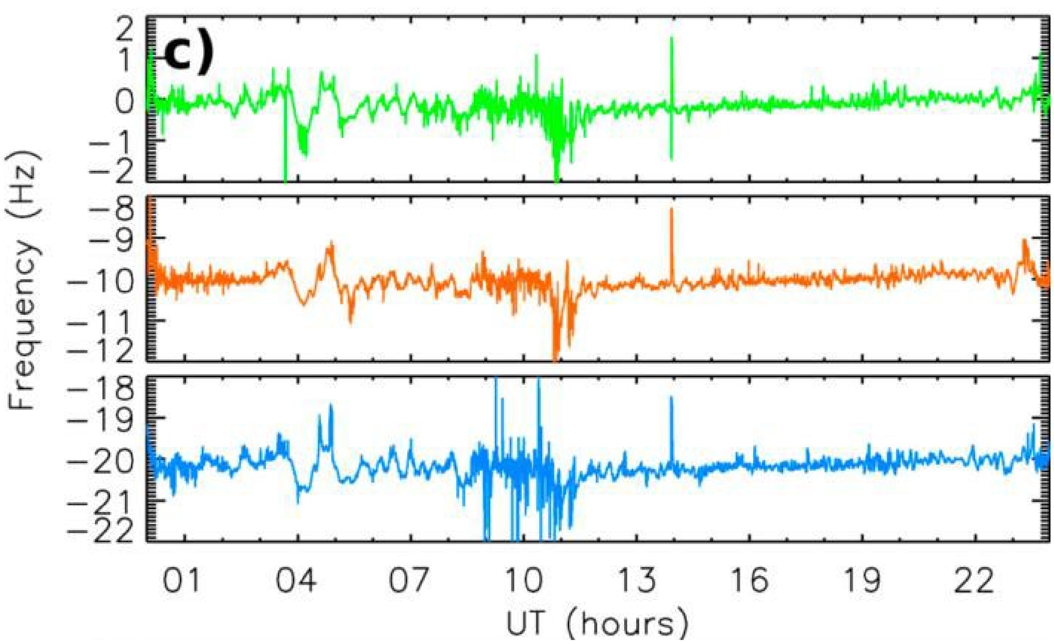

Figure 2: TIDs measured by TIDDBIT system on three propagation paths.

Transmitter Sites:

The three transmitters will be installed at sites within a 90-mile radius of Wallops Island, Virginia. Figure 3 below shows the radius of operations where the transmitters will be installed around the center point where the receiving station will be installed at Wallops Island, Virginia. Because this system requires triangulation, there must be three transmitters installed.

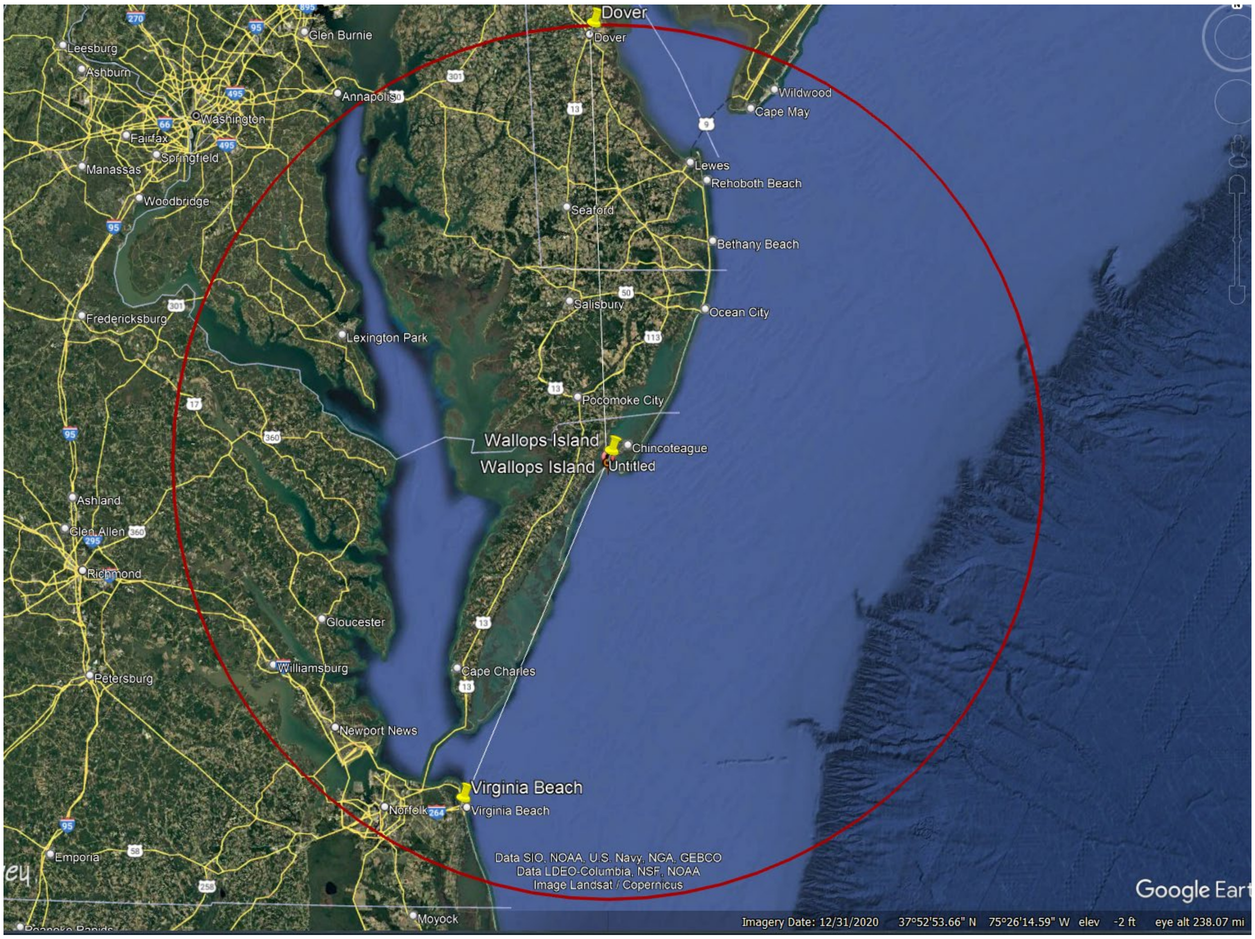

Figure 3: The red circle represents a 90-mile radius from the receiver, which will be positioned at Wallops Island.

The three transmitters will all be positioned within the yellow shaded area in Figure 4, below. The planned demonstration will require that the transmitters be moved occasionally within yellow shaded area below to better illustrate the operations of the system, which is why the application requests mobile operations. The transmitters will not be mobile while in use, but they may be moved from site to site within the proposed area.

The demonstration will require ASTRA to move its transmitters within the proposed area, to demonstrate various performance characteristics of the technology. The southern most point where a transmitter might be installed is in Virginia Beach, VA, and the northern most point is in Dover, Delaware.

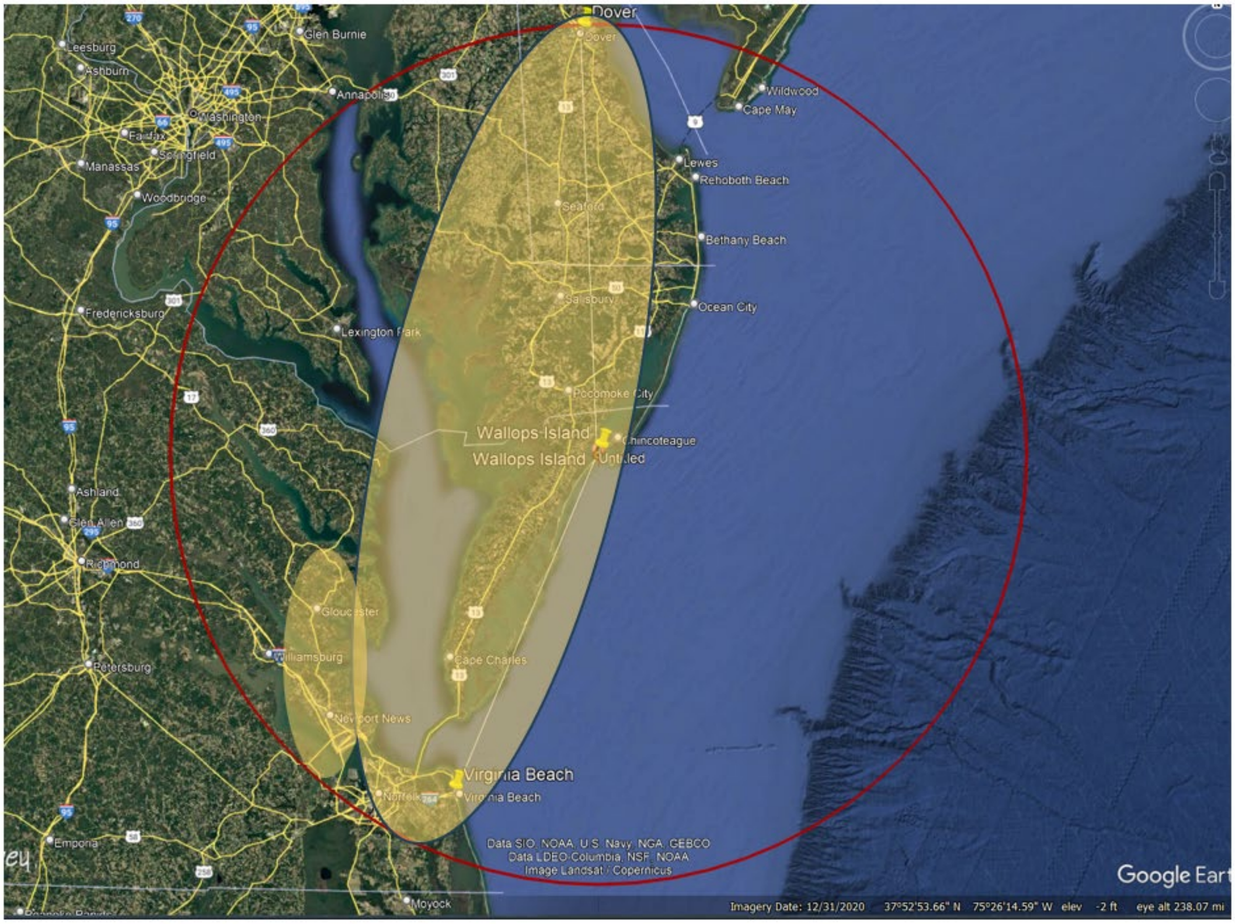

Figure 4. Shaded area shows limits of where the three transmitters might be installed.

Frequency Selection:

In selecting the frequencies used for these operations, Orion used the International Reference Ionosphere (IRI) model to predict the ionospheric conditions. The operations use two frequencies that reflect off the ionosphere at an altitude greater than 150 km, and Orion has used the altitude separation between these two frequencies, greater than 20 km, to obtain vertical wave information.

Given that the ionosphere changes significantly throughout the day and with month of the year, Orion focused on 2 frequencies that gave the greatest amount of time to provide useful scientific data over the course of the demonstration period.

<u>Stop Buzzer POC</u>

Dan Knight, Vice President
Phone: 307-214-7107
dan.knight2@arcfield.com

Conclusion

Orion is requesting authorization for testing and demonstration of a technology that measures traveling ionospheric disturbances in support of its US DoD customers.

If there are any questions about this application, please contact Anne Cortez, Esq. Counsel to Orion, anne@washingtonfederalstrategies.com or 520-360-0925. Thank you.