ATMOSPHERIC & SPACE TECHNOLOGY

RESEARCH ASSOCIATES, LLC

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EIN: 20-2946717 DUNS# 60-1975803

Re: Application for New or Modified Station (Form 442),
QUESTION 6: STATEMENT OF RESEARCH PROJECT

FCC Registration Number (FRN): 0015091481

To Whom It May Concern:

This letter is written in support of an application being submitted to the FCC, and provides a brief narrative describing the statement of research.

The request is to operate one HF radio transmitter in Boulder, CO, to support HF Doppler sounder systems measuring traveling ionospheric disturbances (TIDs) in the F-region of the ionosphere in Florida and Hawaii. 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 systems provide crucial measurements of TIDs. ASTRA's TIDDBIT sounder is able to map the TIDs as they propagate, as depicted in Figure 1 below.

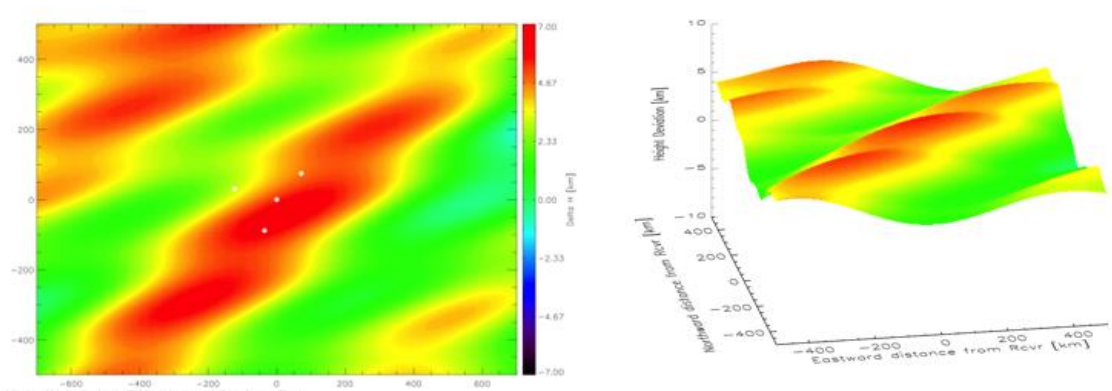

Figure 1. Reconstruction of isoionic contours perturbed by various TID components measured by the TIDDBIT TID Mapping System. Color scale represents height perturbation from – 7km to + 7 km. Left panel: horizontal distribution centered on TIDDBIT array (white dots) and extrapolated out to several hundred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

Currently, we have similar transmitters set up in Florida and Hawaii, under FCC Licenses 0388-EX-PL-2015 and 0394-EX-PL-2015, respectively. There are three transmitters at each project site and one receiver that form a TIDDBIT system.

The TIDDBIT systems in Florida and Hawaii developed by ASTRA support both the Air Force and Navy projects related to measuring and monitoring TIDs. The Florida TIDDBIT system supports the operation of an Over The Horizon Radar (OTHR) in the Virginia area. The reflection point of the OTHR is directly above Florida, and the TIDDBIT system serves to monitor TIDs that can alter the reflection point, thus seriously degrading the operation and performance of the OTHR. The Hawaii TIDDBIT system is part of a Navy sponsored research program to monitor TIDs that may be coupled to ocean waves caused by tsunamis. These crucial measurements of TIDs will lead to a better understanding of the link between tsunamis and TIDs, and may lead to improved tsunami detection and warning techniques.

The proposed license would support these projects by setting up a transmitter locally in our office in order to improve the remote systems, and we would test various transmitter components: signal generators, amplifiers, and tuners.

We request permission to operate the experimental TIDDBIT transmitter in Boulder starting December 1st, 2015 (or sooner), and will run for approximately 1 year. This allows us to coordinate and improve with the TIDDBIT systems operating in Florida and Hawaii.

We have deployed and tested the system in Gainesville, FL, Mauna Loa, HI, San Antonio, TX (at higher frequencies in the HF band), and also at Wallops Island, VA (at lower frequencies in the HF band). It has 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. This has been a major development over our previous systems. It was required to enable operations and monitoring from a remote location. It also allows a certain amount of ability to remotely modify and restart the system in the event of software errors. The Web-access and real-time displays have allowed us to recurrently notice and correct problems within hours of their occurrence, rather than the several days or weeks in the past.

Brief Description of the TIDDBIT radar system:

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 three 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. Thus, if one transmitter operates at a frequency of 4.62 MHz, the second would operate at 4.620010 MHz, and the third would operate at 4.620020 MHz.

Antenna Height is less than 6 meters.
RF output power at the transmitter terminals is 50 Watts.
Mean Max Effective Radiated Power is ~82 Watts.
FCC Emission type is N0N.

Necessary Bandwidth: the transmitted signal only occupies at most 35 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 we 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).

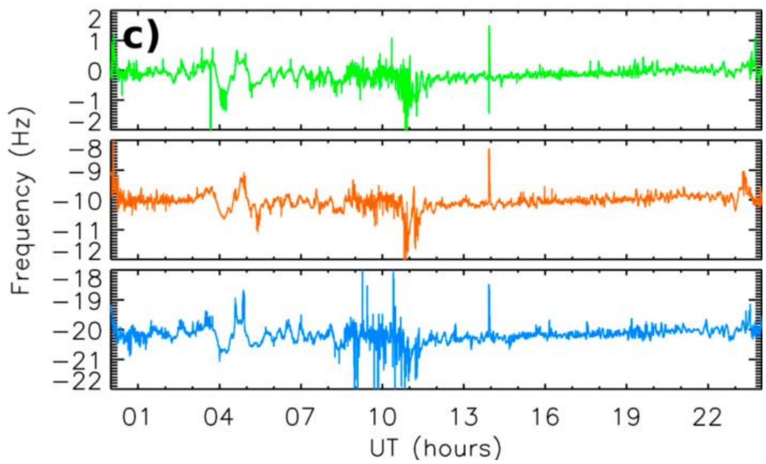

Figure 2: TIDs measured by TIDDBIT system on three propagation paths.

Rationale for Transmitter Site Selection:

Currently, we have similar transmitters set up in Florida and Hawaii, under FCC Licenses 0388-EX-PL-2015 and 0394-EX-PL-2015, respectively. There are three transmitters at each project site.

We would like to set up a transmitter at our Boulder, CO, office to test various transmitter components in order to improve the transmitters currently set up in Florida and Hawaii. The tests would include experimentation with signal generators, amplifiers, and tuners. The effective radiated power would not exceed 82 W.

Rationale for Frequency Selection:

We have used the International Reference Ionosphere (IRI) model to predict the ionospheric conditions near Boulder, CO, during the coming year. Ideally, we would like to use two frequencies that reflect off the ionosphere at an altitude greater than 150 km, and we would like the altitude separation between these two frequencies to be greater than 20 km (in order to obtain vertical wave information).

Given that the ionosphere changes significantly throughout the day and with month of the year, we would like to pick 2 frequencies that give us the greatest amount of time to provide useful scientific data over the course of a year. We have conducted a trade study to determine the optimal frequencies, and this information is summarized in Figure 3.

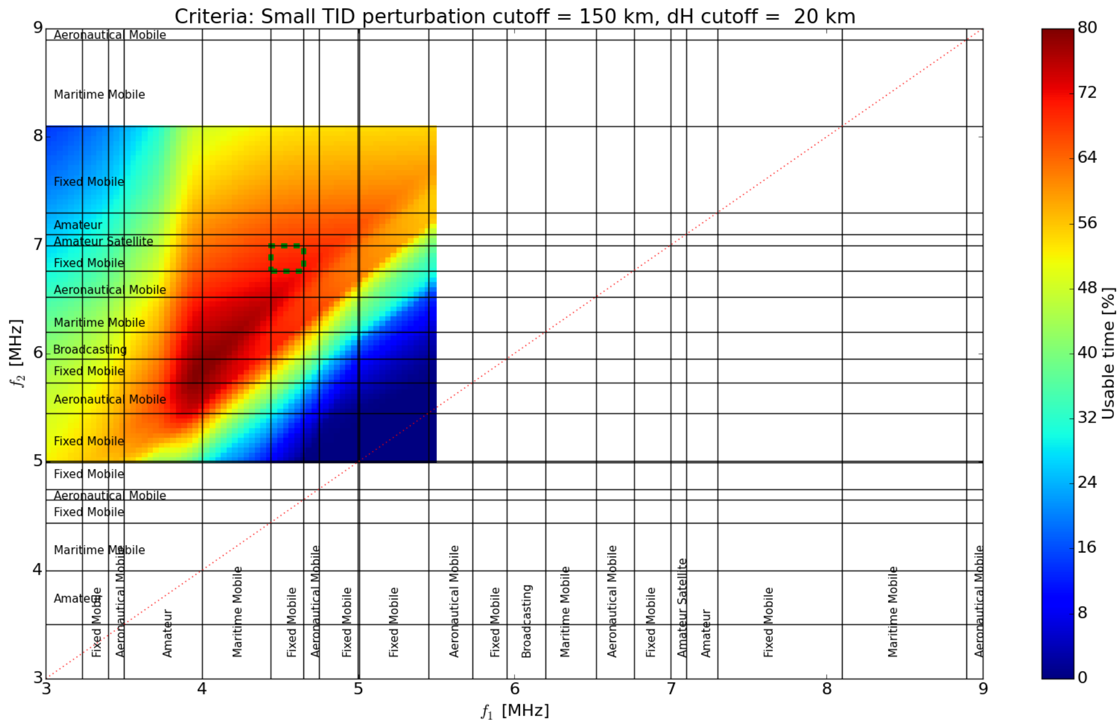

Figure 3: Optimization analysis for frequency selection. The color represents the percent of time that the two frequencies can provide robust scientific data for the duration of the experiment. The green dashed box shows the requested frequencies from two bands in Fixed Mobile.

In this figure, the first selected frequency is on the x-axis, and the second selected frequency is shown on the y-axis. Each axis is also labeled with the relevant primary user group. The color represents the percent of usable time that we would obtain useful TID information on both frequencies, and ideally we would like this to be 100%. Unfortunately, the maximum value in the graph is 80%, and it falls in a range of frequencies set aside for Maritime Mobile and Broadcasting, which are therefore not available for our use.

For the proposed experiment, we request permission to operate at frequencies in the Fixed Mobile bands, and here we see a maximum of ~70% for f_1 between 4.438 and 4.650 MHz, and for f_2 between 6.765 and 7.000 MHz (green dashed box in Figure 4). Therefore we are requesting permission to transmit at frequencies within these two bands:

Fixed Mobile: 4.443 MHz
Fixed Mobile: 4.647 MHz
Fixed Mobile: 6.769 MHz
Fixed Mobile: 6.993 MHz

Also, we would like to use similar frequencies to mimic our HF sounder systems in Florida and Hawaii.

Please contact Dr. Geoff Crowley at ASTRA with any additional questions.

Your help in approving this application would be much appreciated.

Sincerely,

Dr. Geoff Crowley
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