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. A second accompanying letter describes the government contract affected by the project.

The request is to operate three HF radio transmitters in the Gainesville, FL area, as part of an HF Doppler sounder system to measure traveling ionospheric disturbances (TIDs) in the F-region of the ionosphere. TIDs are wave-like corrugations in the ionosphere that propagate from various sources including the aurora (northern lights), thunderstorms, and even ocean waves.

The proposed TID Detector Built in Texas (TIDDBIT) sounder system will provide crucial measurements of TIDs. ASTRA's TIDDBIT sounder is able to map the TIDs as they propagate, as depicted in Figure 1 below.

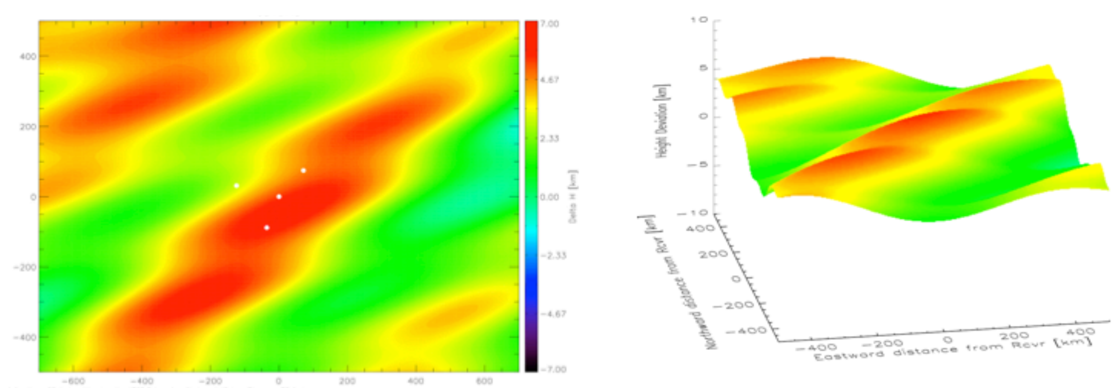

Figure 1. Reconstruction of isoionic contours perturbed by various TID components measured by the TIDDBIT TID Mapping System. Color scale represents height perturbation from – 7km to + 7 km. Left panel: horizontal distribution centered on TIDDBIT array (white dots) and extrapolated out to several hundred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

The proposed TIDDBIT operation will support the US Air Force in conducting Over the Horizon Radar (OTHR) measurements, detailed in the accompanying letter. It is crucial that the transmitters measuring TIDs be in the Gainesville region in order to accurately characterize TIDs that may affect the OTHR measurements conducted by the Air Force, and it will aid the Air Force to generate corrections for their OTHR system.

We request permission to operate the TIDDBIT sounder starting August 1st, 2015 (or sooner), and will run for approximately 1 year. This allows us to coordinate with the Air Force to detect TIDs during the operation of the OTHR, and to establish baseline climatologies in the Gainesville region.

We have 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 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. The complete system is ready for deployment in the Gainesville region, as early as possible.

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 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 100 Watts.
Mean Max Effective Radiated Power is ~100 Watts.
FCC Emission type is N0N.

Necessary Bandwidth: the transmitted signal only occupies 20 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).

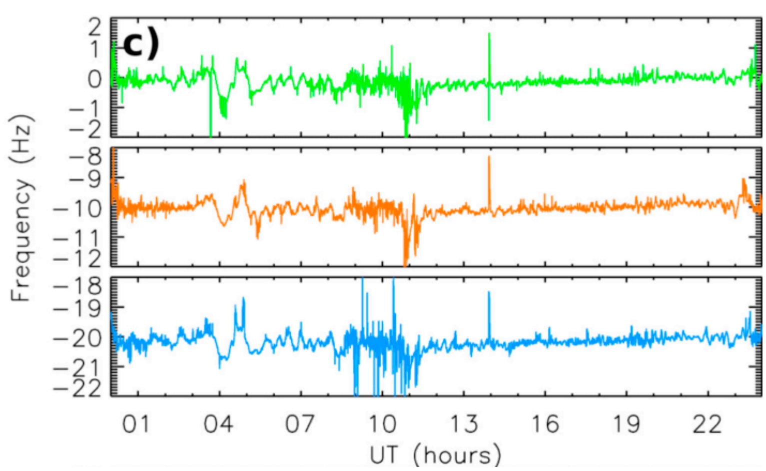

Figure 2: TIDs measured by TIDDBIT system on three propagation paths.

Rationale for Transmitter Site Selection:

For this project, we are coordinating with the US Air Force while they are making OTHR measurements. An OTHR operates by using the ionosphere as a reflection, or mirror, for the signal to propagate large distances. TIDs introduce errors into OTHR measurements, and therefore it is crucial for the irregularities to be measured and characterized.

During the proposed study, the ionospheric reflection point for the OTHR is directly above the Gainesville, FL, area. Therefore, it is necessary that the TIDDBIT transmitters be within this region in order to accurately characterize TIDs that may affect the OTHR measurements conducted by the Air Force. A map of the proposed sites are listed in Figure 3.

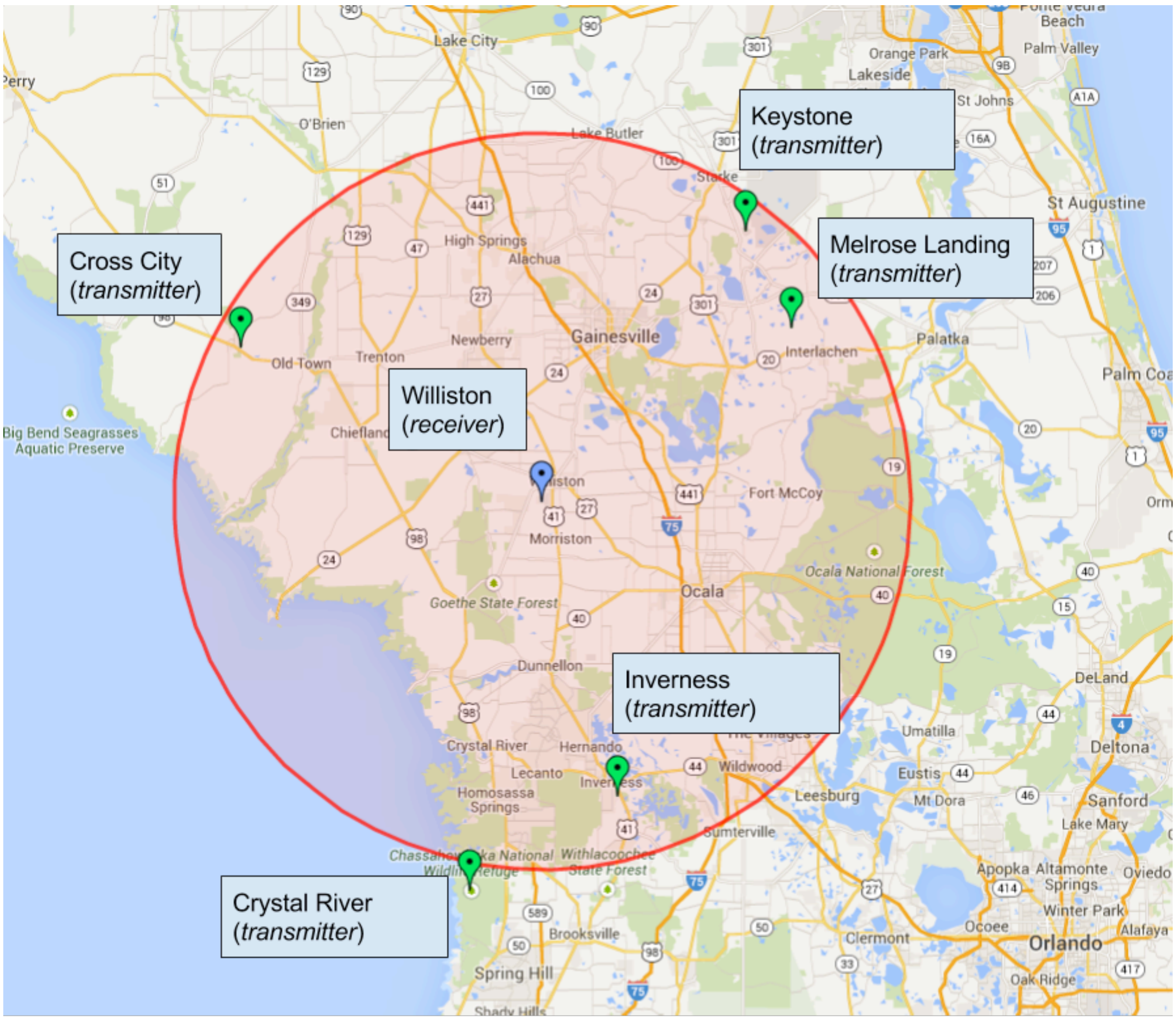

Figure 3: Proposed transmitter locations (green pins) and the receiver station (blue pin). The red circle represents a 75 km radius fom the receiver, which is suitable for the TIDDBIT system.

Rationale for Frequency Selection:
We have used the International Reference Ionosphere (IRI) model to predict the ionospheric conditions for Gainesville, FL, 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 4.

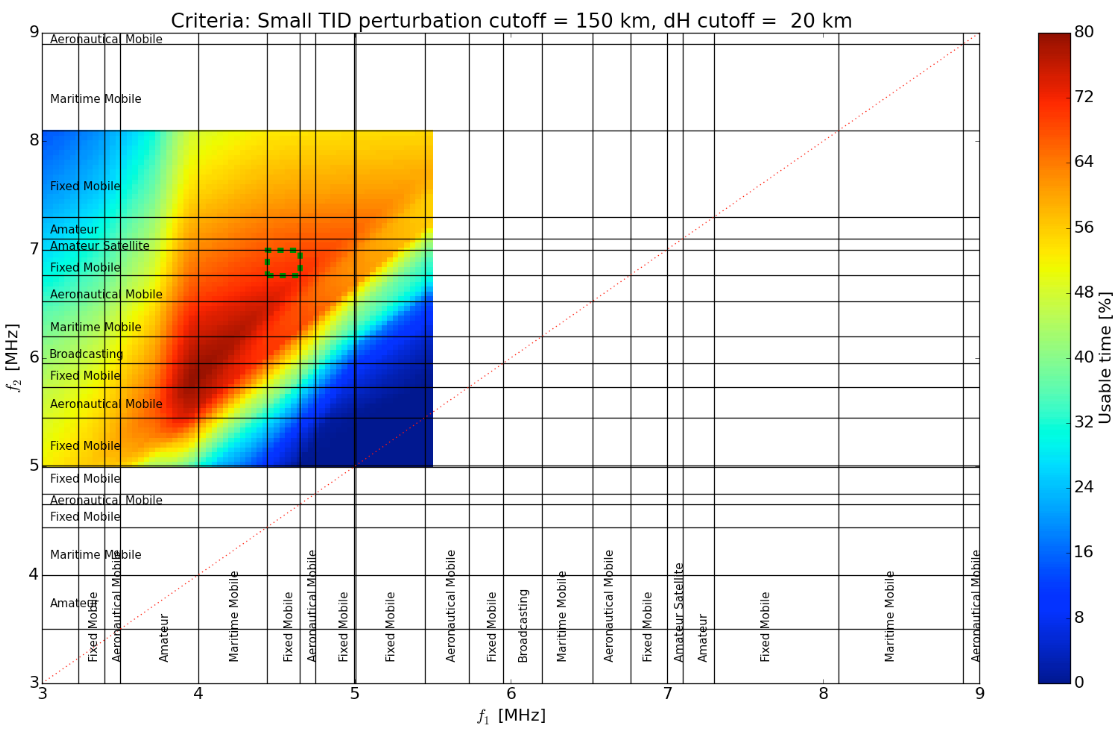

Figure 4: Optimization analysis for frequency selection. The color represents the percent of time that the two frequencies can provide robust scientific data for the duration of the experiment. The green dashed box shows the requested frequencies from two bands in Fixed Mobile.

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 Gainsville 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

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

The Air Force contract monitor for the TIDDBIT sounder is Dr. Jonah Colman, who is based at:
The Air Force Research Laboratory,
Kirtland AFB,
Albuquerque, NM
tel: 505-846-3172
Your help in approving this application would be much appreciated.

Sincerely,

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