Atmospheric and Space Technology Research Associates
d/b/a Orion Space Solutions
Experimental License Application
File Number: 0524-EX-CN-2026

Explanation of Experiment

Atmospheric and Space Technology Research Associates d/b/a Orion Space Solutions ("Orion") is filing this application to request ongoing authorization for the testing and demonstration of HF radio transmitters, which was originally granted under experimental STA WA9XDR. The system is a 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 allows MDA to understand the impacts of human made activities on the ionosphere. The test locations have been selected to allow Orion to further develop the technology at its offices in Colorado and also to have a testbed available for customer demonstrations.

The Missile Defense Agency has requested ongoing development of this technology so Orion is seeking a conventional experimental license to continue the operations.

Technical Synopsis

Spectrum Needed:	3.1-3.2 MHz
	4.4-4.5 MHz
	5.2-5.3 MHz
	6.6-6.7 MHz
Emission designator:	100KF3N
Output Power and ERP:	20 W, ERP: 33 W
Federal Contract #:	W9124-P-19-9-0001

Description of Operations

This application seeks authorization for the Orion Space TRIDENT ionospheric mapping system. The TRIDENT system needs to be tested and demonstrated to further its development as it is a more advanced system than the first generation system for TID detection. The results of this testing will be used for further product development and to develop data that is essential for national defense. The TRIDENT system is the latest generation of a system that was designed based on technology used for decades to detect and measure TIDs.

TIDs are wave-like corrugations in the ionosphere that propagate from various sources including the aurora (northern lights), thunderstorms, and even ocean waves. The first generation effort for TID detection was 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.

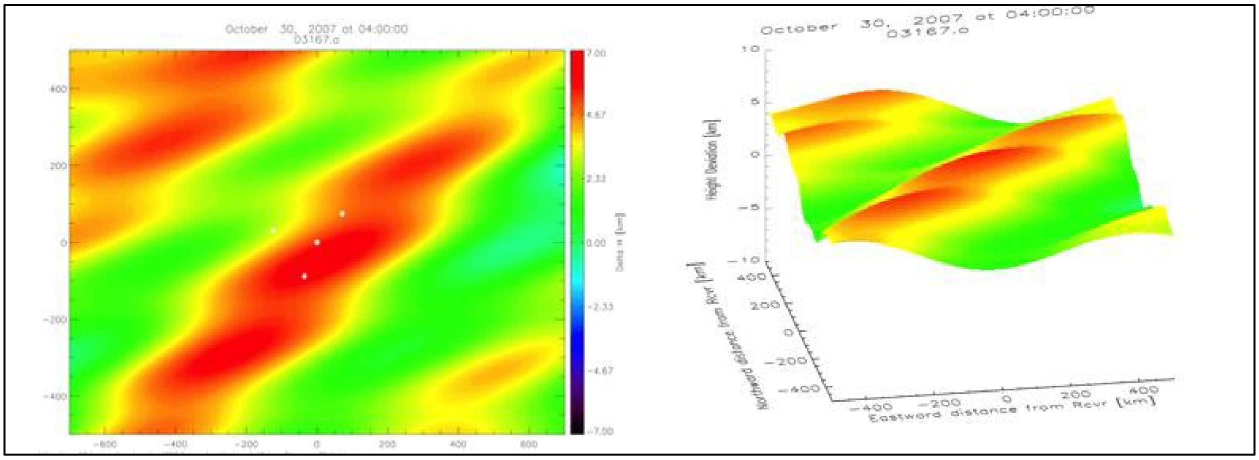

Figure 1. Reconstruction of isoionic contours perturbed by various TID components measured by the TIDDBIT TID Mapping System. Color scale represents height perturbation from – 7km to + 7 km. Left panel: horizontal distribution centered on TIDDBIT array (white dots) and extrapolated out to several hundred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

The radio signals are bounced off the bottom of the ionosphere, with the return signals showing height and activity in the perturbations in the atmosphere. The data is in the differing reflections that come from the different frequencies.

Previously, Orion deployed and tested an earlier version of this system in Central Florida (at 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 with greater capabilities.

Brief Description of the Detector:

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.

The newer versions of this system use 100 kHz of spectrum at each of four different frequencies to provide more detailed results. The system is installed and turned on. Each chirp is brief.

Transmitter:

The transmitter system consists of 2 transmitters at different locations. Each transmitter consists of a direct-sampling arbitrary waveform generator, which generates time-synchronized 100 kHz bandwidth FMCW chirps at two HF frequencies simultaneously. This output is fed into an HF power amplifier, which then feeds a broadband HF antenna. The antenna is designed such that the major lobe of the radiation pattern is in the vertical direction. One transmitter location is configured to generate up-chirps while the other location generates down-chirps, to allow their signals to be differentiated at the receiver. A GPS receiver is used to discipline the local oscillator that runs the HF transmitter channel, as well as to synchronize the start time of the chirps.

The technical details include: Antenna Height is less than 6 meters. RF output power at the transmitter terminals is 20 Watts. Max Effective Radiated Power is ~33 Watts. FCC Emission type is F3N. The transmitted signal only occupies 100 kHz of spectrum at each of two different HF frequencies (eg: 3.1-3.2 MHz and 4.4-4.5 MHz).

Receiver:

The receiver system consists of 4 receivers at different locations. Each receiver consists of two direct-sampling wideband HF receive channels to extract signal polarization. The radar will operate on two frequencies simultaneously, and both O- and X-modes will be differentiated at the receiver, so four distinct channels will be analyzed at each receiver site. The wideband HF data is downconverted digitally to these four 100 kHz bands, which is then transferred to a secondary processor. The secondary processor identifies the up- and down-chirps in each of the four bands and extracts the resulting range and doppler information for each signal. The result is eight delay-doppler-amplitude maps, corresponding to the two transmitters, two frequencies, and two polarizations. This data is logged on a large hard drive at each of the four receivers, for later system-wide analysis. The antenna feeding the receivers is a crossed inverted V dipole (less than 6 m tall). A GPS receiver is used to discipline the local oscillator that runs the HF receiver channels, as well as to timestamp the resulting data for analysis.

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).

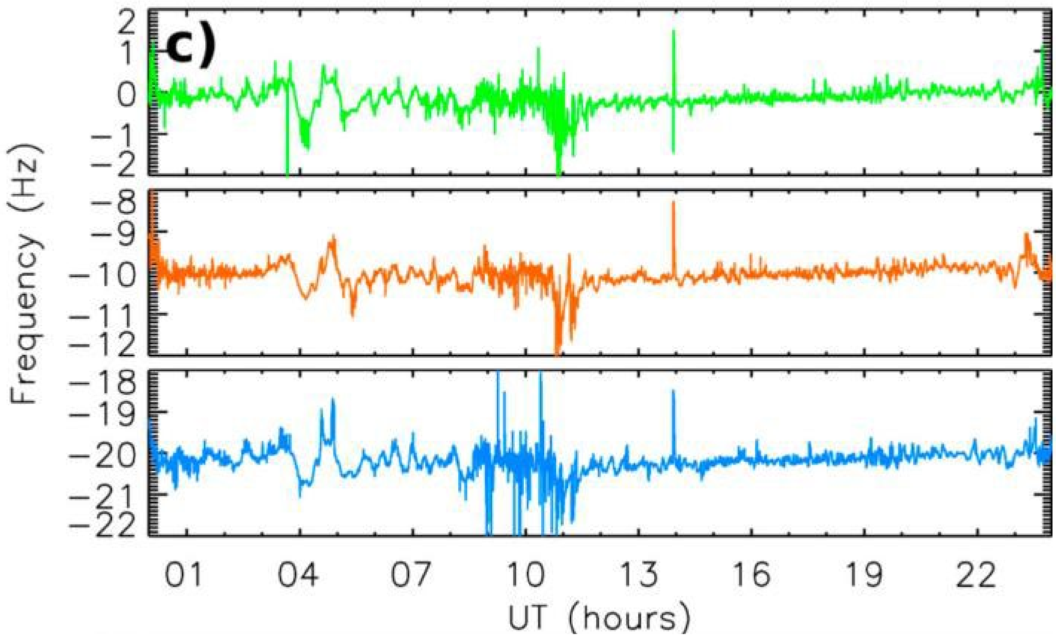

Figure 2: TIDs measured by early generation TIDDBIT system on three propagation paths.

<u>Time of Use:</u>

Once the system was installed, the radios were turned on. They are in operation constantly, sensing the ionosphere, to deliver data back on perturbations. The signal will use two of the four requested frequencies to chirp depending the ionospheric conditions and modified by operator command. Chirping at the same time continuously then, it will repeat the pattern. The signal bounce backs from the chirps will provide the data needed to show how the system is working to map the ionosphere.

The chirps are short. This limits the possibility of harmful interference to any other operations.

<u>Transmitter Sites:</u>

The transmitters were installed at sites in the area of Louisville, Colorado, Monument, Colorado Springs, Denver, CO and Limon, Colorado. Because this system requires triangulation, there must be two or more transmitters installed. For this experiment, Orion Space has chosen four locations as options to place the two transmitters. The figures below show each of the individual sites, and the area among the sites selected for this experimental operation.

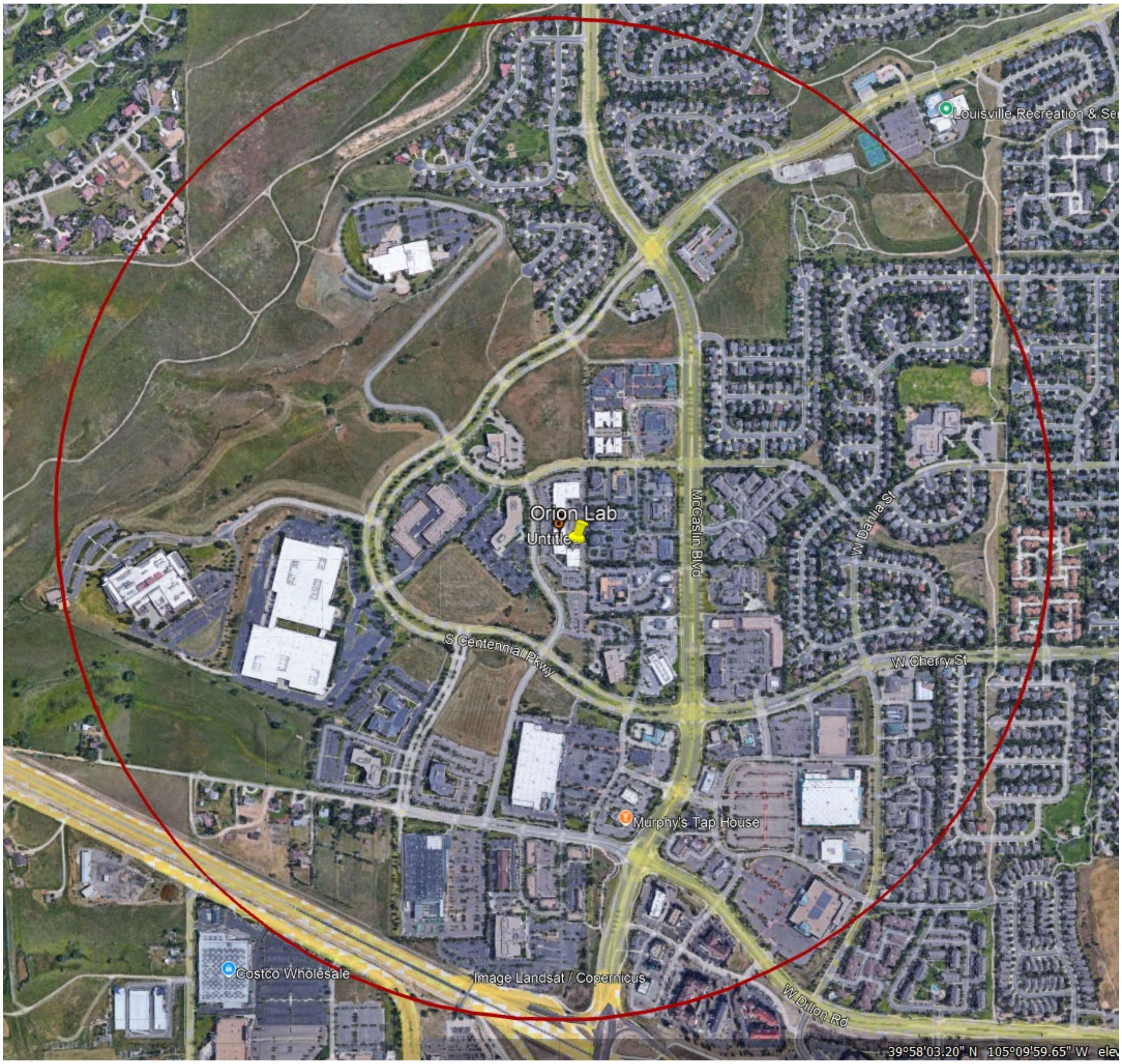

Figure 3. Louisville site. The red circle represents a 1 km radius around the center point, and the transmitter will be moved within that area to optimize operations.
282 Century Place, Louisville, Colorado
Lat. 39-58-03 N, Long. 105-10-00 W

Figure 4: Monument area of Colorado Springs. The red circle represents a 1 km radius around the center point, and the transmitter will be moved within that area to optimize operations.
4487 Settlers Ranch Road, Colorado Springs
Lat. 39-04-27 N, Long. 104-44-44 W

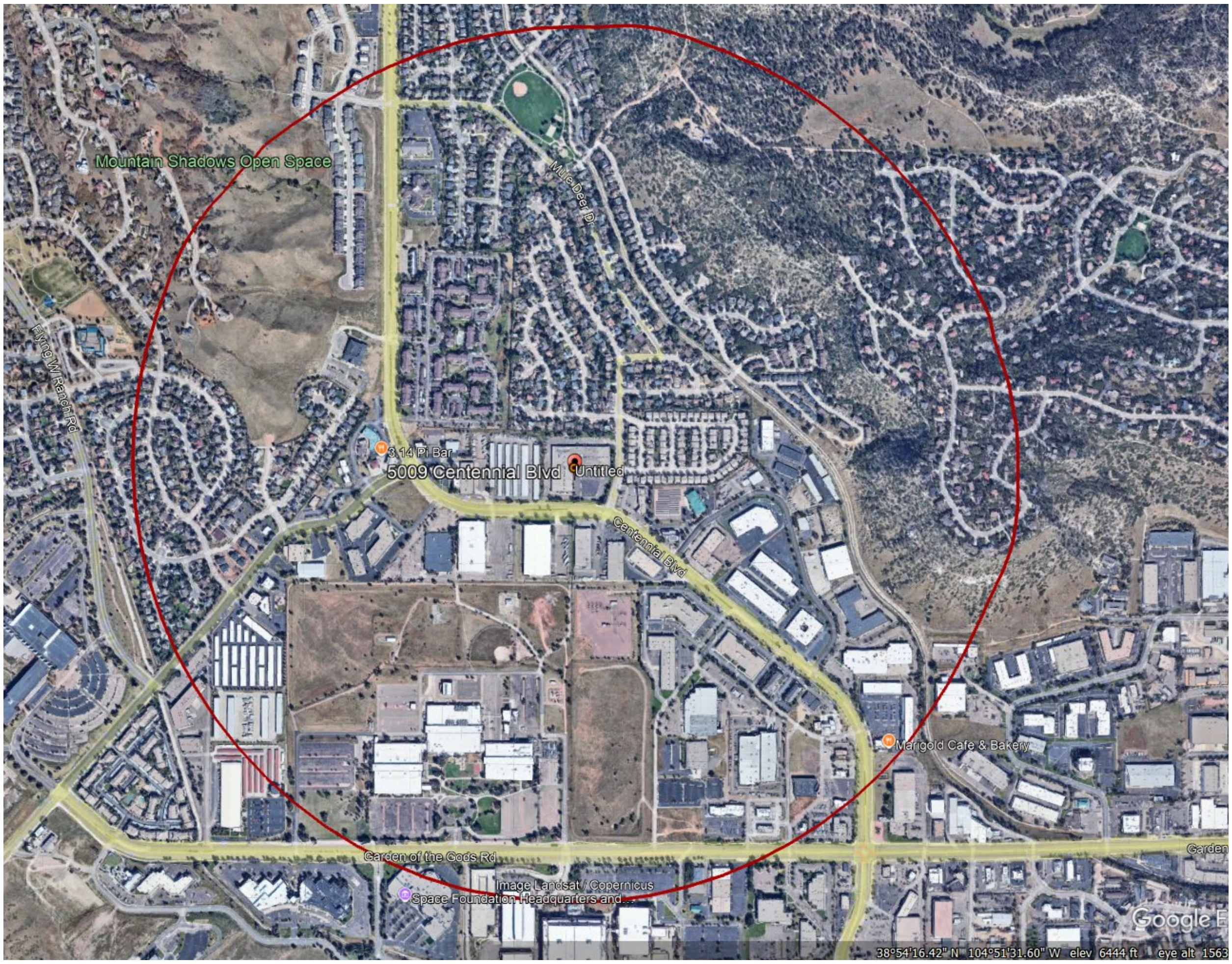

Figure 5: Colorado Springs Installation. The red circle represents a 1 km radius around the center point, and the transmitter will be moved within that area to optimize operations.
5009 Centennial Blvd, Colorado Springs
Lat. 38-54-16 N, Long. 104-51-32 W

Figure 6: Limon Installation. The red circle represents a 1 km radius around the center point, and the transmitter will be moved within that area to optimize operations.
Lat. 39-15-50 N, Long. 103-41-32 W

The two transmitters are positioned within the shaded area in Figure 7, below. The ongoing operations require that the transmitters be moved occasionally within 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 within the proposed radius area around each of the four locations, operating on a temporarily fixed basis. The system operates best with the transceivers able capture the signal back from more than one direction.

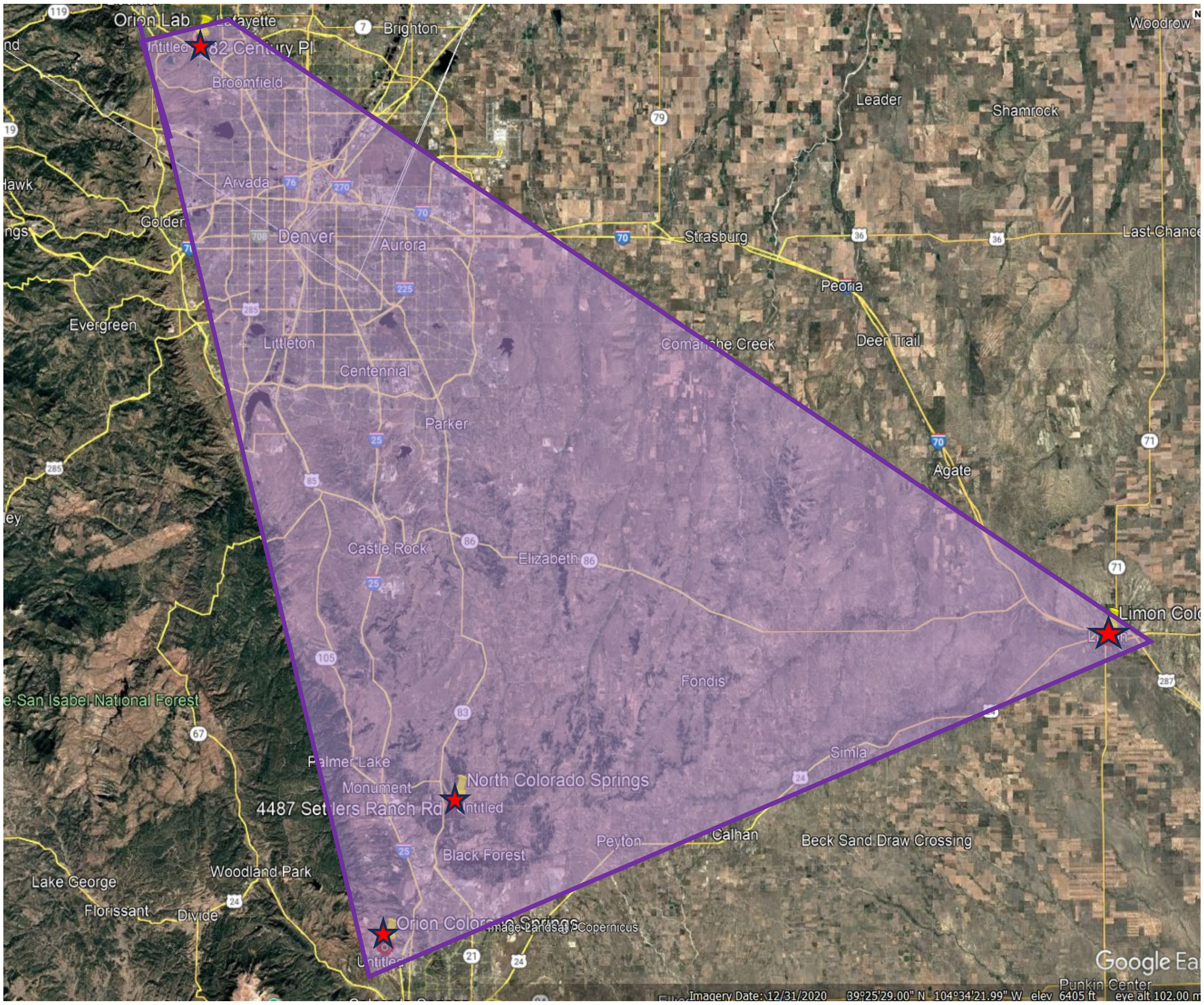

Figure 7. Shaded area shows the potential locations for the two transmitters (red stars) will be installed.

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 four frequencies that reflect off the ionosphere at an altitude greater than 150 km, and Orion has used the altitude separation between these four 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 frequencies that gave the greatest amount of time to provide useful scientific data over the course of the demonstration period.

If these frequencies are not available, other frequencies are workable; in all cases 100 kHz of spectrum is required for the system to perform.

Stop Buzzer POC

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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.