Form 442 Question 7: Experimentation Description

The Department of Electrical, Computer and Energy Engineering (ECEE) at the University of Colorado Boulder is seeking an FCC Conventional Experimental License to facilitate a research operation 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). The department has developed the first Transportable Dynasonde System (TDS), as a part of the Defense University Research Instrumentation Program (DURIP) sponsored by the Air Force Office of Scientific Research (AFOSR; Award Number FA9550-18-1-0468). There are also other research projects supported by Defense Advanced Research Projects Agency (DARPA; Award Number 140D6319C0032) and Air Force Research Laboratory (AFRL) aimed at development of the Dynasonde technique and its numerous applications.

Dynasonde is an advanced technique of ionospheric radio sounding based on comprehensive use of the phase information in pulsed HF/MF signals reflected by the ionosphere. Historically it has been developed in Boulder, Colorado, first at the NOAAs Space Environment Laboratory and then at the University of Colorado (https://www.ngdc.noaa.gov/stp/iono/Dynasonde/history.htm). The Dynasonde, together with its mature data analysis software, belongs to the category of universal instruments capable to provide quantitative information about a broad range of ionospheric and thermospheric parameters. It is particularly useful for detecting and studying Traveling Ionospheric Disturbances and atmospheric waves. One of the first operational installations of the Transportable Dynasonde System is planned in Tierra del Fuego, Argentina, where it will participate in the Traveling Ionospheric Disturbance Experiment (TID-Ex). TID-Ex is a comprehensive AFOSR and National Science Foundation (NSF) sponsored measurement and modeling program that will be conducted in 2020-2021 and will leverage significant resources to examine the hypothesis that Traveling Ionospheric Disturbances (TIDs) arise from Gravity Waves (GWs) propagating into the ionosphere/thermosphere from sources located below. ECEE has a separate plan (pending DURIP proposal) to turn the temporary installation site at Tierra del Fuego into a permanent installation. This requires procurement and testing of another set of Radar equipment. The ECEE program of Dynasonde installations goes beyond Tierra del Fuego and will include other projects.

The Dynasonde will contribute tremendously into studying connections between the ocean, mountain and the thermospheric waves. In addition to participation in the TID-Ex program the Transportable Dynasonde System will participate in a series of experiments for the Defense Advanced Research Projects Agency's Space Environment Exploitation (DARPA SEE) program (Award number 140D6319C0032 to the North West Research Associates and the University of Colorado). Also planned (another pending DARPA proposal) the use of both stationary and transportable Dynasonde systems for broad studies of atmospheric responses to natural disturbances.

The Transportable Dynasonde System include two components: a mobile fully capable transmit-and-receive subsystem and a stationary transmit-only system. Our current license request is for the transmit-only subsystem. This subsystem will include the VIPIR (Vertical Incidence Pulse Ionospheric Radar) HF Radar manufactured by Scion Associates Inc. After initial assembly and a thorough acceptance testing the transmit-only subsystem will remain in its current setup inside of a lab-equipped 20 feet shipping container currently located on the roof of the CUs Engineering Center in Boulder (see Fig. 1).

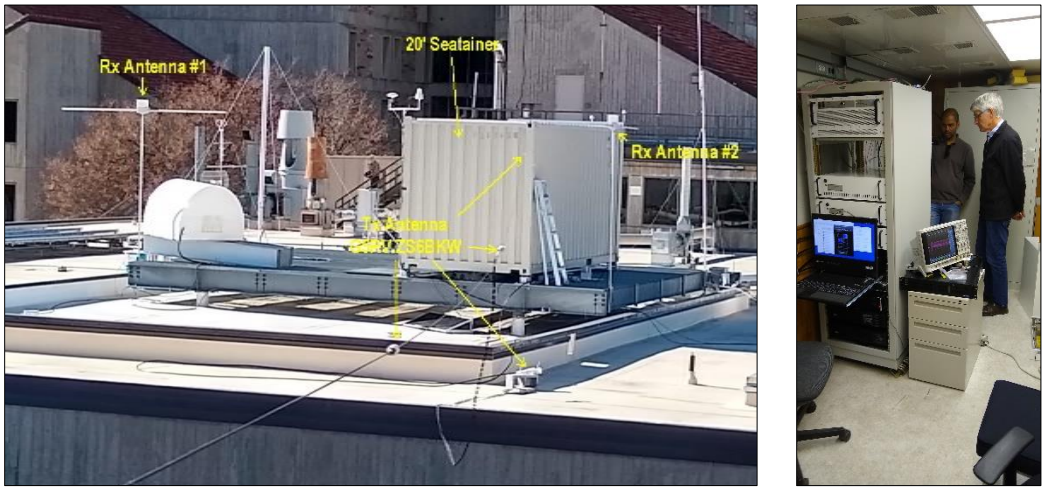

Figure 1. Interior and exterior of the test site on the roof of the CU's Engineering Center.

This installation site will be used as a test bed for all new Dynasonde systems. Every new system and all its components, before shipping to its destination location, must undergo a thorough acceptance testing, including a long continuous run in Dynasonde mode and data gathering. The system's stability, including coherency of the inter-channel phase differences in both calibration signals and ionospheric echoes, must be verified in the tests. These data will also be used to adapt the Dynasonde analysis code for use with the new systems. The second application of the installation site is participation of the transmit-only subsystem in experiments on bistatic ionospheric radio sounding. These experiments will involve other existing Dynasonde installations. The Dynasonde technique is the most advanced and RFI-friendly technique of the ionospheric radio sounding. We expect a significant expansion of its applications as a result of our research program what will eventually become a gross benefit to other users of the EM spectrum.

The tests of the VIPIR HF Radar hardware intended for Dynasonde applications have been started on this site using earlier approved by FCC two Special Temporary Authorizations (File Number 1895-EX-ST-2019 and File Number 2220-EX-ST-2019). Operations proved to be completely non-disruptive for other users of the radio spectrum. The standard Dynasonde sounding session is characterized by a pulse repetition interval of 5-10 ms and by the number of base frequencies from 500 to 600 in the frequency band 2–25 MHz. Base frequency is progressing steadily within each sounding session, so that only 8 pulses can occur at

approximately the same frequencies (minimizing detectable effects for other users of the frequency band). Pulses are grouped into a carefully designed pattern that facilitates echo detection and application of higher-level phase-based analysis routines. The 2 min interval between sounding sessions guarantees sufficient temporal resolution for sampling wave and other dynamic processes in the ionosphere. Pulse bandwidth of 30 kHz and raised cosine pulse envelope are specifically chosen to minimize possible Radio Frequency Interference (RFI) to other users of the spectrum. Effective Radiation Power of the system is only 10 W, and the duty factor 0.4-0.7%. For our experiments we will be using a version of the simple horizontal dipole G5RV ZS6BKW antenna optimized with 1:1 balun for low parasitic emissions. The antenna will be installed on the roof of the Engineering Center, at a level of the rooftop and 70 feet above the ground, with approximately West-East orientation. The planned test operation will be strictly on a non-interference basis. 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 FCCs 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). Dynasonde is a well-established low-RFI instrument. It has operated in many locations worldwide, without any RFI-related complaints. This includes the current multi-year Dynasonde operation at the NASA’s Wallops Island Flight Facility and previous Dynasonde operation in Boulder, CO on NOAA campus.