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). The Transportable Dynasonde System will be used in research projects supported by Defense Advanced Research Projects Agency (DARPA; Award Number 140D6319C0032 granted, other proposals pending) 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, the only one 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. On the territory of the Continental United States the initial experiments with the Transportable System are planned in the states of Colorado and New Mexico. Other proposed projects include Florida, Wyoming and the Washington state.

The Transportable Dynasonde System includes two components: a mobile fully capable transmit-and-receive subsystem and a stationary transmit-only subsystem. Our current license request is **for the mobile transmit-and-receive subsystem**. This subsystem includes the VIPIR (Vertical Incidence Pulse Ionospheric Radar) HF Radar manufactured by Scion Associates Inc., a specialized trailer with 33-m high telescopic tower manufactured by Aluma Tower Company, and a set of 8 receiving antennas professionally designed and manufactured by CU ECEE (see Fig. 1). The telescopic tower will support a broadband delta antenna optimized with a balun and a resistive load for low parasitic emissions (see the Antenna Registration Question 5: FAA Antenna Sketch attachment). The mobile system is also equipped with a portable power generator what makes its operations fully autonomous and site selection independent of existing infrastructure. Most of the planned deployments of the system will therefore be done in rural areas and other remote locations. Planned period of performance at each location will vary from few weeks to few months.

Figure 1. The radar's rack, specialized trailer with 33-m telescopic tower, and one of the receiving antenna assemblies.

The main benefit of the Transportable Dynasonde System is that it brings Dynasonde capabilities to locations representing significant research interest where, however, permanent installations are either unjustified or simply impossible. This facilitates of utilization of the Dynasonde technique in observational campaigns involving other kinds of instruments. It also allows one to explore potential sites for permanent installations. Some of the examples of research applications include studies of atmospheric waves generated by winds blowing over mountains, by volcano eruptions, by rocket launches, and by ocean waves. Another important application of the mobile system is participation in experiments on bistatic ionospheric radio sounding. These experiments will involve other existing Dynasonde installations. The mobile character of the system will allow one to cover various distances and propagation directions. 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 the Transportable Dynasonde System have been conducted in Boulder, Colorado for several months 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. Actually, nobody noticed them. 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 among specifically chosen design solutions aimed at minimizing possible Radio Frequency Interference (RFI) to other users of the spectrum. Effective Radiation Power of the system is only 30 W, and the duty factor 0.4-0.7%.

All planned operations 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), and 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. Nevertheless, we are fully aware about the FCC/FAA regulations imposed on utilization of tower structures. In case if the installation site of the mobile system appears in close proximity to an existing aircraft landing area, we will follow the FCC rules based on the FAA Advisory Circulars. 47 CFR §§ 17.21-17.58. Each new installation site will be verified with the FCC TOWAIR program to determine whether or not registration with the FCC is necessary.