Raytheon IIS
Experimental License Application
File No: 0044-EX-CR-2017

Explanation of Experiment

Raytheon Intelligence, Information, and Services Division (Raytheon IIS) is a division of Raytheon Company. Raytheon IIS develops a number of defense systems including advanced voice and data communications systems for the US military.

Raytheon IIS is continuing to develop a small satellite (cubesat) program for the Defense Advanced Research Projects Administration (DARPA). This small satellite program will use innovations in small, easy-to-deploy satellite payloads to create temporary, low earth orbit constellations for military use to address urgent situations. This experimental license renewal application is being filed to allow for the continued testing of the ground control segment of the satellite systems under development. Advancements on the satellite platform have resulted from this ongoing testing. Because the launch of the satellite has been delayed by SpaceX, Raytheon will continue to refine the operation of its systems through ground testing with the additional time it has. This application is being filed to continue testing through the period it is waiting for the satellite launch.

This application is for testing only of ground stations. Raytheon has sought and obtained experimental approval for operation of the satellite system, which will be used once the satellite launches.

Synopsis of Technical Data

Spectrum Requested:	437.250 MHz, 437.275 MHz, 437.300 MHz 437.325 MHz, 437.350 MHz, 437.375 MHz, 437.400 MHz, 437.425 MHz, 437.450 MHz, 437.475 MHz, 437.500 MHz – at each of seven locations; Not all frequencies in use at once.
Time of Use:	Spectrum use will be limited to 10 minutes per simulated satellite contact, with only 6 contacts per day. That would be a total of 60 minutes of use per site.
Signal is Directional:	The ground stations use high-gain antennas with very directional beams All transmissions directed toward the simulated satellites – see below

Explanation of Experiment

The experiment being conducted is in furtherance of a small satellite technology mission. The nature of the program seeks to conduct mission operations in low Earth orbit and be able to telemeter data back to a terrestrial ground station. This application is for the ongoing testing of the ground station network so that it is fully functional prior to the launch of the actual satellites.

Once the whole system is active, the ground stations at Raytheon's facilities that are being tested under this authorization will be used to receive telemetry data from the satellite and to send command and control information up to the satellite.

This testing is intended to complete the development and testing of the ground station network, ensuring that the ground stations will function properly when the whole system is live. The testing is designed to take a mock-up of the satellite to a location remote from the Raytheon plant sites and test the functioning of the communications link design. Those are the sites in the mountains near the two Raytheon facilities, where the satellite mock-ups will be in motion and communicate with the ground stations.

Limited Time of Spectrum Use

The expected low earth orbit of the satellite means that the satellite is only expected to be in view of a ground station for 10 minutes each orbit. Thus, the expected use of the ground station at each location is only 10 minutes at a time. The satellite is expected to contact each ground station approximately six times per day when the satellite is operational. The ground station testing that is the subject of this application will replicate that usage pattern.

Beamwidth and operation of ground station transmissions:

As noted in the application, the half power beamwidth of the ground stations is 50 degrees. The ground stations will be used in this early testing stage to contact ground-based transceivers as if they were contacting the actual low earth orbit cubesat. The directional nature of the antenna is expected to minimize the effects of any radio transmissions on the surrounding area.

The frequencies proposed on this application would be for transmission of command and control information. The telemetry data reception is a receive-only function of the ground station.

Orientation of the ground stations for testing:

This application proposes use of three ground stations for development and testing of the network. There will be two ground stations at the Raytheon plant in Tucson, Arizona, and one at the Raytheon facility in Aurora, Colorado.

Tucson: Both ground stations in Tucson are aimed north-northeast and angled up toward Mt. Lemmon, a mountain peak in the Santa Catalina Mountains northeast of Tucson. The mountain peak rises to a height of over 8000 feet, and it is situated about 25 miles from Raytheon's Tucson plant. (See Figure 1 below.) There are two ground stations at the Tucson plant because there is a great deal of work being done by the laboratory team working on the project. Both ground stations will communicate with the same transceiver on Mt. Lemmon. For the testing phase, the time of use will be very limited, and the narrow-beamed antennas will be focused to try to minimize any chance of harmful interference.

Figure 1. Tucson to Mt. Lemmon transmission path

The transceiver on Mt. Lemmon will use the same frequencies to communicate with the ground station, mimicking what will be the future operation of the satellites. The Tucson ground stations will be oriented to azimuth 30 degrees; the Mt. Lemmon transmitter will be mobile in a 2 mile radius around the designated location on the mountain top, and the transmitter will be oriented at about azimuth 210 degrees.

Aurora: the ground station will be aimed west-northwest to northwest along test paths that stretch across 75 miles to peaks in the nearby Rocky Mountains. (See Figure 2 below.) The mountains rise to over 10,000 feet, so the ground station will be angled up over the intervening area. As in Tucson, the goal has been to test how the ground station operates with a remote transceiver to simulate communications with a satellite. This testing is essential to configuring the ground station network prior to launch of the satellites, to ensure that the ground station is properly functioning to command and control the cubesat once it is launched. In Colorado, it is possible to move the simulated satellite transceiver along the mountain ridge, to test how the ground station will track movement of an object far away and in motion. Because the cubesat will have an established orbit and no propulsion to shift their orbit, having an effective communications network is all the more essential to ensure their proper functioning when in orbit. The proposed ground-based testing is the only chance to ensure that the satellite launch is not wasted.

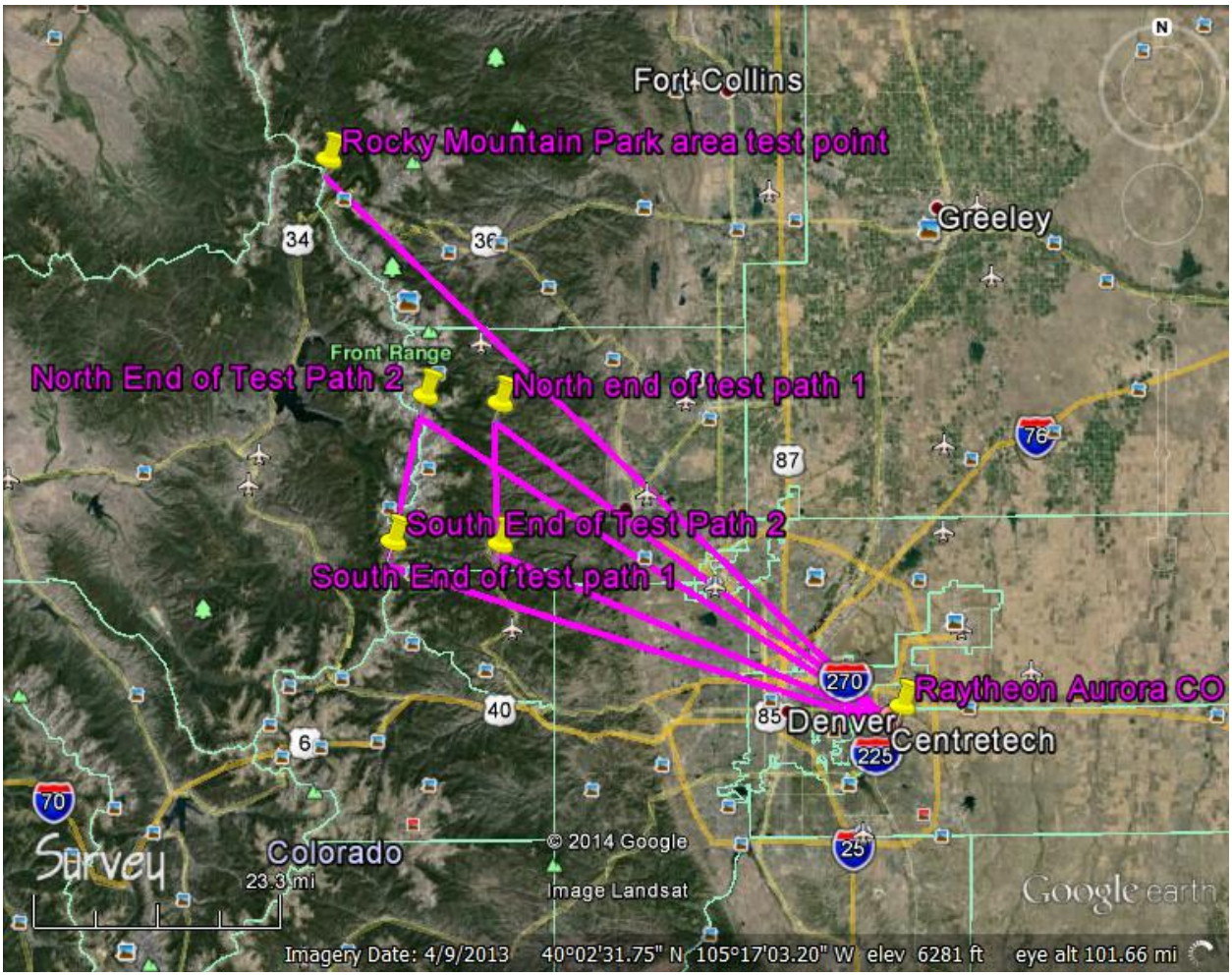

Figure 2. Aurora Colorado to Rocky Mountain Test Paths

The ground station in Aurora, CO will be pointed toward the mountains, with its operations aimed between azimuth 280 and 320 degrees. Up in the mountains, the transmitter will be used in motion, approximately along the test paths shown on the maps above. The distance of the link will be, at most, about 80 miles. The mobile transmitter will be oriented from azimuth 100 to 140 degrees.

Stop Buzzer POC

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Conclusion:

This application proposes to license ground stations for testing and calibration so that the network of ground stations will be prepared for use when they will be part of a small satellite mission under development for DARPA. The small satellite program has advanced, and expedited testing of the

ground station network is needed to ensure that the system will be ready when the satellite is finally launched in late 2015.

The beamwidth is narrow and focused. The time of spectrum use is expected to be short, to mimic the short low earth orbit period. Testing in this limited timeframe will allow the program to simulate the communications between the ground station and the remote satellite to see how to make the communications most effective in a limited time over a great distance.

For questions about this application or any additional information, please contact Brian R. Kavalar, Spectrum Manager, Raytheon IIS at 371-517-9989 or brian_r_kavalar@raytheon.com