Raytheon Missile Systems
Experimental License Application
File Number: 0540-EX-PL-2015

Explanation of Experiment and Procedural and Coordination Information

Background:

Raytheon Missile Systems (Raytheon) is a company that develops innovative technologies that have both defense and civilian uses. Raytheon draws on the expertise of its varied engineering departments to develop technologies that address previously unsolvable problems.

This application is for the launch and operation of a micro-satellite that incorporates a number of commercial-off-the-shelf technologies to prove a concept of how one could build and quickly launch an inexpensive satellite to address short-term, immediate imaging needs.

Procedural and Coordination Information:

IARU Coordination:

In accordance with FCC requirements, Raytheon has conducted prior coordination of its proposed operations with the International Amateur Radio Union (IARU).

NOAA Imagery Licensing:

On October 22, 2015, Raytheon received a license for satellite imaging from the NOAA office of commercial remote sensing requesting a license for satellite imaging.

Orbital Debris Assessment Report:

Raytheon is submitting as an additional attachment to this application its Orbital Debris Assessment Report, containing information about the projected effects of the launch of this satellite.

Explanation of Experiment

In the sections below, Raytheon provides an explanation of the experimentation.

Satellite System

System Name: SeeMe Satellite System; Number of Satellites: 1

Number of Ground Stations: one primary command and control station based in Aurora, Colorado. Raytheon is also seeking authorization for operation of backup command and control stations at other locations.

Spectrum Requested

Command (uplink and downlink) frequencies: 437.425 and 437.450 MHz half-duplex

Mission data (downlink) frequencies: 2425 MHz with 2 MHz bandwidth

Figures 1 and 2 below show the anticipated signal coverage for the transmitters on the satellite.

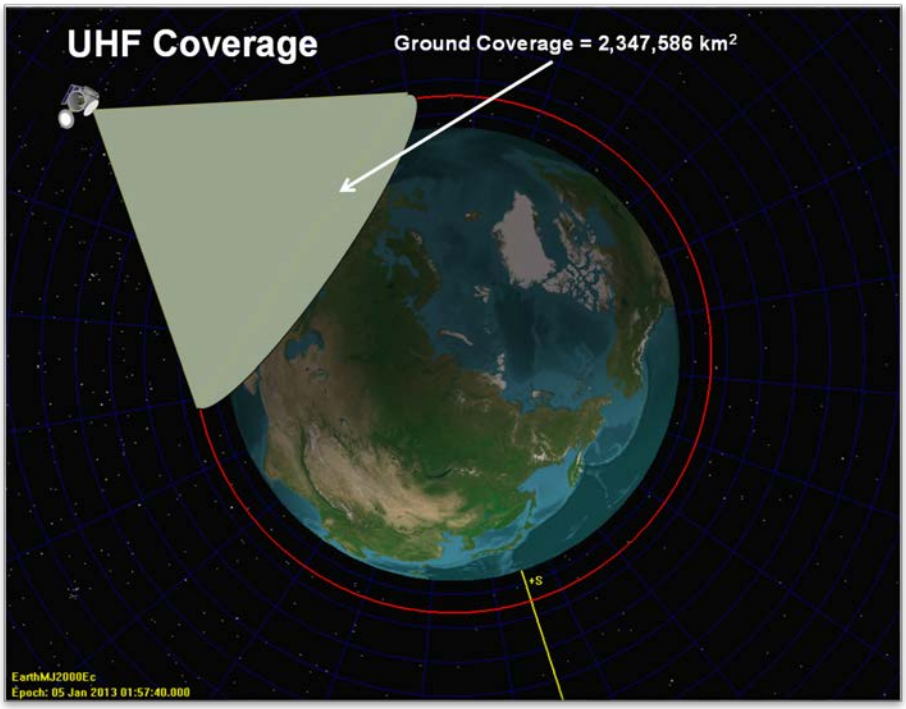

Figure 1: Satellite UHF Frequency coverage

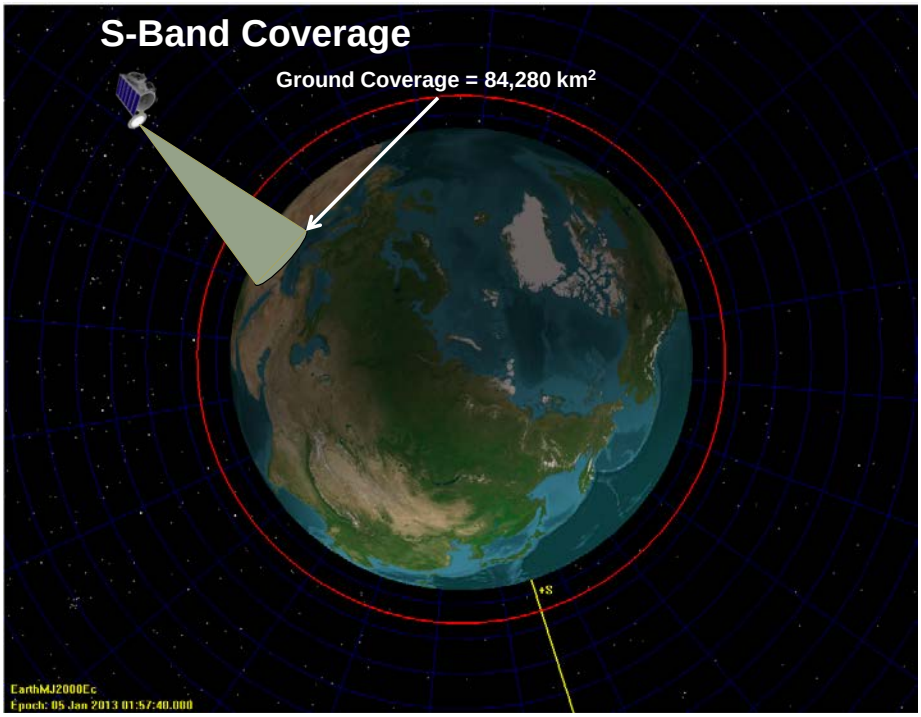

Figure 2: Downlink Beam Coverage at 2425 MHz; Downlink data rate: ranges between 1 MBPS and 2 MBPS (more likely 1 Mbps)

Explanation of Operations

This project is intended to demonstrate the capabilities of a small, quickly deployable satellite to provided advanced imaging and communications. It uses an inclined low earth orbit to be able to make multiple passes each day. The demonstration model is attempting to show how the images can be captured, downloaded, and moved to a central point to be of use. The demonstration is planned to be short-lived, and the controls built in to the satellite and network ultimately will disable the satellite if there are any technology failures.

Communication between the control ground station in Aurora, Colorado and the satellite will use the 437 MHz half duplex links.

Raytheon expects that the system will operate successfully for at least 180 days and possibly continue for up to two years. Raytheon does not anticipate seeking renewal of this license, because the components of the satellite are expected to begin to fail at the two-year mark.

Launch Segment Information

1. Launch Schedule:

   Currently, the satellite launch is scheduled for in late March 2016, depending on delivery of the space vehicle, weather, and other factors that are not in the control of the applicant.

2. Launch vehicle source:

   Space X Falcon 9 space vehicle

3. Launch site:

   Vandenberg, California

4. Anticipated operational date:

   The Raytheon system will be operational about 3 weeks after launch. Raytheon's use of the frequencies requested in this application will NOT start until the satellite is released into free flight.

5. Range of orbits and altitudes:

   Nominal apogee: 720 km;
   Nominal perigee: 450 km.

6. Inclination angle:

   98°

7. Orbital period:

   90 minutes, however given the elliptical nature of the orbit and the altitude changes, the orbital period could range between 90 and 95 minutes.

Anticipated System Lifetime

This is a demonstration project. It is planned to test a variety of parameters for up to 180 days. Therefore, the anticipated system lifetime is 180 days after release into free flight. Raytheon expects to disable the satellite after that time. The technology built into the satellite is capable of being used for up to 2 years, at which point the embedded electronics will begin to fail. If there is still some utility, the program will be continued for up to 2 years. Orbital decay is expected to take place in year 7, which is based on the mass of the satellite which is 27 kg.

Ground Station Network Architecture

a. Primary Command and Control ground station location: Raytheon IIS secure facilities, Aurora, Colorado

   The Aurora ground station will be used to send command and control signals to the satellite.

   437 MHz frequencies: The ground station will communicate with the satellite to verify the health and proper functioning of the satellite components every time the satellite orbit passes over the Aurora ground station.

The 437 MHz frequencies will be used for both uplink and downlink of command and control, acknowledgement of command and control and reports on satellite health.

b. Other ground station locations:
   i. Raytheon facilities, two locations Tucson, Arizona
   ii. St. Petersburg, Florida
   iii. Sterling, VA
   iv. Waimea, Kauai
   v. Virginia Beach, Virginia

2425 MHz telemetry frequency: This frequency is only going to be used as a downlink to transmit images from the satellite to one of the ground stations.

Contingency planning: If there is a system failure in Aurora, Colorado, or if there is an emergency need to uplink commands when the satellite is not in range of the ground station at Aurora, Colorado, each of the remote ground stations is equipped with the technology to allow it to be used as a "back up" command and control station.

Time of Use

The spectrum will be in use only sporadically and – due to the nature of the orbital period – only for short times.

The satellite is expected to orbit above the Aurora, Colorado ground station at least once every 24 hours. During every orbital pass, the ground station will attempt to communicate with the satellite to verify satellite operational health and to confirm proper operations.

Because of the low earth orbit, the satellite will pass over ground stations quickly. In an estimated 16 orbits per day, the satellite is only expected to be in range of the ground stations for 10 of those orbits. Therefore, image download over the 2425 MHz link will be sporadic. Once images are captured, it is expected to take several orbits to get the first image downloaded.

Conclusion:

Raytheon has been developing technology for a small, temporarily deployable satellite system. The system is intended to provide customers with quickly deployable capabilities. The small satellite being tested here, known as SeeMe, will be the first of its kind. Its size, weight, and capabilities are all the subject of testing to see how the system will perform

If there are any questions about this application or any of the attachments, please contact Thomas J. Fagan, Spectrum Manager, Raytheon Missile Systems, 520-794-0227 or tjfagan@raytheon.com, or Anne Linton Cortez, Counsel, WFS, 520-344-8525 or alc@conspecinternational.com.