Raytheon Missile Systems
Experimental License Application
File Number: 0331-EX-PL-2011

Exhibit I – Explanation of Need to Use Radio Spectrum

Raytheon Missile Systems (Raytheon) is requesting the use of frequencies in the 1755 to 1850 MHz and 4500 to 4700 MHz bands to develop improved interference resistance for command and control signals used when its products are in flight.

Raytheon builds missiles used by the US military. Those products are used in an increasingly crowded RF environment. Various command and control signals are used when the missiles are in flight to ensure their proper operation. The experimentation proposed here is intended to further the development of radio system and transmissions that will be robust and reliable even in a crowded RF environment to ensure that vital command and control signals are received, without harmful interference.

Synopsis:

- Frequencies requested: 1755 – 1850 MHz and 4500 – 4700 MHz
- Testing is to develop enhanced command and control signals that will not cause nor receive interference in a crowded RF environment
- Testing is on missiles; there is airborne use in a 25 mile radius around the Raytheon Tucson facility.
- After waveform analysis, testing will be listen before transmit and use frequency hopping.
- Frequency bands requested are needed for comprehensive testing and development required.

Description of experimentation:

The application proposes to use two frequency bands: 1755 – 1850 MHz and 4500 to 4700 MHz. The power levels are just high enough to test out operations that mimic real-world conditions for when the missiles would be in use. The bandwidth per transmission is 6 MHz. The experimentation proposed here will help Raytheon determine what type of transmission will guarantee that the command and control signal is received and will withstand interference from the operation of other radios in the area and on or near the same frequency.

The 1755 to 1850 MHz band experimentation will use off-the-shelf technologies that are readily available. The purpose of testing in this band is to use easy-to-access technologies to learn as much as possible about designing an interference-resistant transmission before migrating the experiments to the 4500 to 4700 MHz band. In the 4500 to 4700 MHz band, Raytheon must design and build equipment before testing the nature of the transmission of command and control signals. Using

1755 to 1850 first minimizes the variables to be explored in any one test, and therefore it maximizes the efficiency of the testing. The application requests authority to operate in both bands, because that will allow the program to most effectively build and test equipment in each band as it learns.

Use of Frequency Hopping and Listen-Before-Transmit Technologies

For much of the field testing, the radios will listen for a clear channel and transmit only on a clear frequency. The radios will change to clear channels if a signal appears on the frequency to be used. In the early phases of testing, the program will be testing waveforms, and it will not use frequency hopping technologies, because that would make analysis of the waveforms nearly impossible. However, the analysis of waveforms will mostly be conducted over cables in the laboratory. Field testing of the waveform analysis is expected to last only two (2) days per month.

Once the waveform is analyzed, then the program will begin to incorporate frequency hopping and listen-before-transmit technologies. At that point, the program will always use listen-before-transmit technologies, unless it needs to debug a system or undertake additional waveform analysis. In the event the program must debug a system or analyze a new waveform, the program will again return to the lab and use of cable for most of the analysis, except that there will be about two days of field-testing per month.

Request for full bands is necessary for adequate experimentation:

Raytheon is well aware that both of the bands it proposes to use for this experimental testing are highly occupied by other users. It is important to repeat that almost all of the proposed operations will either be in the lab over a cable or will be "listen-before-transmit" to ensure that there is no chance of harmful interference. Furthermore, testing in a crowded RF environment is key to developing the sort of robust radio system that is needed for safe operation of the command and control systems on the missiles.

The radio systems that Raytheon hopes to develop through these experiments should be able to transmit command and control signals without suffering – or **causing** – interference. These systems will be used by Raytheon's customers in crowded RF environments. Raytheon is aware that its customers will be operating other radio systems on the same spectrum at the same time, and the new systems under development must not cause interference to those other vital communications. At the same time, the new system must be able to withstand the radio traffic and still communicate effectively. This is a great engineering challenge, which is why this experimental license is needed.

In an effort to maximize the effectiveness of the testing, Raytheon is proposing to test across both bands, but it will not be operating across both bands continually. In the initial phases, testing will be primarily in the lab on a cable, with only two days of field testing per month. Later, the testing will be sporadic, with short bursts of radio use, when and where there is clear spectrum, based on the listen-before-transmit technology. The occupied bandwidth of the transmission will be only 6 MHz, to ensure minimal spectrum occupancy. Based on Raytheon's experience in developing new radio systems, the most effective way of developing a system is to design a test that incorporates flexibility to allow for the engineers to test, learn, adapt, redesign, and repeat the process. By asking for the ability to work across the designated spectrum bands, Raytheon is trying to allow its engineering team flexibility to design a system that can be used effectively and to do so in a cost-effective manner.

Time Schedule for Experiment:

The proposed plan of experimentation is scheduled to start in the fourth quarter of 2011. The experimentation is scheduled to continue for at least four (4) years, to allow sufficient time to explore and test waveforms, test frequency hopping and listen-before-transmit technologies, re-analyze waveforms, and refine the systems being developed to ensure that they achieve optimal performance – neither causing nor receiving interference while operating in a crowded RF environment. Therefore, Raytheon is seeking an experimental license term of five years.

Area of Test:

The operations will be used within a 25 mile radius of the Raytheon Missile Systems main facility in Tucson, Arizona. The experimental radios will be used on a mobile basis, probably in aircraft that will fly at a maximum altitude of 10,000 ft.

Conclusion:

Raytheon hopes to build on other, ongoing experimentation with radio systems to enhance the quality of frequency hopping technologies as well as to develop interference-resistant command and control radio systems to make the use of Raytheon missiles more secure.

The proposed testing here is intended to develop robust, interference-resistant command and control radio transmissions that will enhance the safety and effectiveness of Raytheon's missile systems. The testing has been designed to minimize the power needed, limit the occupied bandwidth, and produce an efficient, effective radio system. The testing will all be "listen-before-

transmit" both to protect existing users in these bands as well as to improve the quality of the product under development.

Should there be any questions about the proposed application, please contact Thomas J. Fagan, Spectrum Manager, Raytheon Missile Systems, 520-794-0227 or tjfagan@raytheon.com or Anne L. Cortez, Washington Federal Strategies, 520-344-8525 alc@conspecinternational.com.