Raytheon Missile Systems
Application for Experimental License
File No:

Explanation of Experiments and Need for Experimental License for use of Several Frequency Bands for Lab and Factory Missile Communications Testing

Overview:

Raytheon Missile Systems builds and sells missiles to the US military. As a part of the engineering development and production process, RMS tests its missile communications systems to make sure they meet customer specifications. That process requires the use of radio transmissions to make sure all the antennas, receivers and transmitters work properly. The testing proposed here is to be conducted in labs and on production lines to ensure that the installed radio systems are operating properly. These three radio systems are used in the field by the customers for Range Safety. The three radio systems used for testing are the Flight Terminate Receiver, S-Band Telemetry transmitter and the C-Band transponder. These systems must be tested and retested as part of the production process for the Range Flight Safety System. They are only installed on missiles that will be tested at government ranges. Prior to delivery of the product to the customer, the product must be tested as part of engineering development and production testing.

The actual flight testing is conducted using federal frequency assignments. Since the lab and production testing is taking place at Raytheon's facilities, and because some of the work being done is actually internal to Raytheon as part of independent research and development, it is necessary to request an experimental authorization to allow for the proper, licensed operation of the missile during development and production testing.

Description of spectrum use for missile test:

UHF (420-430 MHz), C (5400 to 5900 MHz) and S (2200-2390 MHz) band transmitters are installed on the missile to allow for control and monitoring of the missile while it is in flight. Most missile flight tests are very short in nature, about 5 minutes. Raytheon conducts approximately 40 lab or production line tests each day on various programs, for a total time in which there might be spectrum use of about 200 minutes, or just over three hours. Because the UHF, C band, and S band frequencies are used throughout the flight tests, the experimental testing proposed in the lab or production facilities in this application mimics the flight test use of the radio systems to ensure proper operation when the products are actually engaged in flight testing. The Spectrum Managers at Raytheon Missile Systems coordinate the use of these transmitters to mitigate any interference problems.

To minimize any potential interference, most of the testing is done using hooded transmitters in the lab and on the production line. Those hoods are placed over the antennas on the missiles, and the hoods are shielded and filled with anechoic material.

This minimizes the potential for any radio signals to get out of the building in which the radio testing is being conducted. There are some instances in which hoods cannot be used, and the application requests authorization for the parameters of the unhooded use.

The UHF (420-430 MHz) Flight Terminate Receiver on the missile receives information on a very specific frequency that can be used to steer the missile and/or destroy it in the unlikely event that the range deems the missile a safety hazard. For development engineering and or production testing, a test transmitter is used to test all of the functions of the Flight Terminate Receiver and its antenna. No flight testing is performed at Raytheon Missile Systems' facility. Most of the test sets have the following characteristics:

Carrier Frequency 406 to 450 MHz in 100 kHz Steps (in this case 420-430 MHz only)
Carrier Frequency Stability +/- .005%
Power Output 0 to -127 dBm
Modulation WBFM, +/- 30 kHz Per Tone
Tone Frequencies Any combination of up to 20 tones per IRIG 313-01 (6 simultaneous, max)
Spurious Outputs -50 dBc

The S-band telemetry transmitter operates on a very narrow frequency in one of three frequency bands; 2200-2290 MHz, 2310-2360, 2360-2390 MHz. Power output is 2 to 40 watts of power. For purposes of the application filed here, Raytheon has requested authorization to use the full 40 W of power which may rarely be required, but most of the testing will be done at much lower power levels. When this system is used in actual flight test, missile telemetry data is sent to the test center to provide information such as temperature, altitude, speed, voltages, and vibration levels as the missile is in flight.

The information is normally transmitted using Pulse code modulation (PCM)/frequency modulation (FM). The newer systems, which require less bandwidth, are the Feher patented quadrature phase shift keying (FQPSK-B and FQPSK-JR), the shaped offset quadrature phase shift keying (SOQPSK-TG), and the Advanced Range Telemetry (ARTM) continuous phase modulation (CPM). We have entered emission designators also reflecting the maximum bandwidth usage, based on the PCM/FM transmissions, but most of the transmissions will use narrower bandwidth than that proposed. Each of these methods offer constant, or nearly constant, envelope characteristics and are compatible with non-linear amplifiers with minimal spectral regrowth and minimal degradation of detection efficiency. All these systems operate in accordance with the IRIG-106 standard. For the development engineering and/or production testing proposed here, a test receiver will be used to receive the telemetry data. No flight testing is performed at Raytheon Missile Systems.

The C-band transponder system, operating at 5400-5900 MHz, is used for tracking the missile in flight. This system includes an interrogator radio fixed on the ground and a transponder on the missile. In actual use, the power output can be up to 100 watts. In an

actual flight test, the government range radar (AN/FPS-16) interrogates the missile transponder with a single or dual pulse. The transponder receives coded or single pulse interrogation from ground stations and transmits a single-pulse reply in the same frequency band. The radar ground stations determine the position of the vehicle C-band transponder by measuring range, azimuth angle, and elevation angle. Range is derived from pulse travel time, and angle tracking is accomplished by amplitude-comparison monopulse techniques. As many as four radar stations may track the beacon simultaneously. The proposed experimental use in the lab and at the production facility will replicate the radar interrogations – but at a power level of only 1 watt, because that is all the power needed for the indoor interrogation transmissions and responses at the normal power level of 100 watts to ensure the proper functioning of the C Band system on the missile.

For our use at Raytheon a Lab test of the interrogator set with the following characteristics is used to test the missile transponder:

RF POWER OUTPUT: -5 DBM TO -65 DBM ± 1.5 DB INTO A 50 OHM LOAD, N-TYPE CONNECTOR
RF FREQUENCY: 5.4 TO 5.9 GHZ, SYNTHESIZED IN 1 MHZ STEPS
PULSE WIDTH: 0.25 TO 1.0 MICROSECONDS
PULSE SPACING: 3 TO 12 MICROSECONDS
PRF: 100 TO 2600 HZ
OPERATING MODES: CW, AUTOMATIC TEST, REPEATING PULSE, MANUAL, CAL
ANALYSIS RESULTS: GO/NO GO, RETURNED PULSE COUNT, TRANSPONDER POWER RETURNED,

The transponder on the missile operates as it would in test flight, with 100 W of power with a -6dB gain antenna for an ERP of 25 Watts.

For development engineering and or production testing a test transmitter is used to test the operation of the C-Band Transponder and its antenna. No flight testing is performed at Raytheon Missile Systems.

Spectrum Use Coordination

Raytheon has submitted a frequency coordination request to AFTRCC for the use of the S band telemetry frequencies. AFTRCC will send its response to both Raytheon and the FCC after it has completed consideration of the formal request. Informal consultation with AFTRCC has shown that they are likely to approve this request. A copy of the AFTRCC response will be submitted to the FCC as soon as it is available.

Expected Effect of Spectrum Use

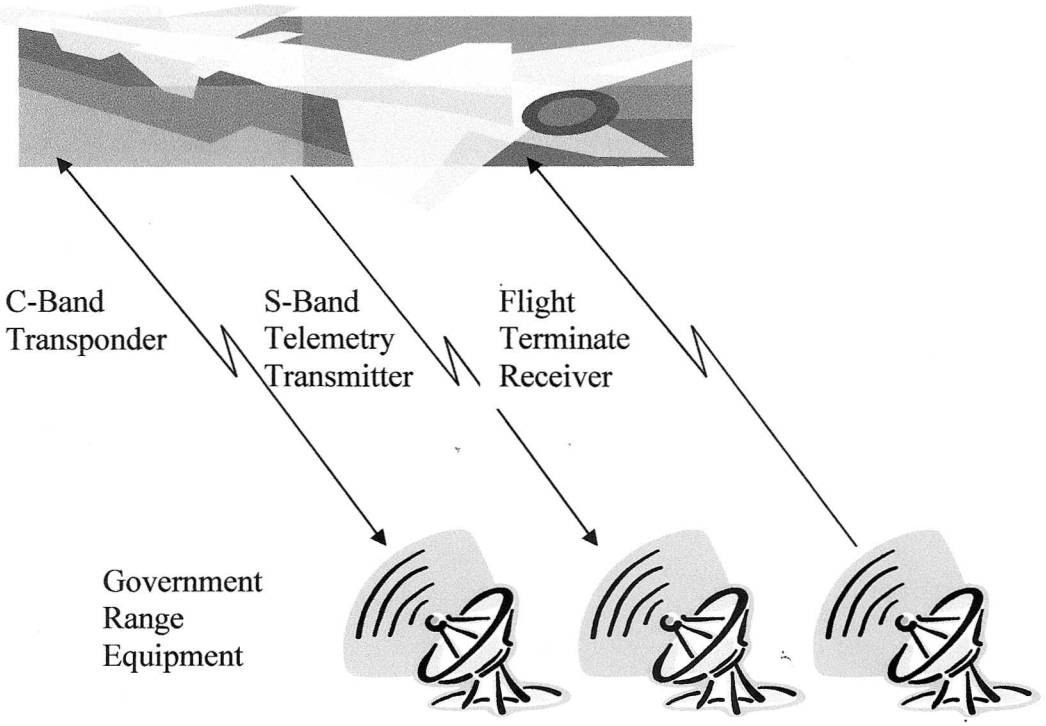
Over the past 50 years, Raytheon has tested its products during engineering, development and production. The federal frequency assignment authorized the use of UHF, S-Band, and C-Band spectrum to control the missile, monitor its flight and as necessary terminate the test flight, exactly as is proposed here. There were no incidents of harmful radio interference during the previous engineering development and or production testing. As a result, no harmful interference is expected from the testing proposed here.

Review of the FCC's regulations shows that in the UHF band, the operations should not involve spread spectrum radio location systems. As explained above, this application proposes to use the 420-430 MHz spectrum for a very discrete purpose and does not employ spread spectrum technology, nor is the frequency used for radio location.

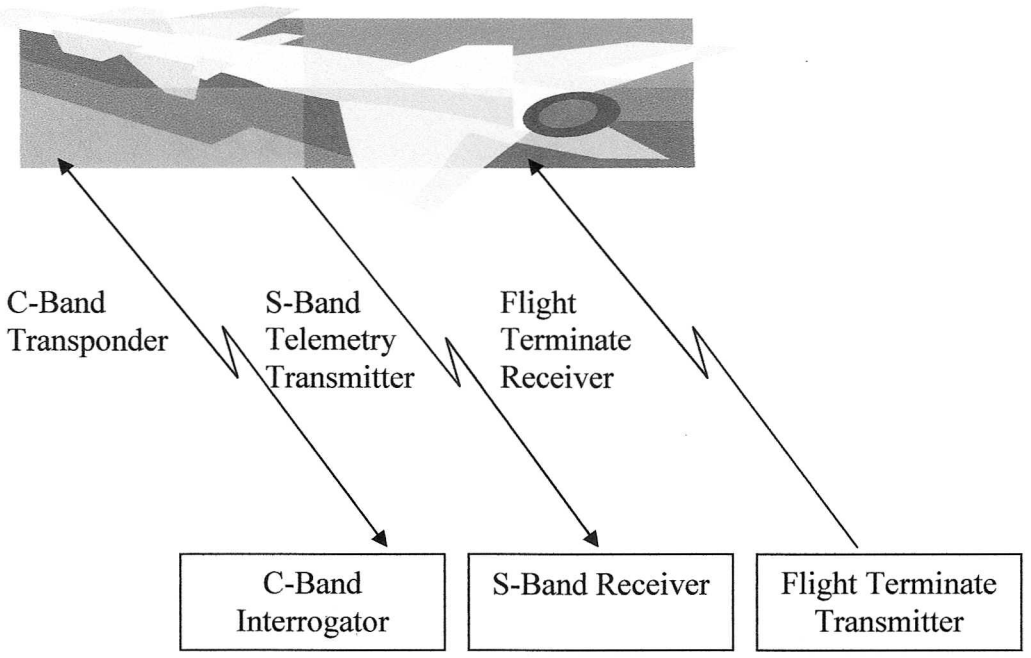
Additionally, in reviewing the FCC's regulations, we noted that the S band frequencies are not to be used for flight test of manned aircraft. The testing being conducted is not for any manned aircraft, but simply for product testing in the lab and on the production line.

As noted above, this application is being filed to request an experimental authorization because some of the testing is conducted by Raytheon for purposes of research and development. The frequencies proposed are those required by the customer, because the systems being tested are the systems that will be used by the customer in actual flight testing that will take place at DOD facilities.

Should there be any questions about this application, they should be directed to Thomas J. Fagan, Spectrum Manager, Raytheon Missile Systems, 520-794-0227, tjfagan@raytheon.com or to Anne Linton, Counsel, 301-980-2335, alc@wfslle.biz.



DOD Flight Test Configuration



Raytheon Engineering Development/Production Test Configuration