Raytheon Missile Systems
Application to Modify WF2XLI
File No: 0121-EX-ML-2016

Explanation of Modification 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, Raytheon tests communications systems in its products to make sure they meet customer specifications. Currently, RMS holds license WF2XLI for operations in Tucson, Arizona and Camden, Arkansas. This application seeks to modify WF2XLI in two ways: the application seeks to add emission designators to two frequency bands already authorized on the license, and it seeks to add an additional frequency band – 1435-1525 MHz – to allow for testing of the radios using that band. The ongoing experimental operations are for testing command and control systems in the lab and for factory missile communications testing, otherwise known as "missile check-out."

With this modification request, Raytheon is now seeking to hold an authorization for the four radio systems used in the field by Raytheon's customers for Range Safety. The four radio systems used for testing are the Flight Terminate Receiver (UHF), the newly requested L-Band Telemetry transmitter, the 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. This will add L band telemetry to the already-licensed systems installed on missiles that will be tested at government ranges. Further, this application would add additional emission designators to two frequency bands to ensure that those are properly tested as well. Prior to delivery of the product to the customer, the product must be tested as part of engineering development and production testing.

The actual missile flight testing is conducted at government test and training ranges using federal frequency assignments. Since the lab and production testing is ongoing 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 license these operations under an experimental authorization to allow for the proper, licensed operation of the missile during development and production testing.

Synopsis:

- New spectrum requested: 1435-1525 MHz
- Operations identical to those already authorized indoors
- Most operations will be hooded, limiting the reach of any RF signals.

- Power levels are limited.
- Time of use is limited – just about three (3) hours per day of spectrum use
- New Emissions requested: UHF: 180KF3D, C band: 15M0P0N

Description of spectrum use for production line preparation for missile test:

Newly requested L (1435-1525 MHz) and already licensed 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 of spectrum use of about 200 minutes, or just over three hours. Because the L, UHF, C band, and S band frequencies are used throughout the flight tests, Raytheon is seeking to modify its authorization for experimental testing in the lab and production facilities to cover the L band testing needed and to include two new emission designators for existing frequencies. The lab and production testing 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.

Transmitters are hooded: 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.

Frequencies in use:

UHF frequencies: 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
- New emission to be added: 180KF3D

S-band frequencies: 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 renewal application filed here, Raytheon has again requested authorization to use the full 40 W of power, which is only rarely required. Most of the testing continues to be done at a power level of approximately 5 watts. 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). Raytheon has 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. The telemetry data received over these frequencies helps the controllers determine the health and status of the missile in flight. No flight testing is performed at Raytheon Missile Systems.

C band frequencies: The C-band transponder system, operating at 5400-5900 MHz, is used for tracking the missile in flight. Raytheon has agreed to notch out operation in the 5600-5650 MHz band. This system includes an interrogator radar 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 missile simultaneously. The proposed experimental use in the lab and at the production facility will replicate the radar interrogations – but interrogations will only be 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 Raytheon's use, 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, 5600-5650 use is notched out
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
New Emission to be added: 15M0P0N

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.

L Band Frequencies: The L-Band telemetry transmitter operates in the 1435-1525 MHz band. 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.

It will use a PCM/FM or SOQPSK frequency modulation to transmit telemetry data to the controllers. Raytheon has 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. The telemetry data received over these frequencies helps the controllers determine the health and status of the missile in flight.

No flight testing is performed at Raytheon Missile Systems.

Spectrum Use Coordination:

Raytheon will submit a frequency coordination request to AFTRCC for the use of the telemetry frequencies. Raytheon will request that AFTRCC 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.

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 simply for product testing in the lab and on the production line.

Stop Buzzer Point of Contact:

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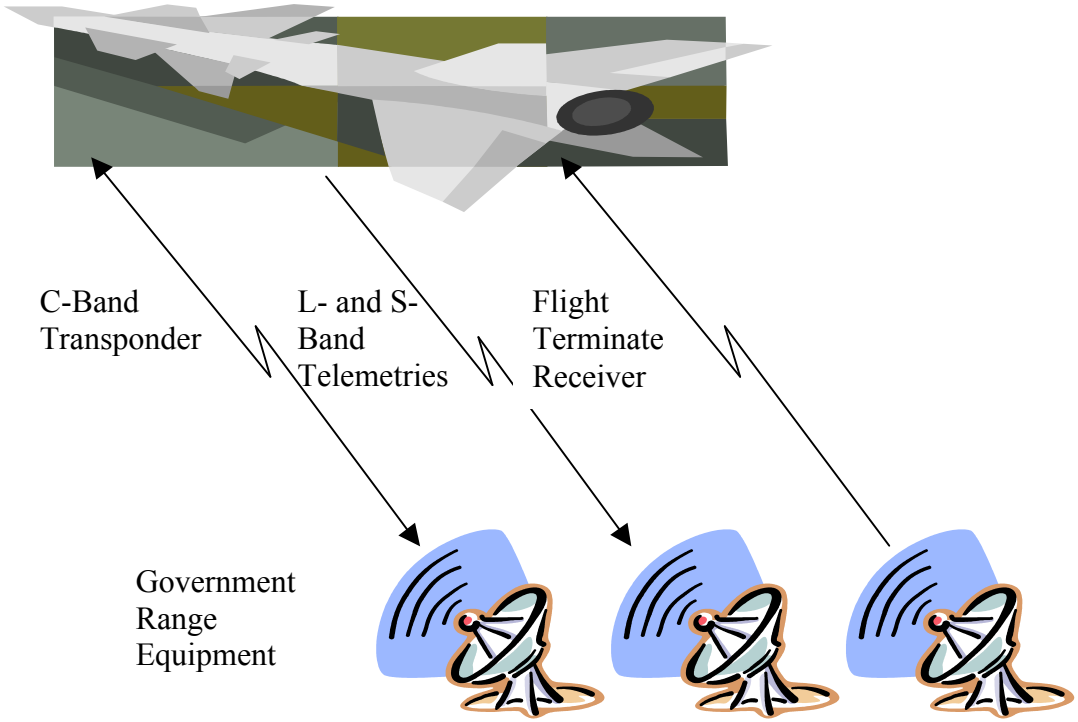
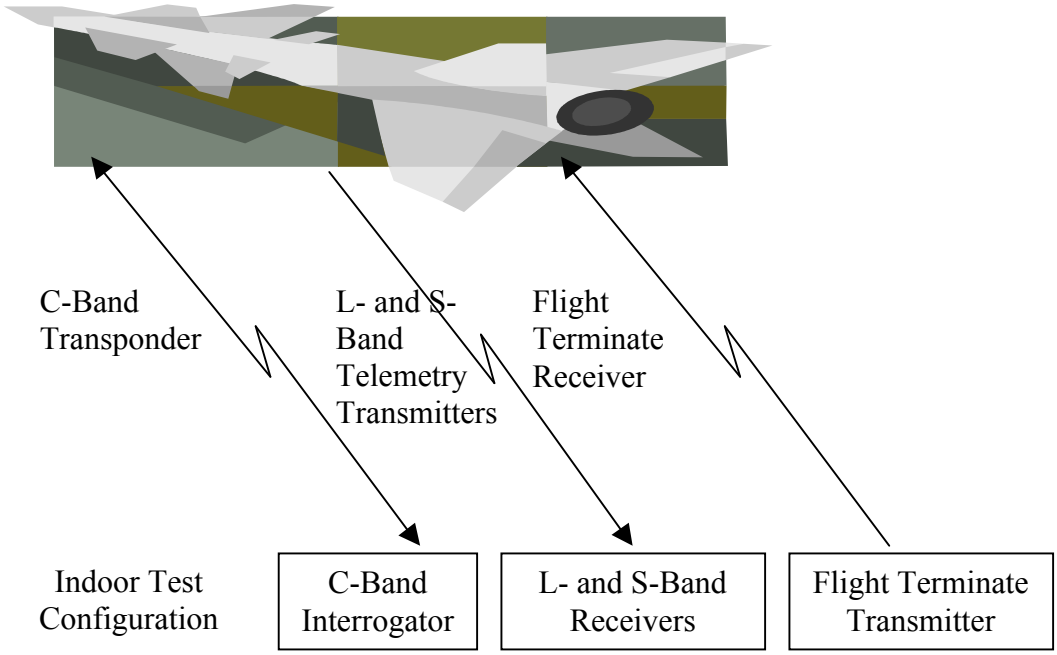
Conclusion:

As noted above, this application is being filed to modify an experimental authorization for testing conducted by Raytheon in its laboratories and production areas 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 Raytheon's DOD customers 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-Cortez, Counsel, 520-360-0925, alc@conspecinternational.com.



DOD Flight Test Configuration



Raytheon Engineering Development/Production Test Configuration