Raytheon Request for FCC Special Temporary Authorization (STA)

STA File Number 0146-EX-ST-2011
STA Confirmation Number EL838437
Dated 3/3/2011

Purpose of Operation:

Frequency authorization is being requested for the period of April 1, 2011 – September 31, 2011 in the 9.3 GHz to 10 GHz band in order to demonstrate the operation of a prototype radar system. This radar demonstration is intended to show maturity of key technologies designed and developed by Raytheon. It is essential that radar performance be demonstrated in a real-time radar environment similar to the proposed radar system. Testing in real-time environments with realistic target profiles is needed to fully prepare for a demonstration to the customer.

STA Explanation:

The Prototype Radar Demonstration System (PRDS) is planned to be operated at the Raytheon Facility in Fullerton, CA over the period of April 1, 2011 – September 31, 2011. The purpose of this request for Special Temporary Authorization is to demonstrate the maturity of our system concept and technology to the customer.

Test Summary:

An experimental license is required to demonstrate the operation of a prototype radar system to our customer. Starting in April 2011, transmit measurements will be made at low power using a subset of the radar array. These measurements will be in the operating frequencies of 9.3 GHz to 10 GHz. Following the subset array tests, the antenna will be fully assembled, calibrated and tested.

The prototype radar demonstration validation trials and dry runs are planned from July 1st to December 31st. A permanent experimental license will be requested to support testing over this time frame. Formal demonstrations for the customer will be conducted between October and December 2011. The system will transmit pulsed Frequency Modulated (Chirp), pulsed Non-Frequency Modulated (unmodulated) and pulsed Phase Coded waveforms. For all waveform types, the maximum pulse duration is 15µs and the maximum duty factor is 10%. It is expected that the radar will be operated 24 hours a day, seven days per week for the duration of the testing.

Raytheon's RF safety group is involved in this demonstration to ensure that no personnel are subjected to RF power density levels exceeding the Maximum Permissible Exposure (MPE) limits of the Part 1.1310 of the FCC Rules and the guidelines in FCC's OET Bulletin Number 65. Raytheon has a Company Policy and Environmental, Health and Safety Standard which addresses electromagnetic energy exposure control. It is Raytheon's policy to ensure that our personnel, the general public and our customers are not exposed to RF levels which exceed applicable standards. To that end, we will have an RF Safety Plan in place for the testing. The RF Safety Plan will define the procedures and controls required to prevent personnel exposure to levels which exceed the MPE. To verify the safety of personnel, an RF survey will be performed at the initial turn-on of the system. All measured levels, where personnel have access, must be below the MPE for uncontrolled environments before testing can proceed.

Raytheon has also evaluated the potential susceptibility of aircraft and Electro-Explosive Devices (EEDs) in or on aircraft during the operation of the prototype radar. The results show that there are no radiation hazards to personnel, aircraft, aircraft equipment or EEDs, during the proposed testing. These results are documented in a separate attachment.

Additional information is also provided in slides attached to this summary which cover test site layout and transmit scan coverage.

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Period of Use:
Start date: *April 1, 2011*
End date: *September 31, 2011*

Equipment Information:
Indicate all equipment that will be involved in this operation.

Transmitter info:
Manufacturer: *Raytheon*
Model: *Prototype Radar Demonstration System (PRDS)*
Number of units: *1*
Experimental (Y/N): *Y*

For each frequency band:
RF output at the transmitter terminals:
20,480 Watts peak, 2048 Watts average (10% Duty Cycle)
(This is the maximum RF output and accounts for losses between the output of the power amplifier and the radiating elements. This does not include front-end losses.)

Effective radiated power from the antenna (if pulsed emission, specify peak power):
The effective radiated power from the antenna, including antenna transmit gain and front-end losses, is 149.4MW (peak).

Frequency Tolerance:
Less than 0.001 %

List each type of emission separately for each frequency (basically list the emission designators)

21M8Q3N - *15µsec FM-Pulsed with a 10 MHz FM chirp, in the 9.3 – 10 GHz band*
27M0Q3N - *1µsec FM-Pulsed with a 10 MHz FM chirp, in the 9.3 – 10 GHz band*
424KP0N - *15µsec Unmodulated Pulsed, in the 9.3 – 10GHz band*
6M36P0N - *1µsec Unmodulated Pulsed, in the 9.3 – 10 GHz band*
21M9Q1N - *0.1µsec/sub-pulse (1.3µsec total pulse width) Phase Coded Pulsed with Barker code sequence, in the 9.3 – 10GHz band*

The transmit waveform pulse sequence is programmable. Three waveform types can be commanded: FM-Pulsed, Non-FM Pulsed (Unmodulated) and Phase Coded Pulsed. The FM-pulses are modulated with a programmable 10 MHz chirp and programmable pulsewidth from 1µsec to 15µsec. The Non-FM Pulses also have a programmable pulsewidth from 1µs to 15µs. The Phase Coded Pulses use a Barker code with a pulsewidth of 0.1µsec per sub-pulse. All waveform types operate in the 9.3 to 10GHz band.

The max duty factor is 10%, and the max pulse repetition frequency is 70kHz for all waveform types. During development, a partial subset of the antenna array may be used. However, the keep out zones for testing the partial subset of the antenna array will be the same as used for the full antenna array.

List as appropriate for the type of modulation:

Maximum speed of keying in bauds:	*Not Applicable, not a communication device*
Maximum audio modulating frequency**:**	*Not Applicable*
Frequency deviation of carrier:	*Not Applicable*
Pulse duration and rep rate:	*15µsec maximum pulse width, 70kHz maximum rep rate (10% duty factor maximum at any pulse duration/rep rate combination)*
For complex emissions, describe in detail:	*Linear and Non-Linear Frequency-Modulated Pulsed (Chirp)*
	Non Frequency-Modulated Pulsed (unmodulated/ pulsed CW)
	Phase Coded Pulsed

Necessary bandwidth. Explain how determined.

The necessary bandwidth was calculated using the equations in Annex J of the NTIA Manual. The slides at the end of this document provide the details of this calculation.

Locations:

The Raytheon facility in Fullerton, CA, is located at North 33°52'52.33", West 117°57'24.74"and ground elevation of 55 meters above sea level. The street address is 1801 Hughes Dr, Fullerton, CA 92833. The approximate location of the radar will be at North 33.881792°, West 117.952497° (North 33°52'54.4", West 117°57'8.9") at 57 meters above sea level.

Is a directional antenna (other than radar used)?
No. (Although not necessary for this application, additional antenna detail is provided)

If yes, give the following info:
Width of beam in degrees at the half-power point:
1.6° Azimuth, 1.7° Elevation
Orientation in horizontal plane:
+/- 45° Electronically Scanned, 360° with Rotating Antenna
(This is the full capability of the system. Orientation will be limited via software-defined radiation control zones)
Orientation in vertical plane:
-10° to 55°, relative to ground horizontal
(This is the full capability of the system. Orientation will be limited via software-defined radiation control zones)

Will the antenna extend more than 6 meters above ground, or if mounted on an existing building, will it extend more than 6 meters above the building, or will the proposed antenna be mounted on an existing structure other than a building?
No, the entire radar and antenna are installed on a small mobile trailer. (Although not necessary for this application, additional detail related to height and location relative to airports is provided)

If Yes,
Overall height above ground to tip of antenna in meters:
3.4m
Elevation of ground at antenna site above mean sea level in meters:
55m
Distance to nearest aircraft landing area in km:

Fullerton Municipal Airport - Fullerton, CA (FUL / KFUL)	*4.8km*
Industry Sheridan - Industry, CA (JID)	*16.1km*
Long Beach Airport - Long Beach, CA (LGB / KLGB)	*19.3km*
El Monte Airport - El Monte, CA (EMT / KEMT)	*24.1km*
John Wayne Airport – Santa Ana, CA (SNA / KSNA)	*24.1km*
LA/Ontario International Airport – Ontario CA (ONT / KONT)	*38.6km*
Los Angeles International Airport – Los Angeles, CA (LAX / KLAX)	*41.8km*

List any natural formations of existing man-made structures (hills, trees, water tanks, etc) which in the opinion of the applicant would tend to shield the antenna from aircraft and thereby minimize the aeronautical hazard of the antenna:
None.

See the attached figure for a top view of the radar test site. The radar normally rotates and scan coverage is controlled through the use of software-set radiation control zones. The Fullerton, CA Test Facility is cordoned off on Raytheon property. Please see the attached slide presentation for a complete analysis of the power density levels to ensure personnel safety and aircraft/EMI

susceptibility. The results of the analysis will define the Keep Out Zones and coverage limitations.

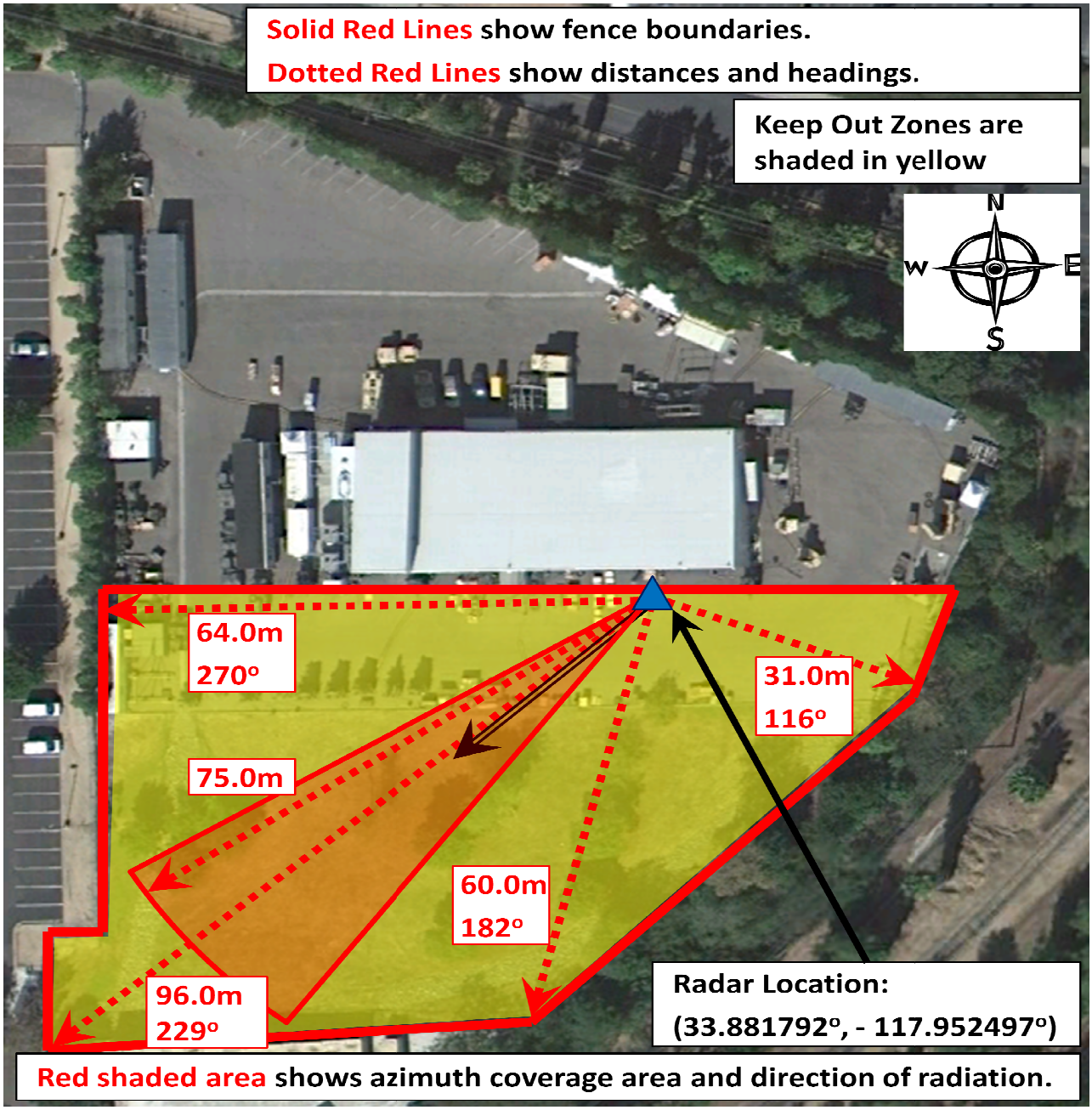

Figure 1: Fullerton, CA Test Facility. *This graphic depicts the location of the radar at the test facility, as well as the intended azimuth coverage area and direction of radiation. The shaded yellow area defines the Keep-Out Zones (KOZ). Beyond the regions of the KOZ, the power density levels are below limits for uncontrolled environments (see attached power density analysis slide presentation).*

Transmission Mode Table

Transmitter Waveform Modes											
Mode Emissions Designator	Center Frequency (GHz)	Azimuth Scan Coverage (degrees)	Elevation Scan Coverage (degrees)	Azimuth Beam Width (degrees)	Elevation Beam Width (degrees)	Pulse Width (µsec)	Max Duty Factor %	Peak ERP (MW)	Average ERP (MW)	Max FM Chirp BW (MHz)	Necessary BW (MHz)
21M8Q3N	9.3-10	+/- 45	(-10 to 55)	1.6	1.7	15	10	149.4	14.94	10	21.8
27M0Q3N	9.3-10	+/- 45	(-10 to 55)	1.6	1.7	1	10	149.4	14.94	10	27.0
424KP0N	9.3-10	+/- 45	(-10 to 55)	1.6	1.7	15	10	149.4	14.94	N/A	0.424
6M36P0N	9.3-10	+/- 45	(-10 to 55)	1.6	1.7	1	10	149.4	14.94	N/A	6.36
21M9Q1N	9.3-10	+/- 45	(-10 to 55)	1.6	1.7	0.1 (sub-pulse) 1.3 (total)	10	149.4	14.94	N/A	21.9

Necessary bandwidth calculation Table

FM-Pulsed Radar		
Pulse Width (µsec)	15	1
Rise Time (µsec)	0.067	0.067
Fall Time (µsec)	0.067	0.067
Chirp BW (MHz)	10	10
Necessary BW (MHz)	21.8	27.0
Designator	21M8Q3N	27M0Q3N

Non-FM Pulsed Radar		
Pulse Width (µsec)	15	1
Rise Time (µsec)	0.067	0.067
Fall Time (µsec)	0.067	0.067
[Pulse Width]/[Rise Time]	223.9	14.9
Necessary BW (MHz)	0.424	6.36
Designator	424KP0N	6M36P0N

Phase Coded Pulsed Radar	
Sub-Pulse Width (µsec)	0.1
Rise Time (µsec)	0.067
Fall Time (µsec)	0.067
[Pulse Width]/[Rise Time]	1.49
Necessary BW (MHz)	21.9
Designator	21M9Q1N

Necessary BW Formula

Symbols:

t	=	*Emitted pulse duration at 50% amplitude (voltage) points. The 100% amplitude point is the nominal peak level of the pulse.*
t_r	=	*Emitted pulse rise time in µsec from the 10% to the 90% amplitude points on the leading edge.*
t_f	=	*Emitted pulse fall time in µsec from the 90% to the 10% amplitude points on the trailing edge.*

FM-Pulsed Radar:

$$B_n = B(-20dB) = \frac{1.79}{\sqrt{t_r t}} + 2B_c$$

**If t_f is less than t_r, then t_f is to be used in place of t_r when performing the necessary bandwidth calculations.*

Non-FM Pulsed Radar:

If $\frac{t}{t_r} < 12.6$, then:

$$B_n = B(-20dB) = \frac{1.79}{\sqrt{t_r t}}$$

Otherwise:

$$B_n = B(-20dB) = \frac{6.36}{t}$$

**If t_f is less than t_r, then t_f is to be used in place of t_r when performing the necessary bandwidth calculations.*

Phase Coded Pulsed Radars:

$$If \ \frac{t}{t_r} < 12.6 \text{, then:}$$

$$B_n = B(-20dB) = \frac{1.79}{\sqrt{t_r t}}$$

Otherwise:

$$B_n = B(-20dB) = \frac{6.36}{t}$$

**If t_f is less than t_r, then t_f is to be used in place of t_r when performing the necessary bandwidth calculations.*

***For phase coded pulse signals the pulse width and rise times are those associated with a single sub-pulse. If the rise time of a single sub-pulse is not available, assume it is 40 % of the time to switch from one phase or sub-pulse to the next*

Designators

FM-Pulsed Radar

Designators (NTIA)			
Prefix	Necessary Bandwidth	##M#	Megahertz with M at decimal
Emissions	Type of Modulation Main Carrier	Q	In which the carrier is angle-modulated during the period of the pulse (i.e. chirp, FM).
Emissions	Nature of signals modulating	3	A single channel containing analogue information.
Emissions	Type of Info transmitted	N	No Information Transmitted.

Non-FM Pulsed Radar

Designators (NTIA)			
Prefix	Necessary Bandwidth	##M#	Megahertz with M at decimal
Emissions	Type of Modulation Main Carrier	P	Sequence of unmodulated pulses.
Emissions	Nature of signals modulating	0	No Modulating Signal.
Emissions	Type of Info transmitted	N	No Information Transmitted

Phase Coded Pulsed Radar

Designators (NTIA)			
Prefix	Necessary Bandwidth	##M#	Megahertz with M at decimal
Emissions	Type of Modulation Main Carrier	Q	In which the carrier is angle-modulated during the period of the pulse (i.e. chirp, FM).
Emissions	Nature of signals modulating	1	Single channel containing quantized or digital information without the use of a modulating sub-carrier, excluding time-division multiplex.
Emissions	Type of Info transmitted	N	No Information Transmitted.