09-August-18

SRI International S-band Land Based and Airborne Radar Experiment

This document describes SRI International's S-band land based and airborne radar experiment which is the subject of the FCC Experimental License application.

Experiment Description

SRI has been testing an experimental S-band radar system under FCC License 0142-EX-CN-2018, Call Sign WJXNG. The radar system is designed to generate synthetic aperture radar (SAR) and interferometric synthetic aperture radar (InSAR) imagery for the purpose of measuring land deformation. The radar system is built by SRI International and consists of a custom transmitter and receiver unit and utilizes an antenna with up to 21 dB gain. The radar system is being tested in stationary ground configurations, on ground vehicles, and on aircraft. Radiative testing of the system will be infrequent: less than one week of outdoor and flight testing per month at 4 hr intervals or less.

SRI is seeking to modify the frequency of operation for the radar, add frequencies for additional communication systems, and increase the area of operation for License 0142-EX-CN-2018. SRI is asking to modify the radar operation frequency to 2.93625-3.35GHz. SRI is seeking to add two additional communication channels, one at L band (1.616 to 1.6265GHz) and one at C band (5.1 to 5.7GHz). Additionally, SRI would like to increase the operation area of the radar to include ~200mi east of Menlo Park, CA. Encompassing a rectangle extending from 36.55N, 117.45W to 38.35N, 122.2W, depicted in Figure 1.

Radar Description

As discussed above, the radar consists of a custom S-band transmitter and receiver unit designed and built by SRI International. The radar transmits a linear FM chirp signal over 2.93625 to 3.35 GHz. The waveform has a 200 MHz bandwidth. The transmitter outputs the waveform with an average power of 60 W. A 21 dBi gain antenna is used with the transmitter, resulting in an EIRP of 7500 W average. The radar will operate with a nominal pulse repetition frequency (PRF) of 2500 Hz, a pulse width of 40 microseconds, and a duty cycle of 10%. The radar antenna has a beamwidth of 10 deg in the azimuth (horizontal) plane and 27 deg in the elevation plane. The directive antenna will be pointed at a depression angle between 20 and 60 deg below the horizon.

During ground-based outdoor testing, the antenna will be placed on the roof of an approved facility or other raised platform and pointed down to the ground. Additional ground based testing would include operation from a truck, car, man-lift, or other ground based moving platform. The antenna could be oriented in any azimuth direction during testing. During airborne testing, the antenna will be mounted to the aircraft in a fixed orientation. As the aircraft flies, the antenna's azimuth pointing direction will change with respect to the aircraft flight pattern, thus the antenna could be pointed in any azimuth direction.

Figure 2 below shows a schematic of the SRI S-band radar system.

UHF Ground-Radar Communication Link Description

SRI will maintain communication with the radar payload via a 900 MHz ISM-band communication link. Both the ground station and the radar will utilize a Digi XLR Pro commercial transceiver that operates over 910 to 920 MHz. The transceiver utilizes a chirp spread-spectrum waveform to minimize interference with other transceivers. For the ground station, the transceiver unit will output an average power of 1 W and be connected to a 13.5 dBi gain antenna for an average EIRP of 22 W. For the radar side of the link, the transceiver unit will output an average power of 1 W and be connected to a 3 dBi gain antenna for an average EIRP of 2 W. SRI will operate a mobile ground station that will follow the that will maintain periodic communication with the radar payload. SRI will utilize a maximum of two mobile ground stations to communicate with the radar payload.

L Band Satellite-Radar Communication Link Description

The Iridium link is a commercial off the shelf satellite communications solution. The Iridium link uses Time-Division Multiple Access (TDMA) and Frequency-Division Multiple Access (FDMA) transmission schemes, with a Differentially Encoded Quadrature Phase Shift Keyed (DEQPSK) modulation scheme. The Iridium satellite constellation operates from 1616MHz to 1626.5MHz. The radar payload will have two of these Iridium links. Each of these links average RF power is ~7W, and a standard 3dBi “Hockey Puck” antenna is connected, giving a EIRP of ~14W. The beamwidth is ~145 degrees.

C Band Ground-Radar Communication Link Description

The C Band link is a commercial off the shelf satellite communications solution, purchased from Cambium Networks. The Cambium Networks link uses Time-Division Duplex (TDD) transmission scheme, with a fast preemptive adaptive modulation scheme, featuring 13 modulation/FEC coding levels ranging from BPSK to 256 QAM dual payload MIMO. The Cambium Networks link operates from 4.9GHz to 6.05GHz, with allowable frequencies and bands dependent on country of operation regulations. The link will be restricted to operation between 5.1 and 5.7GHz to avoid potential interference with DSRC systems supporting public safety in the 5850 - 5925 MHz band and to avoid potential interference with Radio Astronomy in the 4.990 - 5.000 GHz band. The system picks the least-occupied channels available, but can be configured to disable a list of specific channels. The radar payload will have one Cambium Networks PTP670 Transmitter, and the mobile ground station has one as well. Each of these transmitters peak RF power is ~0.5W. These transmitters are certified to comply with FCC 47 CFR Part 90 (Outside the UNII band) and Part 15e (inside the UNII band), FCC Identifier QWP-50670. The radar payload has a MARS 23dBi dual polarization panel antenna, part number: MA-WA56-DP23B, giving an EIRP of ~100W, this antenna has a 3dB beamwidth of ~10 degrees in both V and H planes. The ground station has a MARS 26dBi dual polarization antenna, part number: Mars MA-WA55-27-B, giving an EIRP of ~200 W, this antenna has a 3dB beamwidth of ~7.5degrees in both V and H planes.

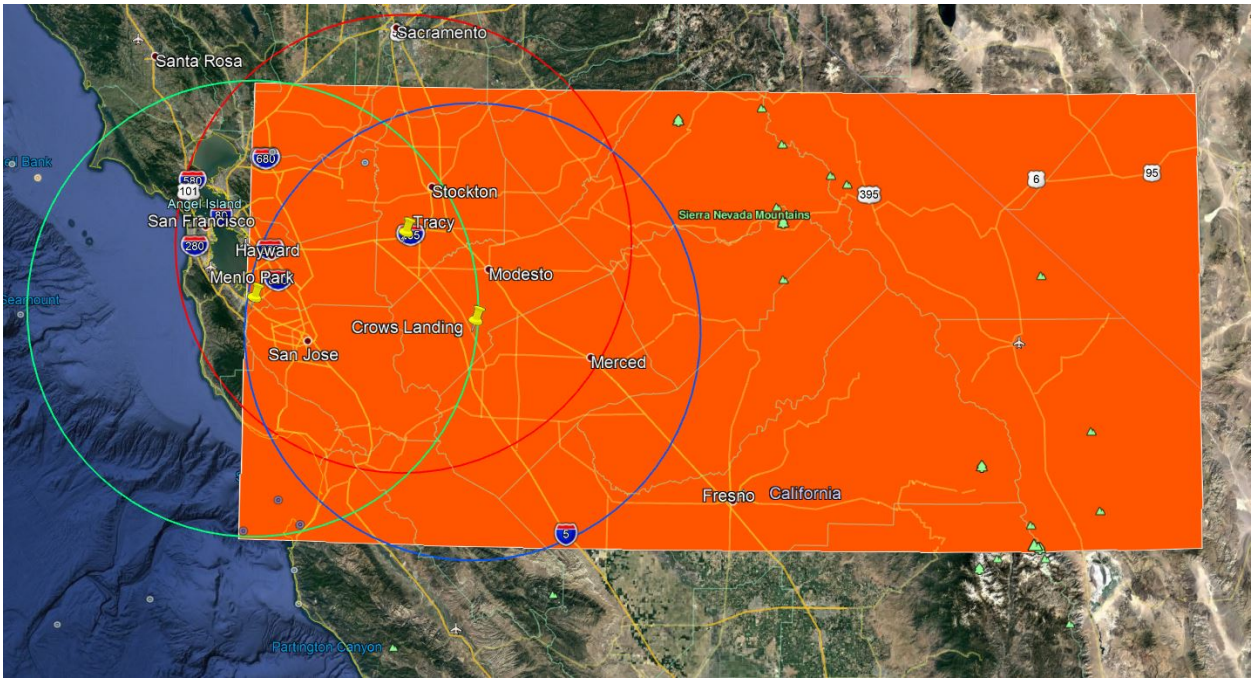

Figure 1. Desired area of operation. Circles indicate already granted areas of operation under 0142-EX-CN-2018. Orange rectangular region is additional area of operation that SRI is requesting.

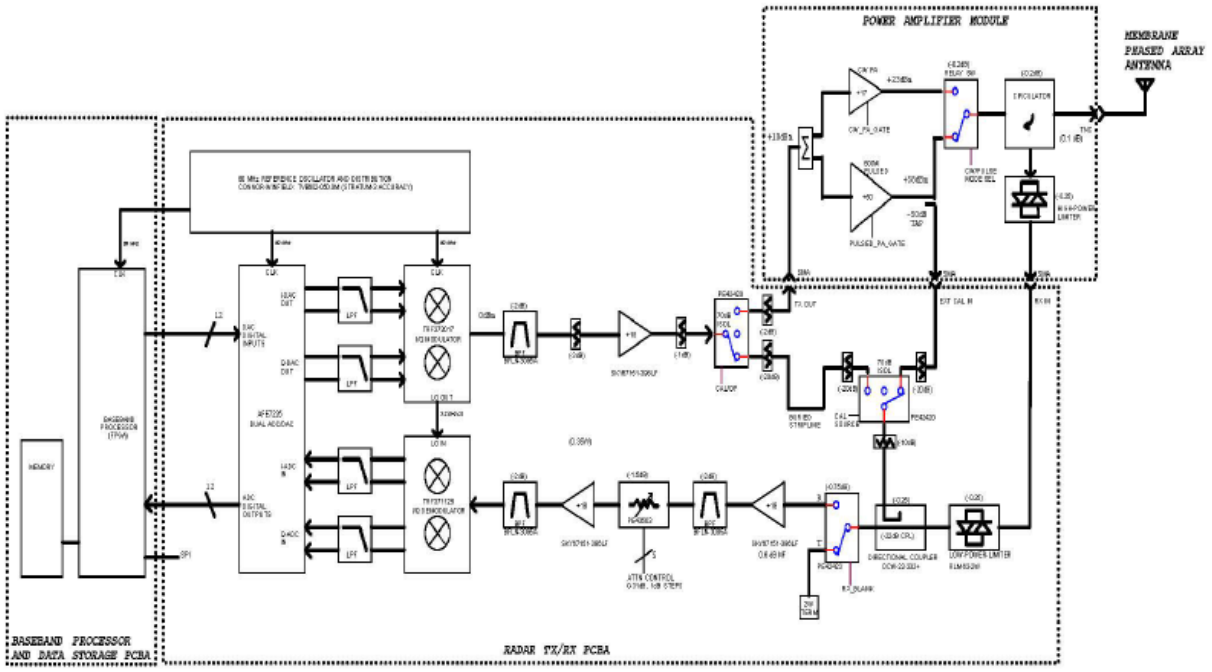

Figure 2. SRI International Experimental S-band Radar System

Table 1. Radar and Comm Link Transmitter Parameters

	Radar Payload Transmitter	**UHF Radar Payload Comm Link Transmitter**	**UHF Ground Station Comm Link Transmitter**	**C-Band Radar Payload Comm Link Transmitter**	**C-Band Ground Station Comm Link Transmitter**	**Radar Payload Satellite Link Transmitter**
Frequency Range	2.93625 to 3.35 GHz	910 to 920 MHz	910 to 920 MHz	4.9 to 6.05 GHz **(Restricted to 5.1 to 5.7GHz)**	4.9 to 6.05 GHz **(Restricted to 5.1 to 5.7GHz)**	1616 to 1626.5 MHz
Bandwidth	200.0 MHz	10 MHz	10 MHz	5, 10, 15, 20, 25, 30, 35, 40, 45 MHz	5, 10, 15, 20, 25, 30, 35, 40, 45 MHz	10.5MHz
Emission Designation	200MM3N	10M0F3D	10M0F3D	5M00D2D 45M0D2D	5M00D2D 45M0D2D	10M5M7D
Waveform Type	Pulsed linear FM chirp	Chirp Spread Spectrum	Chirp Spread Spectrum	OFDM-BPSK, OFDM-QPSK, OFDM-QAM	OFDM-BPSK, OFDM-QPSK, OFDM-QAM	Differentially Encoded QPSK
Transmit Power, Avg	60 W	1 W	1 W	0.5 W (Max)	0.5 W (Max)	7 W
Transmit Antenna Gain	21 dBi	3 dBi	13.5 dBi	23 dBi	26 dBi	3 dBi
EIRP, Avg	7500 W	2 W	22 W	100 W	200 W	14 W
Transmitter Part Number	SRI custom	Digi XLR Pro	Digi XLR Pro	Cambium Networks PTP670	Cambium Networks PTP670	9522B DataMODEM RST600B and RockBlock MK2
Antenna Part Number	SRI custom	L-Com HG903RD-SM	KP Performance KPPA-900DP-FP	MA-WA56-DP23B	Mars MA-WA55-27-B	Iridium Aero Antenna

<u>Key Changes from FCC Experimental License already Granted</u>

- Frequency band: 2.93625 to 3.35 GHz for Radar Transmitter
  - Bandwidth: 200 MHz
- Two additional communications links
  - L Band (1.616 to 1.6265GHz
  - C Band (5.1 to 5.7GHz)
- Area of operation around Menlo Park, CA increased ~200 mi east