

SRI International S-band High Altitude Balloon Radar Experiment

This document describes SRI International's high altitude balloon radar experiment and the need for Special Temporary Authority (STA) license through the FCC.

Experiment Overview

SRI is planning to test an experimental S-band radar system on a high altitude balloon in November 2017. The radar system is designed to generate synthetic aperture radar (SAR) and interferometric synthetic aperture radar imagery for the purpose of measuring land deformation. The radar system is built by SRI International and consists of a custom transmitter, receiver unit, and antenna unit. In addition to the radar, the balloon payload will include a 900 MHz communication link that allows data and control command transfer between the airborne balloon and a nearby ground station.

The planned balloon flight path extends from Elko, NV to Carr, CO. While aloft, the balloon will fly at altitudes between 55,000 and 95,000 ft. The radar will operate on a sporadic basis over this flight path, perhaps only once an hour, while the balloon-ground station link will be operated more regularly over the flight path to upload payload commands and downlink radar data and telemetry.

Balloon Payload Radar Description

The SRI radar consists of a custom S-band transmitter and receiver unit designed and built by SRI International. The radar transmits a pulsed linear FM chirp signal over 2.9375 to 2.950 GHz. The waveform has a 12.5 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. Figure 3 shows a schematic of the SRI S-band radar system.

The radar transmitter has the following emission mask, which was measured in the laboratory with a spectrum analyzer at 330 kHz resolution bandwidth

- -3 dB bandwidth: 12.7 MHz
- -20 dB bandwidth: 15.0 MHz
- -40 dB bandwidth: 19.0 MHz
- -60 dB bandwidth: 27.0 MHz

Spurious and harmonic emission measurements were also made of the radar transmitter outputs:

- Spurious emissions over 2.90 to 2.95 GHz: -40 dBc
- Spurious emissions out of band: -60 dBc
- Harmonics: -40 dBc

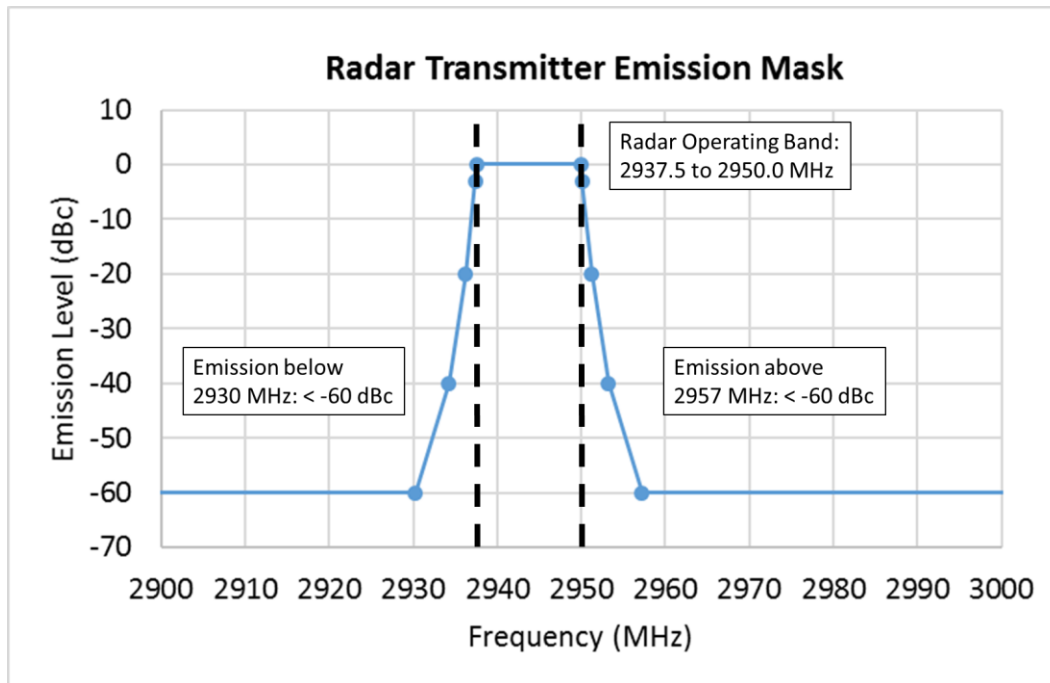


Figure 1. Radar Transmitter Emission Mask

Prior to launching the balloon, the radar will be tested on the ground in Baltic, SD to check EMI emissions. When installed on the balloon, the antenna will be mounted in a fixed orientation. As the balloon flies, the antenna's azimuth pointing direction may change with respect to the balloon flight pattern due to winds aloft, thus the antenna could be pointed in any azimuth direction.

Ground-Balloon Communication Link Description

While the balloon is airborne, SRI will maintain communication with the balloon radar payload via a 900 MHz communication link. Both the ground station and the balloon 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 balloon 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. While the balloon is aloft SRI will operate a mobile ground station that will follow the balloon flight path on the ground and maintain periodic communication with the balloon payload. SRI will utilize a maximum of two mobile ground stations along the balloon flight path at a time.

Balloon Flight Path

The balloon will launch from Elko, NV and fly toward Carr, CO. SRI is requesting the STA license to operate the radar and comm link at any location within 150 km of the expected flight path. The flight path passes within 150 km of the following cities: Elko, NV; West Wendover, NV; Dugway, UT; Evanston, WY; Price, UT; Rock Springs, WY; Grand Junction, CO; Creston, WY; Eagle, WY; Laramie, WY; Carr, CO.

Table 1. Cities within 150 km of Expected Balloon Flight Path

Location	Latitude	Longitude
Elko, NV	N 40 49' 55"	W 115 45' 53"
West Wendover, NV	N 40 44' 21"	W 114 04' 23"
Dugway, UT	N 40 13' 17"	W 112 44' 40"
Evanston, WY	N 41 16' 05"	W 110 57' 50"
Price, UT	N 39 35' 58"	W 110 48' 38"
Rock Springs, WY	N 41 35' 18"	W 109 12' 06"
Grand Junction, CO	N 39 03' 53"	W 108 33' 01"
Creston, WY	N 41 42' 14"	W 107 45' 24"
Eagle, CO	N 39 39' 21"	W 106 49' 43"
Laramie, WY	N 41 18' 42"	W 105 35' 28"
Carr, CO	N 40 53' 35"	W 104 52' 42"

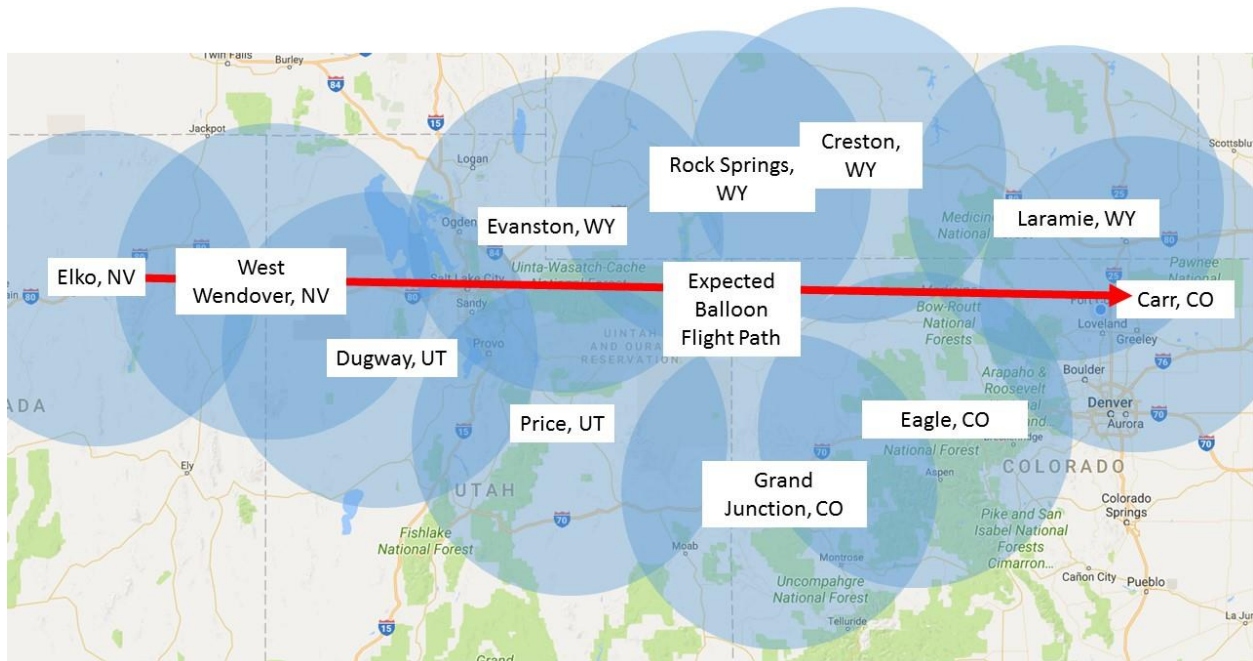


Figure 2. Expected Balloon Flight Path and STA License Application Areas with 150 km Radius

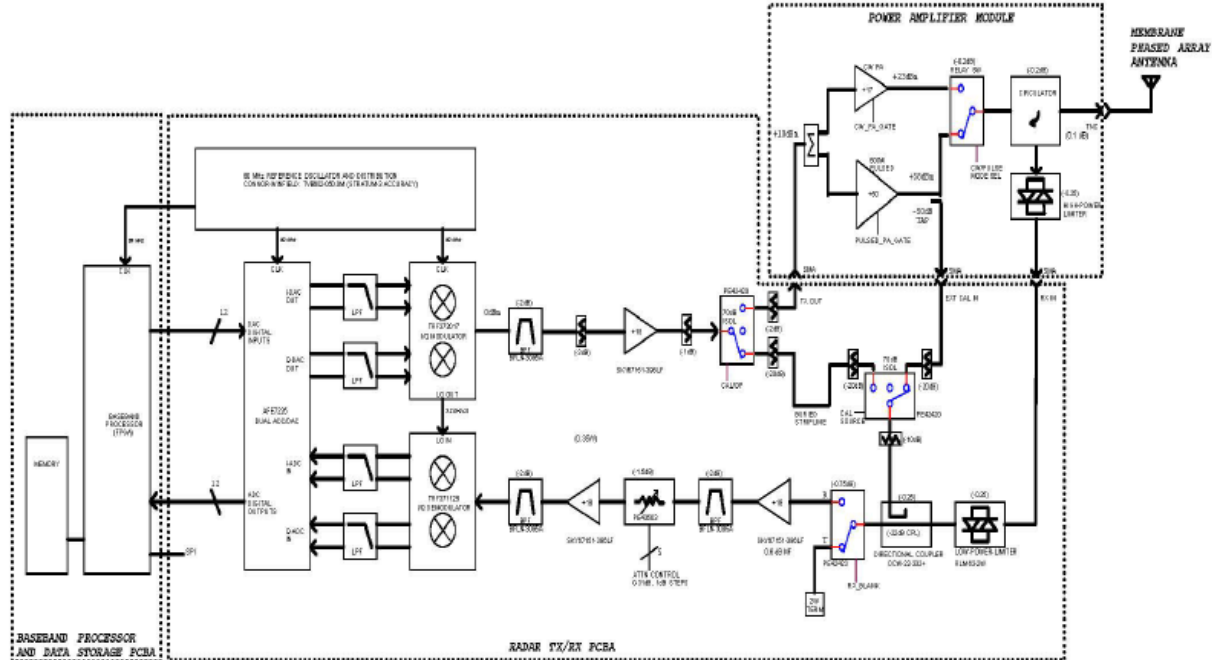


Figure 3. SRI International Experimental S-band Radar System

Table 2. Balloon Radar and Comm Link Transmitter Parameters

	Balloon Radar Transmitter	Balloon Comm Link Transmitter	Ground Station Comm Link Transmitter
Frequency Range	2.9375 to 2.9500 GHz	910 to 920 MHz	910 to 920 MHz
Bandwidth	12.5 MHz	10 MHz	10 MHz
Emission Designation	12M5M3N	10M0F3D	10M0F3D
Waveform Type	Pulsed linear FM chirp	Chirp Spread Spectrum	Chirp Spread Spectrum
Transmit Power, Avg	60 W	1 W	1 W
Transmit Antenna Gain	21 dBi	3 dBi	13.5 dBi
EIRP, Avg	7500 W	2 W	22 W
Transmitter Part Number	SRI custom	Digi XLR Pro	Digi XLR Pro
Antenna Part Number	SRI custom	L-Com HG903RD-SM	KP Performance KPPA-900DP-FP