Space Dynamics Laboratory
Utah State University Research Foundation

FCC FORM 442: Exhibit A

FlexSAR-X Air-to-Air Experimentation Description

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Submitted By:
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1. INTRODUCTION

The Space Dynamics Laboratory (SDL) submits this document as Exhibit A of FCC Form 442 and in accordance with Section 5.3(b), (d) and (h) of CFR Title 47 for the purpose of testing and further developing its Flexible Synthetic Aperture Radar (FlexSAR-X), which operates between 9.5 and 10 GHz . A previous license was granted (WI2XDQ) for the same experiment and the same specifications, but a renewal was not submitted before it expired February 01, 2018. This document provides supporting information and justification for the license application.

2. PROGRAM OF RESEARCH DESCRIPTION

The FlexSAR-X program is a development effort funded internally at SDL. The objective is to build and test a SAR system that is capable of working in X-band as a research tool for airborne SAR applications.

2.1 EQUIPMENT DESCRIPTION

The FlexSAR-X system consists of a Versa Module Eurocard (VME) chassis, solid state power amplifiers (SSPA) and an antenna. The VME chassis is 19”W x 15.75”H x 19.5”D, weighs 40 lbs and contains cards that provide a stable local oscillator, frequency conversion, pulse generation, analog to digital conversion, signal processing, and command and control. A chirp pulse is generated from the output of a digital to analog conversion (DAC), then up-converted to L-band and finally up-converted to X-band. The receiver reverses the process by down-converting from X-band to L-band and then from L-band to baseband. Bandpass and lowpass filters are incorporated on each stage of the transmitter and receiver to suppress unwanted out-of-band frequencies. The SSPA is only enabled during transmission of a pulse.

Each antenna polarization, horizontal and vertical (H and V), has a dedicated channel. The transmitter and receiver share the same antenna polarizations and are isolated from each other by a circulator. Each channel is connected to an SSPA before being connected to the antenna through the circulator. An X-band antenna built by Technology Service Corporation (TSC), is used for transmit and receive.

Figure 1. The FlexSAR-X VME chassis.

The FlexSAR-X system specifications are detailed in Table 1. The modification to the existing license are shown in bold.

Table 1. FlexSAR-X Specifications

RF Hardware	Space Dynamics Laboratory
Frequency	9500 to 10,000 MHz
Waveform Modulation	Pulse
Peak Transmitter Power	**300 W (54.8 dBm)**
Avg Transmitter Power	**60 W (47.8 dBm) (max)**
Pulse Repetition	16,000 pps (typ), **100,000 pps (max)**
Transmitter Type	Linear Frequency Modulated Pulse
Transmitter Tuning	**Digital to Analog Converter (DAC)**
Transmitter Frequency	0.0000001 ppm
Transmitter Power Amp	
Manufacture	Comtech PST
Model Number	BPMC958109-300
Transmitter Harmonic	
2^{nd} (dBc)(max)	-40.0
3^{rd} (dBc)(max)	-50.0
Maximum Spurious	-60.0
Fundamental Curve	
-3.0 dBc	9560.10, 10085.00 MHz
-20 dBc	9543.00, 10130.68 MHz
-40 dBc	9513.00, 10155.80 MHz
-60 dBc	9459.00, 10185.95 MHz
Transmitter Filter	Bandpass, pre-power amplifier
Antenna Manufacture	TSC
Antenna Model Number	I1114
Antenna Gain	30 dBi
Antenna Beamwidth	
Horizontal	5 degrees
Vertical	5 degrees
Antenna Mounting	Antennas are aircraft-mounted, under aircraft

2.2 THEORY OF OPERATION

The FlexSAR-X system collects data from an airborne platform while being controlled by an onboard operator. The RF card chassis is mounted inside the aircraft, and the antenna is mounted on a 2-axis gimbal on the outside of the fuselage.

The gimbal is capable of pointing the antenna through an elevation range of 60 degrees below to 60 degrees above the horizon, as shown in Figure 2. This enables air-to-ground and air-to-air data collection. During the pre-flight planning process, areas of interest are identified that present scenes and objects to test the imaging fidelity of the SAR system.

For air-to-ground operations the aircraft typically flies a race-track pattern around the area of interest, with FlexSAR-X actively transmitting and receiving energy during the straight portion of the track, as shown in Figure 3. Top-down view of a typical flight path used to collect data of an area of interest.

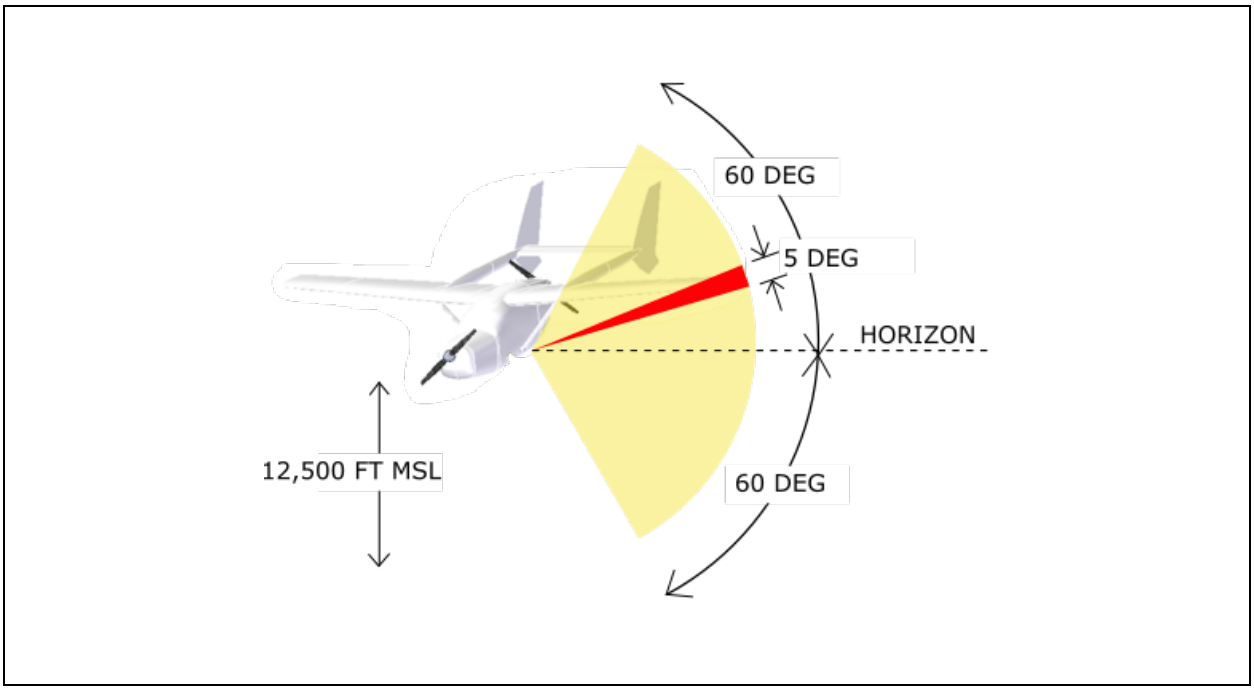

Figure 2. The antenna is mounted such that energy is directed to the left and angled downward towards the ground.

The race-track pattern is pre-planned to present the scene at a nominal altitude and slant range. The onboard operator monitors the aircraft position and heading to determine when the areas of interest enter the beam of the antenna. The operator turns on and off the transmitter when the area of interest enters and leaves the beam, respectively. The system operation modes and transmit on/off are controlled by the operator from a software application developed by SDL, but there are also panel switches that can disable the transmitter in the event the software is not functioning. The operator is an experienced member of SDL staff.

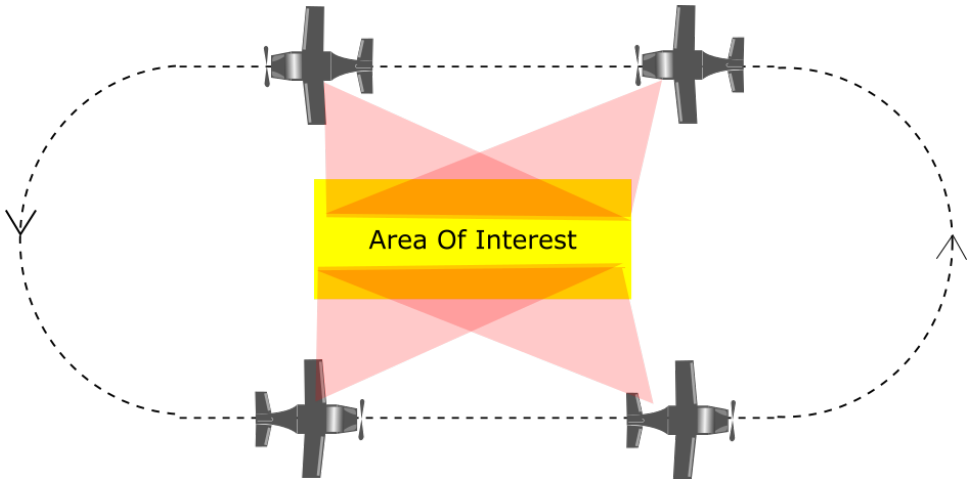

Figure 3. Top-down view of a typical flight path used to collect data of an area of interest.

For air-to-air operations there will be a second, cooperating aircraft acting as a target. The aircraft flight patterns will be de-conflicted for safety. One example, shown in Figure 4, is having the two aircraft fly parallel paths in opposite directions at different altitudes for de-confliction. The target aircraft will be imaged at slant ranges ranging from 5 to 18 km.

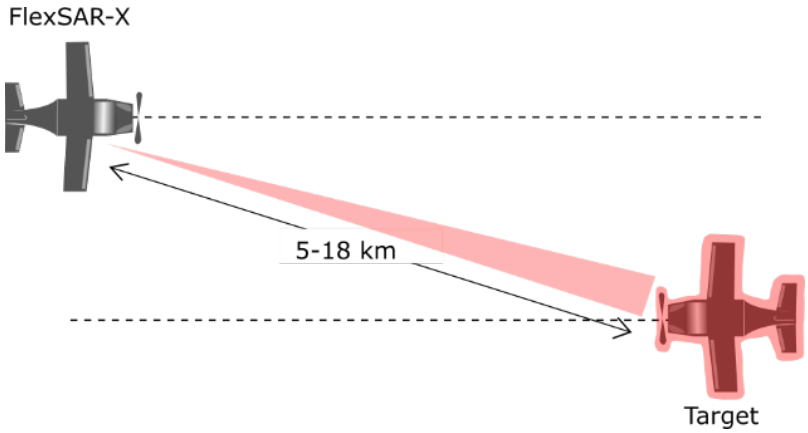

Figure 4. Top-down view of an air-to-air collection scenario.

3. DESCRIPTION OF EXPERIMENT

3.1 EXPERIMENT OBJECTIVES

The primary purpose for flight testing the FlexSAR-X system is to observe system performance in a real-world environment. This includes the characterization of key metrics, such as signal-to-noise ratio, and provides feedback for engineering further improvements. Also, it is desired to obtain a better understanding of how system parameters affect the sensor's ability to resolve certain objects of interest in different clutter backgrounds.

3.2 PROPOSED LOCATIONS

SDL seeks authority to carry out its test flights in three locations as specified in the table and shown on the map in Figure 4. The areas were chosen due to the variety of natural and man-made scenes that will exercise the FlexSAR-X system's capability. The areas are defined by a center coordinate and radius as follows:

Table 2. Location Specifications

	Center Latitude	Center Longitude	Radius (km)	Altitude (ft)
Logan	*41°46'42"*	*111°51'12"*	40	<8200 AGL
Evanston	*41°16'24"*	*111°01'46"*	60	<8200 AGL

A map of the proposed location and the surrounding area is shown in Figure 4.

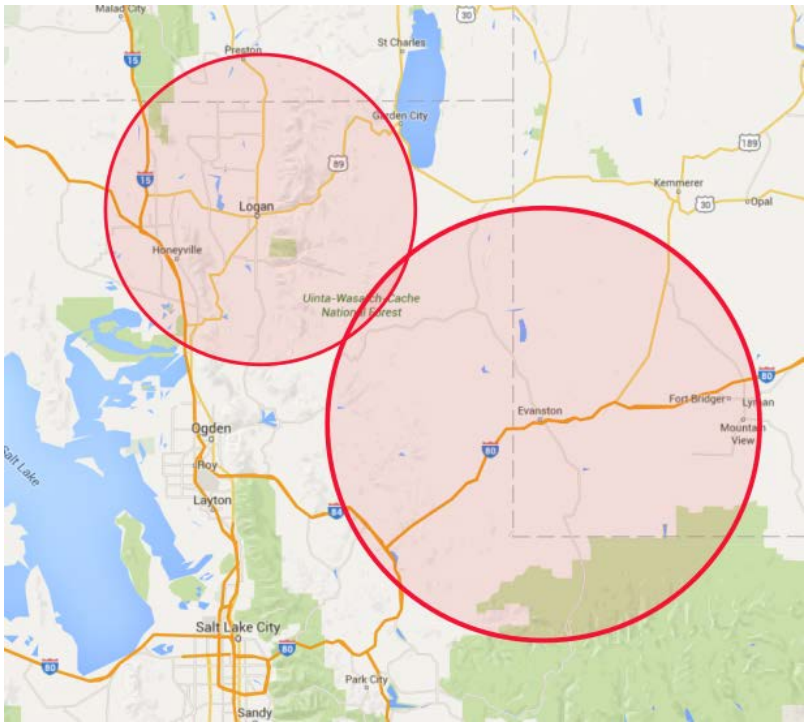

Figure 4. Map of the proposed locations and surrounding area. Map courtesy of Google Maps.

Areas of interest within these circular areas of operation will be chosen to meet test objectives and aircraft flight paths planned accordingly. For air-to-ground operations these areas of interest are typically 1.5 miles in width and 3 miles in length.

3.3 EQUIPMENT USED

The flight test will be carried out using a Cessna 337 aircraft. The FlexSAR-X system as described in Section 2.1 will be installed on the aircraft along with a Novatel CPT GPS/INS. The TSC I1114 antenna will be mounted on the left side of the aircraft.

4. PROGRAM CONTRIBUTION AND IMPACT

FlexSAR-X will be key to advancing the art of airborne radar for detection and tracking and for SAR processing and image formation work at SDL and Utah State University (USU). It will enable SDL to work with other researchers, engineers and scientists across the country to expand radar and SAR capability. Not only will SDL be able to use FlexSAR-X data for its own studies and advancement of radar and SAR, but it will also be able to provide data to researchers at other institutions as well. FlexSAR-X can be easily configured for various airborne collection scenarios and studies, including concurrent collections with other sensors. The RF hardware will be studied and characterized in an effort to further refine and improve radar and SAR measurements and images.

5. CONTACT INFORMATION

Questions regarding this application should be referred to the following individuals.

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