LPAR (Low Power Phased-Array Radar)

Stony Brook University
FCC Experimental License Application Narrative

FCC Form 442 File Number: 0829-EX-CN-2021
Updated: September 28, 2021.

Purpose of operation:
An experimental FCC license is requested for operation of LPAR, an advanced radar, by the School of Marine and Atmospheric Sciences at Stony Brook University (SBU). SBU is part of the State University of New York, an agency of the State of New York. Stony Brook previously operated this identical system under identical circumstances with FCC experimental license, call sign WJ2XUL, from November 1, 2018 through November 1, 2020. The new license is requested for the continental US so that research may be conducted nationwide.

The LPAR is an existing radar unit donated to Stony Brook University by Raytheon Corporation (Raytheon Model LPR2). This advanced prototype has special capabilities required for our research. Stony Brook University will use the LPAR for environmental, climate, and meteorological research, as well as tracking small unmanned aircraft systems and their performance in varying environmental conditions. The LPAR will collect unique observations in clouds and precipitation and is expected to push our frontiers in basic knowledge in ice/snow microphysics and warm clouds lifecycle.

An experimental license is requested for the SBU LPAR for the period of November 1, 2021 – October 31, 2023.

Operational Summary:
The system will transmit pulsed Frequency Modulated (Chirp) waveforms. For all waveform types, the maximum pulse duration is 55 μs and the maximum duty factor is 22%. It is expected that the radar will be operated periodically, < 5days per month on average, 5-8 hours per day, Mon - Sun. These operating times correspond to SBU time zone (EST/EDT).

RF Hazard Calculations and Site Safety Measures:
Initial calculations show that general public exposure limits will be reached at a 2.25 meters distance and occupational exposure limits at 1.0 meter, using formula (7) from FCC OET Bulletin 65 “Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields”, dated August 1997. These calculations take into account the highest duty factor of 22% and the raster scan pattern utilized by the radar.

SBU has in place an operational procedure document and an RF safety group that will be involved in all testing that requires free space radiation 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. An RF Safety Control Plan will be in place for the tests. The 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 limits before testing can proceed.

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Period of Use:
Start date: November 1, 2021
End date: October 31, 2023

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

Transmitter info:
Manufacturer: Raytheon
Model: LPAR
Experimental (Y/N): Y

For each frequency band:
RF output at the transmitter terminals:
160 Watts peak

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 953.4 kW (peak power).
Power * gain = EIRP, gain = 39.9 dBi, EIRP = 160*9772.37=15635972 W
ERP=EIRP/1.64 =953402 W or 953.4 kW

Frequency Tolerance:
Less than 0.001 %

List each type of emission separately for each frequency (basically list the emission designators):
The LPAR can tune at 1 MHz intervals within the band(s) authorized. For 9.2 to 9.3 GHz operation, Ftune is 9.250 GHz.

For each tunable frequency authorized, the LPR2 has the following emission designators:
4M7Q3N - 55μsec FM-Pulsed (LP) with a 2 MHz LFM chirp, centered at Ftune – 1.5 MHz
7M1Q3N - 6μsec FM-Pulsed (SP) with a 2.5 MHz NLFM chirp, centered at Ftune + 1.25 MHz

The transmit waveform chain-pulse sequence transmits a Long Pulse (LP) then a Short Pulse (SP) for each pulse repetition interval (PRI). The PRI for a pulse sequence is 256 usec (PRF = 3906.25 Hz). The Long Pulse (LP) is 55 usec pulse length using a 2 MHz linear FM chirp at a 22% duty factor. The Short Pulse (SP) is a 6 usec pulse length using a 2.5MHz non-linear FM chirp at a 2.3% duty factor.

List as appropriate for the type of modulation:
LP: Linear Frequency-Modulated Pulsed(Chirp)
SP: Non-Linear Frequency-Modulated Pulsed (Chirp)

Necessary bandwidth. Explain how determined.
The necessary bandwidth was calculated using the equations in Annex J of the NTIA Manual.

Locations:
The LPAR will be mobile (truck mounted) but stationary when in use. The home base of the LPAR will be the SBU radar facility at the South P Lot of the SBU west campus, located at North 40°07'58", West 105°14'42"and ground elevation of 30 meters above sea level.

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Is a directional antenna (other than radar used)?
No.

If yes, give the following info:(Although not necessary for this application, additional antenna detail is provided below)

Width of beam in degrees at the half-power point:
1.98° Azimuth, 2.1° Elevation at boresight

Orientation in horizontal plane:
+/- 45° Electronically Scanned

Orientation in vertical plane:
0° to 90°, relative to ground horizontal, mechanically tilted.
0° to 30°, relative to antenna tilt, electronically scanned

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 truck. (Although not necessary for this application, additional detail related to height and location relative to airports around home base is provided).

Overall height above ground to tip of antenna in meters:
Approximately 3 meters.

Elevation of ground at home base above mean sea level in meters:
30 m

Approximate distances from home base to major aircraft landing areas in km:

Islip MacArthur Airport	12 km
Republic Airport	31 km
Frances S. Gabreski Airport	42 km
John F. Kennedy International Airport	61 km
LaGuardia Airport	64 km

Note: This is not a complete list.

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.

Necessary Bandwidth Calculation Table

FM-Pulsed Radar		
Modulation	LFM	NLFM
Pulse Width (μsec)	55	6
Rise Time (μsec)	0.128	0.128
Fall Time (μsec)	0.128	0.128
Chirp BW (MHz)	2	2.5
Necessary BW (MHz)	4.7	7.1
Designator	4M7Q3N	7M1Q3N

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.

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

FM-Pulsed Radar:*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.