

FCC STA - New England Regional SpectrumX Coexistence Experiment

Application Exhibit - Revision 1

2026-06-23

1.0 Overview

We request permission to conduct an experiment at specific carriers in the 7.125 to 7.145 GHz and 7.3 to 7.8 GHz bands to explore spectrum coexistence techniques related to next generation wireless use of future lower 7 GHz bands. As part of these efforts we will perform conventional propagation studies, explore tropospheric propagation, and test coexistence approaches and theoretical predictions. Our efforts will also prepare students, faculty, and staff for experimental field work in spectrum related measurements. The transmissions associated with this specific STA request will occur from the Westford Radio telescope configured to emulate a satcom station (i.e. similar to NASA or NOAA assets), a phased array demonstrator used on the MIT Haystack Observatory property, a set of regional fixed transmitter locations used to emulate next generation wireless base-stations, and a set of low power mobile systems that emulate future user terminals in the band. The experiment will have a number of measurement sub-components and be executed in the greater New England region during the period of July 24th to August 24th. .

Four types of transmissions will be included as part of these experiments:

1. Transmission at **7130.0 MHz** at 78.7 dBm EIRP (with 100 mW RF power) using the 18.3 meter Westford Radio telescope.
 - a. The telescope will be used to **emulate** a lower 7 GHz capable Earth station for coexistence experiments with other potential near band signals.
 - b. **Transmissions will be directed away from actual satellites** (e.g. via offset pointing from an actual satellite direction).
 - i. Pointings will be derived from up to date TLEs or NASA Horizons predictions.
 - ii. Transmissions will not be directed at the Moon to avoid interference with NASA LRO radar operations.
 - iii. The test frequency selected is below normal NASA DSN uplink bands.
 - c. Transmitted data will not contain any valid satellite control commands and will consist of pseudo random ranging sequences.
2. Transmission at **7130.0 MHz, 7300.0 MHz, and 7700.0 MHz** at 43 dBm EIRP (with 160 mW RF power) using a prototype 16 element digital per element phased array.
 - a. The phased array will be used to emulate the beamforming behaviors of a next generation wireless system in the lower 7 GHz band.
 - b. The array can beamform +/- 40 deg in a single axis at a mechanically fixed elevation angle and orientation (i.e. H-pol or V-pol).

- c. Transmit locations will be restricted to the MIT Haystack Observatory property.
 - i. The Array transmitters may be located inside or outside buildings.
 - ii. The transmitter will be used from fixed locations on the property.
 - iii. Heights above local terrain may be varied from 0.1 meters to 5.0 meters using a portable platform and tripod.
- 3. Transmission at **7130 MHz** at up to 36 dBm EIRP (with 100 mW RF power) using mobile omni-directional and small directional antennas.
 - a. Transmissions will be used to emulate potential reallocation of the lower 7 GHz range to next generation cellular (3GPP / 5G like).
 - b. Transmitter data will not contain usable information and will consist of controlled sequences suitable for channel performance estimation.
 - c. Bi-directional links will not be established as part of the emulated band usage.
 - d. Up to 6 transmitters may be used simultaneously to emulate mobile terminals.
 - e. All transmission locations will be geographically restricted to within 250 km of the MIT Haystack Observatory property.
 - i. Transmitters may be located inside or outside buildings.
 - ii. Transmitters may be moved on roads during transmission.
 - iii. Heights above local terrain may be varied from 0.1 meters to 5.0 meters using portable masts. In motion they will typically be rooftop mounted on normal vehicles.
- 4. Transmission at **7130.0 MHz, 7300.0 MHz, or 7700.0 MHz** at up to 43 dBm EIRP (with 1W RF power) using both a fixed omni-directional and a small directional antenna.
 - a. Transmissions will be used to emulate potential reallocation of the 7.125 to 7.775 GHz range to next generation cellular (3GPP / 5G like).
 - b. Transmitter data will not contain usable information and will consist of controlled sequences suitable for channel performance estimation.
 - c. Bi-directional links will not be established as part of the emulated band usage.
 - d. Up to 3 transmitters may be used for the duration of the experiment to emulate fixed wireless base stations and enable propagation and troposcatter measurements.
 - e. Transmission locations include: MIT campus in Cambridge MA (on the Green Building), UNH in Durham NH, and SUNY in Albany NY.
 - i. Transmitters will be located on building roof tops.
 - ii. Transmitters will be fixed with an omni-directional antenna and a directional antenna.
 - iii. The directional antennas will be pointed towards MIT Haystack Observatory at low elevation angle.
 - iv. Heights above building rooftops may be varied from 0.1 meters to 5.0 meters using portable masts.

1.1 SpectrumX

SpectrumX is an NSF Spectrum Innovation Center funded via Award 2132700 operated under cooperative agreement by the University of Notre Dame. The Center's Core Activities focus on research, education and workforce development related to coexistence research for the radio spectrum. Center research efforts are supportive of technical and policy goals related to radio spectrum issues of national concern. This includes support for work related to issues facing the FCC and NTIA. As part of Center efforts, Flagship projects have been developed that include educational and experimental research components.

This request is to support an experiment in the greater New England region around MIT Haystack Observatory. The experiment will be used to explore coexistence approaches for use of the lower 7 GHz band by existing satcom and radio astronomy systems with next generation fixed wireless. The effort will also be part of our education and workforce development efforts to involve our faculty and students in field use of modern radio measurement techniques.

2.0 Relevant Government Contract

The work associated with this request is to achieve goals associated with an NSF supported research cooperative agreement with Notre Dame. The specific experiment is part of our overall SpectrumX Flagship project efforts to address scientific and workforce development aspects of our agreement with NSF. This work is supported by MIT as part of a subcontract to the overall NSF SpectrumX Center.

Agency : NSF

Award Title: **SII-Center: SpectrumX : An NSF Spectrum Innovation Center**

Award Number : SII-2132700

Government Agency: the National Science Foundation

Government PoC: Jonathan Williams

Government PoC Phone Number: 703-292-2455

Government PoC email: jonwill@nsf.gov

3.0 Description of the Planned Experiment

The experiment will consist of several separate measurement elements involving faculty and student teams. Measurements will include:

1. Propagation and clutter measurements including troposcatter.
 - a. We will collect data for comparison to propagation and clutter models. Both conventional approaches to these measurements and novel techniques will be explored.
 - b. The measurements will be conducted regionally in New England around the proposed fixed transmitter sites (i.e. MIT campus, UNH, SUNY Albany) and MIT Haystack Observatory.

- c. For propagation measurements the transmitter systems will use different combinations of simple carriers, coexistence beacons, and channel characterization waveforms.
 - d. Troposcatter paths will be measured with signals generated at the fixed transmission sites and transmitted using directional antennas. These will be received at the Westford telescope using either the primary antenna or directional secondary antennas.
 - e. Propagation measurements will be made around the Westford telescope and the fixed transmission sites. For the fixed transmission sites this will use omni-directional transmissions .
 - f. Propagation measurements using a MIMO configuration of our mobile transmitters and receivers will also be made in selected New England regional locations.
 - g. A variety of propagation and clutter environments will be measured using the mobile systems.
2. Coexistence measurements using radio beacons to detect transmissions and coordinate protection zones.
- a. Using radio beacons for coordination is a potential approach for decentralized operational data sharing and zone management.
 - b. We will compare ODS approaches to reciprocity based sharing and coordination using radio beacons.
 - c. Our measurements will be centered around MIT Haystack Observatory both on the property and regionally.
 - d. Protection of astronomy and satcom users from transmitters will be explored using beacons integrated in the astronomy / satcom system and located locally around the system.
 - e. Attribution of RFI using coexistence beacons sent by transmitters (e.g. user terminals and basestations) and received by the astronomy / satcom station will also be evaluated.
3. Phased Array Beamforming coexistence measurements
- a. These measurements will be conducted on the MIT Haystack Observatory property.
 - b. A prototype all digital phased array will be used to evaluate protection of radio telescope and satcom systems using beamforming approaches.
 - c. Measurements will be made of direct system interference over moderate distances, directional and sector nulling to protect a telescope, and the effects of the local propagation and clutter environment on beamforming effectiveness.
 - d. Evaluation will be made to allow comparison to exclusion zone and ODS coexistence approaches.
 - e. Array backlobe and sidelobe interactions nulling other sites and following user terminals will be explored.

Transmissions will be limited to the specific carriers requested in this STA request. Band pass filters will be used after the power amplifier and immediately prior to the transmit antennas to

control harmonics. Operating bandwidths will allow for appropriate analog and digital filtering to enable compliance with licensed bandwidth limitations.

3.1.0 Stop Buzzer Information

The following contacts will be capable of terminating transmissions during the experiment. The primary contact will be available for direct coordination. Either the Westford Control Room or MIT Haystack Observatory personnel listed may also be contacted in the event the Primary contact were to become unavailable.

Primary Contact

Name : Frank Lind
Cell: 978-399-4017
Work: 617-715-5561

Westford Control Room

Direct Line : 781-981-5554
Additional Westford Contacts: Aleks Burns

MIT Haystack Observatory

HAYSTACK Main Number: 617-715-5400
Additional Haystack Contacts: Mary Knapp, Aleks Pop Stefanja, Will Rogers

3.1.1 Westford Radio Telescope Details

This is a single location with a fixed transmitter at 42.61N, 71.49W, and 116 meters elevation.

Carrier of transmission: **7130.0 MHz**

Power Level: 78.7 dBm EIRP (100 mW RF power) / 46,238W ERP

Emission Designators (beacon): 4K00N0N, 125KW1D, 2K50W1D, 150HA1A,

Emissions Designators (satcom): 1M20G1X, 6M00D1X

Modulations: carrier, WSPR beacon, station ID (morse), Digital Phase Modulation

Pointing restrictions: Transmissions will avoid pointing within +/- 0.5 degrees of the Moon on boresite to prevent interference with the NASA LRO radar.

Data Content: Transmitted data will not contain any valid satellite control commands and will consist of pseudo random ranging sequences. Transmissions may utilize CCSDS data framing to emulate NASA transmissions. Transmitted beacon data will contain station information and propagation measurement codes.

Number of transmitting platforms : 1 site, at the Westford Radio telescope.

3.1.2 Phased Array Demonstrator Details

The Phased Array demonstrator is a prototype array transmitter which will be used on the MIT Haystack Observatory property within 2 km of 42.61N, 71.49W, and 116m elevation. The array

will be used to collect data relevant to the practical capability of beamforming to protect satcom and radio telescope systems.

Carrier of transmission: **7130.0 MHz, 7300.0 MHz, or 7700.0 MHz**

Power Level: 43 dBm EIRP (160 mW RF power) / 12.2W ERP

Steering angles: +/- 40 degrees from boresite in one axis

Emission Designators (beacon): 4K00N0N, 125KW1D, 2K50W1D, 150HA1A

Emission Designators (5G): 10M0W7X, 20M0W7X

Modulations: carrier, WSPR beacon, station ID (morse), 5G emulation waveforms

Data Content: Transmitted beacon data will contain station information and propagation measurement codes. 5G emulation waveforms will contain synthetic 5G packets with known content.

Number of transmitting platforms : 1 site, at the MIT Haystack Observatory

3.1.3 Fixed Transmission Sites

Each site will radiate propagation and troposcatter measurement signals consisting of narrow band beacons, channel measurement digital codes, and 5G like waveforms. Each site will have both an omni-directional antenna and a directional antenna. Directional antennas will be pointed towards MIT Haystack Observatory close to the horizon.

Carrier of transmission: **7130.0 MHz, 7300.0 MHz, or 7700.0 MHz**

Power Level: 45 dBm EIRP (1W RF power) / 20W ERP

Emission Designators (beacon): 4K00N0N, 125KW1D, 2K50W1D, 150HA1A

Emissions Designators (propagation / troposcatter): 1M0D1X, 10M0D1X

Emission Designators (5G): 10M0W7X

Modulations: carrier, WSPR beacon, station ID (morse), troposcatter measurement digital sequences, 5G emulation waveforms

Data Content: Transmitted beacon data will contain station information and propagation measurement codes. Tropospheric data will contain mathematical codes and sequences for measurement of channel characteristics. 5G emulation waveforms will contain synthetic 5G packets with known content.

Number of transmitting platforms : 3 total sites.

Location of transmitting platforms : 1 at MIT campus in Cambridge MA (42.3605 lat, -71.08926 lon, bearing 310 deg), 1 at the University of New Hampshire in Durham NH (43.13473 lat, -70.9361 lon, bearing 218 deg), and 1 at the State University of New York in Albany (42.68343 lat, -73.82389 lon, bearing 92 deg).

3.1.4 Mobile Experiment Platforms

These are platforms that can be moved around using vehicles with up to 6 systems that may be simultaneously operated. The systems will be representative of typical vehicle integrated user terminals in a next generation cellular network (i.e. both in antenna configuration and power level). Transmissions will be restricted to the greater New England region within a 250km radius

circle around 42.61N, 71.49W, and 116m elevation. We can accommodate avoidance zones as is necessary.

Carrier of transmission: **7130.0 MHz, 7300.0 MHz, or 7700.0 MHz**

Power Level: 36 dBm EIRP (100 mW RF power) / 2.43W ERP

Emission Designators (beacon): 4K00N0N, 125KW1D, 2K50W1D, 150HA1A

Emissions Designators (propagation / troposcatter): 1M0D1X, 10M0D1X

Emission Designators (5G): 10M0W7X

Modulations: carrier, WSPR beacon, station ID (morse), troposcatter measurement digital sequences, 5G emulation waveforms

Data Content: Transmitted beacon data will contain station information and propagation measurement codes. Tropospheric data will contain mathematical codes and sequences for measurement of channel characteristics. 5G emulation waveforms will contain synthetic 5G packets with known content.

Number of transmitting platforms: Up to 6 may be simultaneously operated to emulate mobile user terminals.

3.2 Request Time Frame

Our field experiment will occur from July 24th, 2026 to August 26th, 2024 with transmissions during this entire time frame in scheduled blocks for specific emitters. Testing prior to this time frame will be conducted into terminated loads or via attenuated loopback configurations.

3.3 Haystack Site Coordination with Existing Transmitters

Several existing radars and experimental transmitter systems are licensed on the MIT Haystack Observatory property. As part of our experiment planning and safety process we will coordinate with these systems to ensure that interference does not impact their planned or scheduled operations. The requested frequencies of transmission and power levels are consistent with avoidance of interference with the existing radars on site as they are well away from existing carrier frequency licenses.

3.4 Necessity of this request

Realistic testing of equipment and training of personnel is necessary for successful future coexistence approaches and optimal protection of existing band users. SpectrumX hopes to contribute in a significant manner to evaluation of co-existence options and potential impacts of repurposing the lower 7 GHz on NASA, NOAA, and radio astronomy applications. This request will contribute significantly to relevant measurements. It will also contribute to workforce development by readying personnel for future experimental efforts.

4.0 Equipment to Be Used for the Experiment

The equipment used for transmission is specific to each type of system. In general, experiments will use commercial software radio systems in combination with custom analog RF up-converters. Frequency references used will be of high quality to ensure well controlled carrier frequencies. Details of each major system type are below.

Longitude	71.49°W
Latitude	42.61°N
Height above m.s.l.	116 m
MIT Haystack Observatory 99 Millstone Rd Westford, MA 01886-1299 U.S.A. https://www.haystack.mit.edu	

Parameter	Westford
primary reflector shape	symmetric paraboloid
primary reflector diameter	18.3 meters
primary reflector material	aluminum honeycomb
feed location	primary focus
focal length	5.5 meters
antenna mount	elevation over azimuth
antenna drives	electric (DC) motors
azimuth range	90° – 470°
elevation range	4° – 87°
azimuth slew speed	3° s ⁻¹
elevation slew speed	2° s ⁻¹



4.1 Westford Radio Telescope Overview

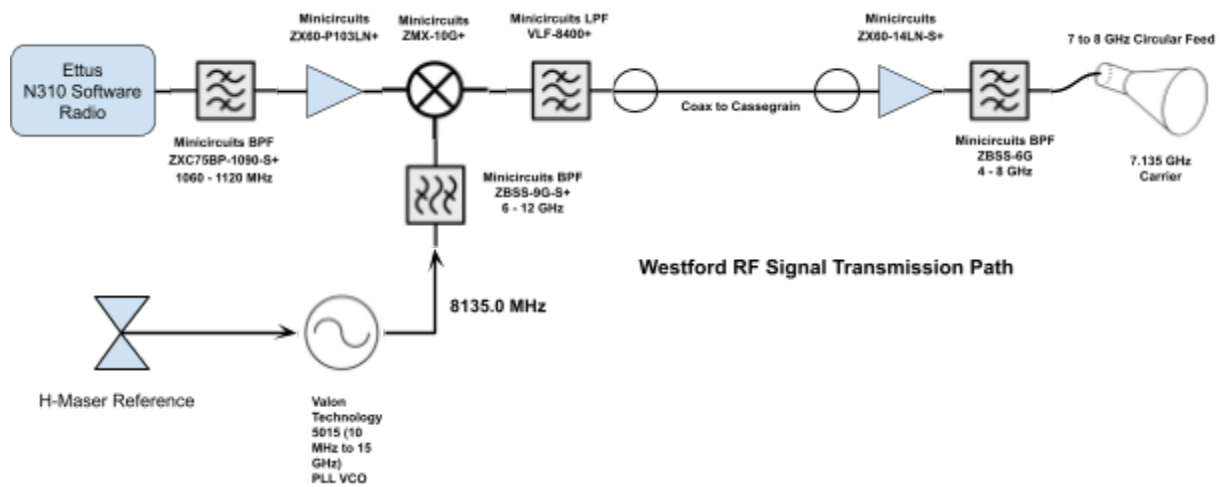
The Westford Antenna will be used for emulation of 7130.0 MHz Satcom transmissions. The system is located approximately 70 km northwest of Boston, Massachusetts, the antenna is part of the MIT Haystack Observatory complex. The Westford antenna is an 18.3 meter parabolic reflector

enclosed in a 28-meter air inflated radome constructed of a 1.2-mm-thick Teflon fabric (Raydel R-60). The primary frequency standard on site is an NR-4 Hydrogen maser which is stable to better than 1 part in 10E13. The antenna is equipped with feeds specific to the project or application. In this case a cassegrain feed will be used to allow the system to transmit at the 7130.0 MHz band. **The Westford half power beamwidth at 7130.0 MHz is approximately 0.1 degrees (3dB).**

4.1.1 Westford Transmitter Details

RF signals will be generated using an Ettus N310 radio at an IF carrier frequency, this signal will be filtered, amplified, and upconverted to the 7.130 GHz carrier frequency using a custom upconverter design. The signal will be carried to the cassegrain feed point from the control room on coaxial cable and a final amplifier, commercial cavity filter (Minicircuits ZVBP-7100-S+), and 90 degree hybrid will be used to set the final 100 mW RF output power level into the antenna feed. Harmonics and spurious signals will be filtered to better than -60 dBc by the narrow final filter stage. An appropriate horn antenna feed design will be used to transmit from the Cassegrain point via the installable antenna sub-reflector. **Different polarizations may be used during experiments H, V, RHCP, or LHCP depending on the feed configuration.**

Transmission path components will be measured using a network analyzer prior to installation and amplifier power levels will be trimmed using fixed attenuators to ensure that transmitter power cannot exceed the licensed maximum (i.e. with the Ettus N310 radio at full power). Radio signals for Westford are stabilized using the Hydrogen Maser system which supports allan deviation better than 1 part in 10E13 at 1 second.

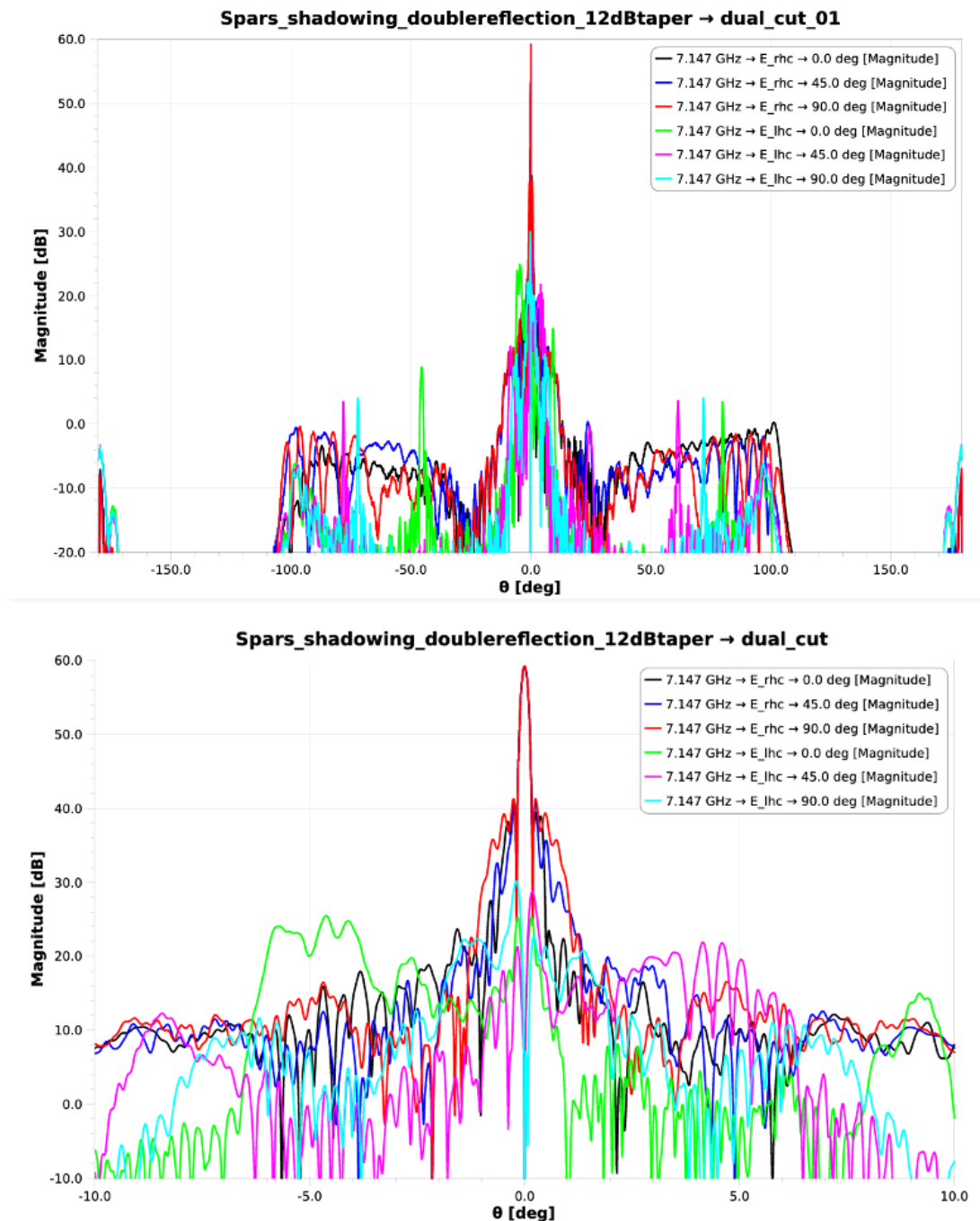


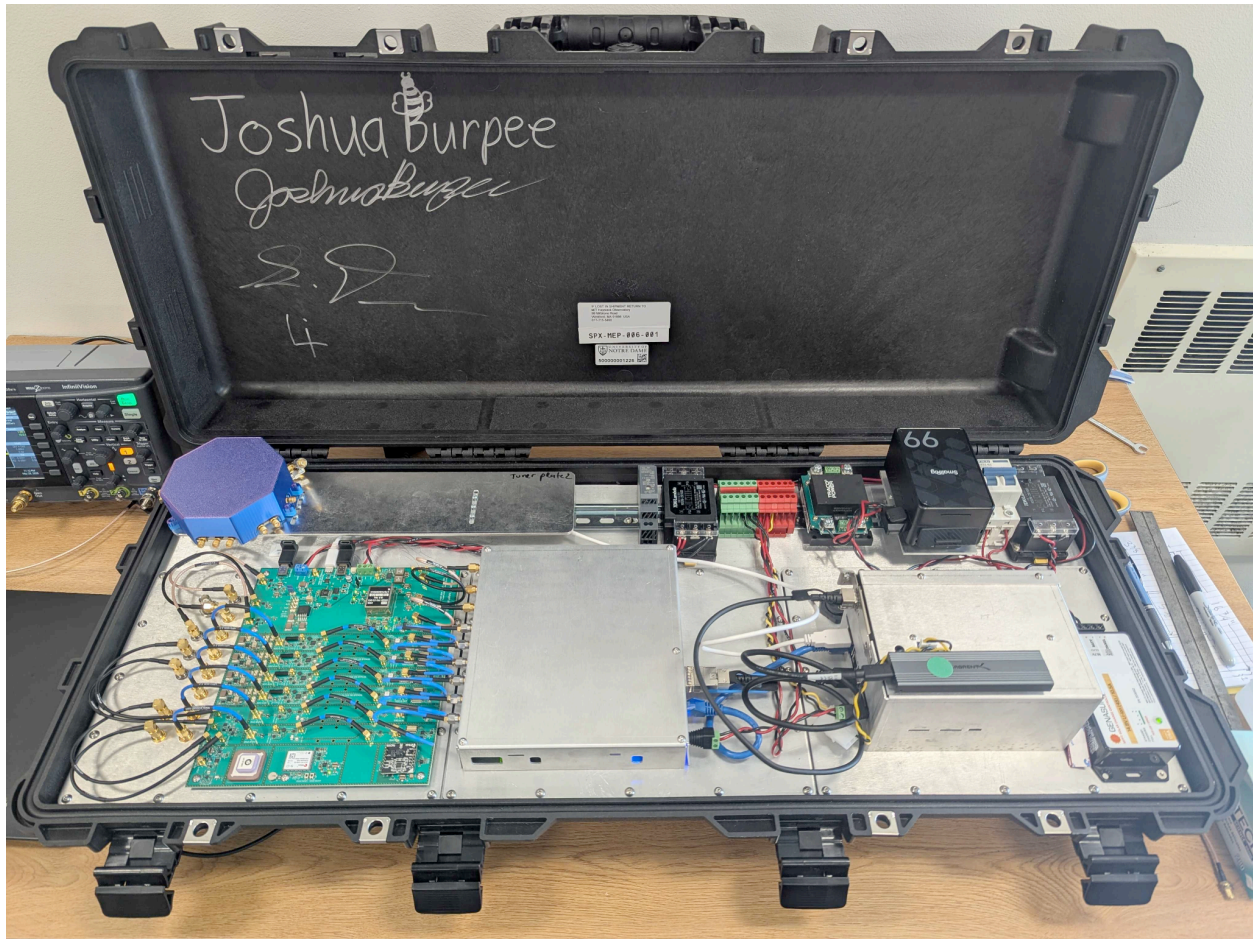
4.1.2 Westford Antenna Drawing Exhibit

WESTFORD Satcom Exhibit				
Basic Input Parameters				
Band	Frequency Range GHz	Mid Frequency GHz	Power W	Gain dBi
X-band	7.1	7.2	0.1	58.8
Diameter: 18.3 m	Power (W)	Main (dBi)	1st side lobe	Back Lobe
RHCP / LHCP	0.1	58.8	30.6583	0.0

4.1.3 Westford Antenna Pattern

A combined transmitter and feed antenna pattern for 7.1 GHz shows a total gain of 58.8 dBi with sidelobes down more than 30 dB from the primary beam beyond a few degrees. The relatively high sidelobe levels are due to the asymmetric feed support structure of the telescope and shallow F/D ratio. The antenna simulation includes reflections, spars, and sub-reflector shadowing effects.



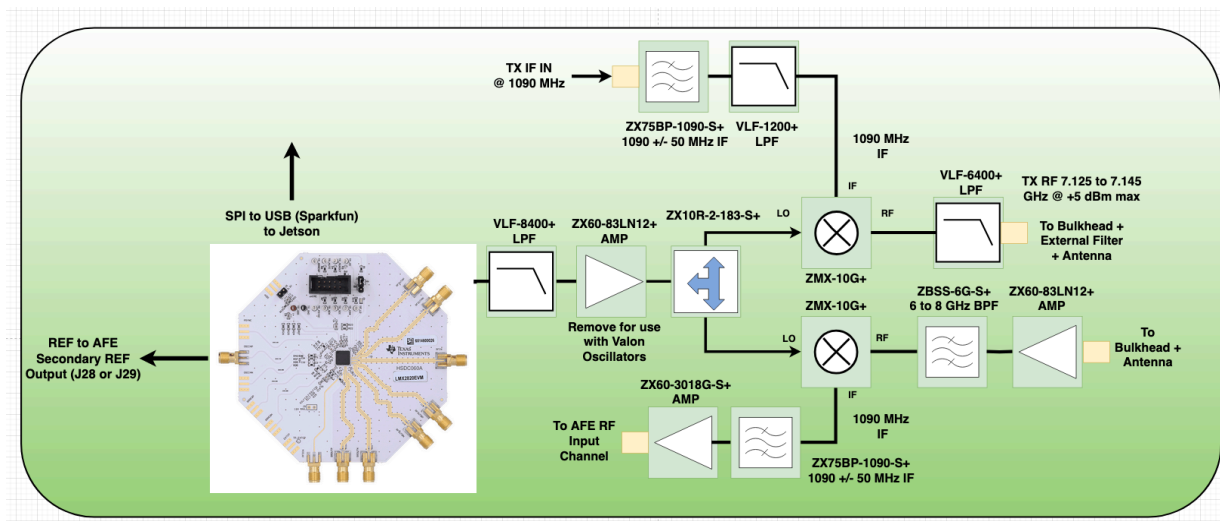


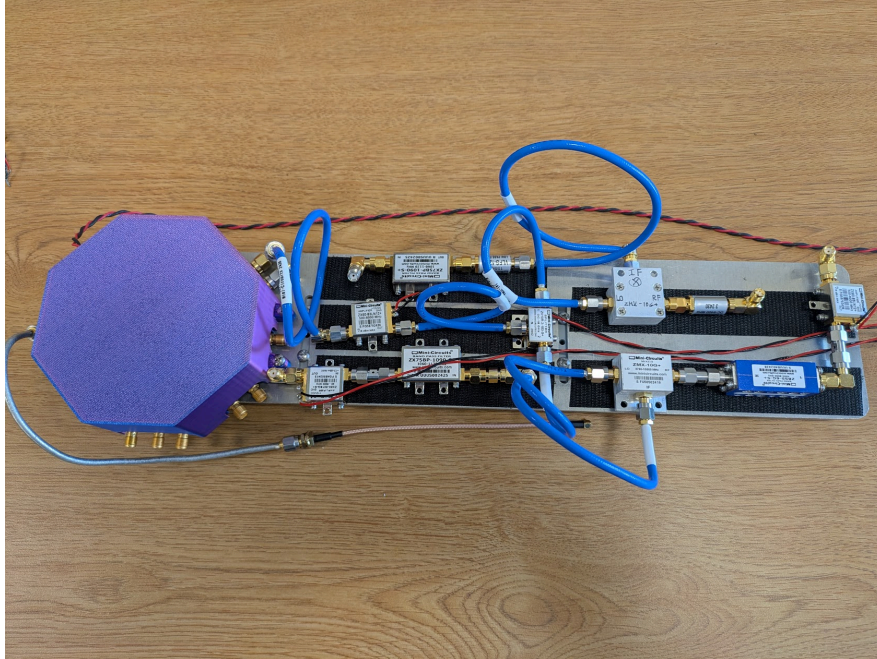
4.2 Mobile Experiment Platform (MEP) Overview

SpectrumX is currently implementing a set of Mobile Experiment Platforms (MEPs) which use the Real Digital / AMD RFSoc 4x2 radio and custom analog up/down conversion. These systems are contained in a pelican case and support both external and battery powered operation. The initial system design supports a single channel of RX or TX in the 7.125 to 7.7 GHz band. The system can be used with a range of commercial antennas. Waveforms and digital signal processing are fully software defined and highly flexible. The MEP platform uses an GNSS locked OCXO frequency reference (Connor Winfield EH320) with measured allan deviation of better than 6 parts in 10^{11} at 1 second. For the proposed experiments it is expected that we use at most 6 MEP units at one time for transmission out of 12 total available MEP units.

4.2.1 MEP Transmitter Details

For the proposed experiments the MEP units will generate RF signals using the RFSoc 4x2 or Ettus B210 radios (i.e. in some cases) at an intermediate frequency carrier of 1090 MHz. This signal will be band limited using analog filters and upconverted to the output RF carrier where it is further filtered. Depending on the required EIRP and emission mask an additional Minicircuits amplifier stage can be used along with an additional filter to reduce spurious and harmonics (i.e. typically an additional ZBSS-6G-S+). The final output will be at one of the proposed carriers for transmissions (7130 MHz, 7300 MHz, 7700 MHz). The upconversion electronics are implemented using Minicircuits and a TI LMX2280EVM PLL/VCO. Frequency stability for the system will be provided by a GNSS locked OCXO.



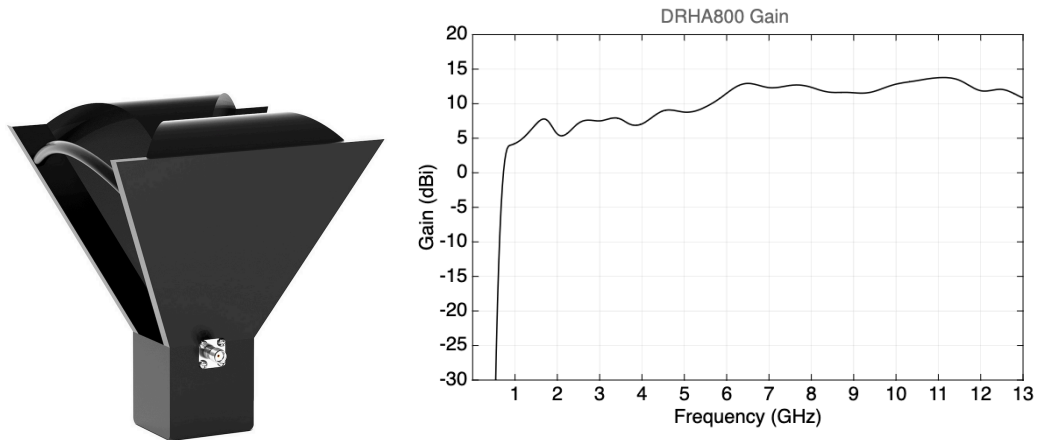


4.2.2 MEP Transmit Antennas and Patterns

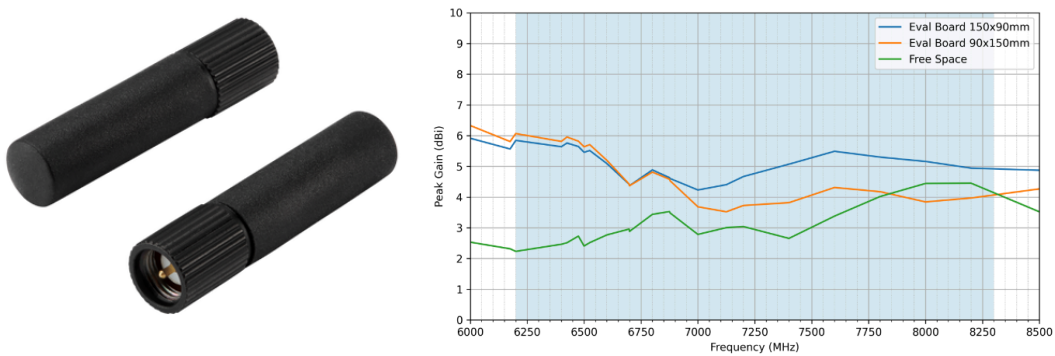
Several commercial antennas will be used with the MEP platforms as part of different coexistence scenarios. In all cases RF power into the antenna will be at most 100 mW combined with an antenna gain no greater than 16 dBi the overall EIRP will be below 36 dBm at all times.

Antennas we expect to use with the MEP platform for transmission include:

Antenx Wideband Dual Ridged Horn (DRHA800 ; < 14 dBi of gain over proposed frequency range)

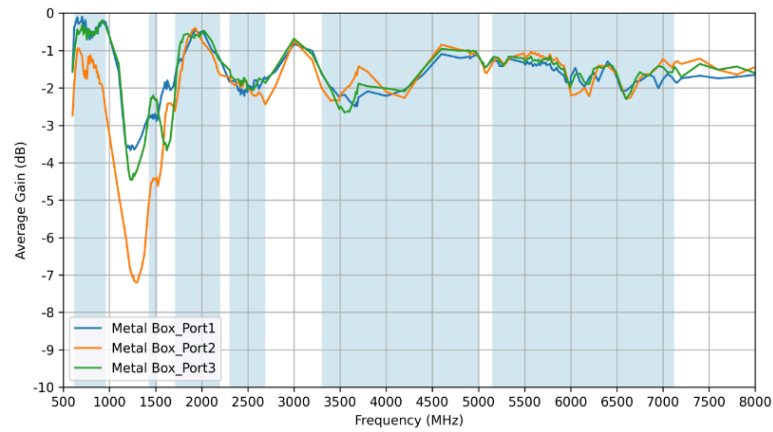


Taoglas TU.63.2111 UWB Terminal Mount Antenna (< 6 dBi over proposed frequency range)



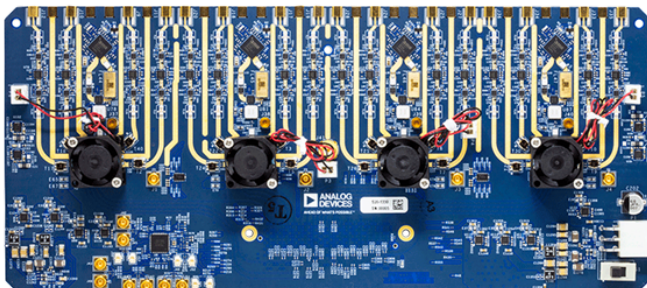
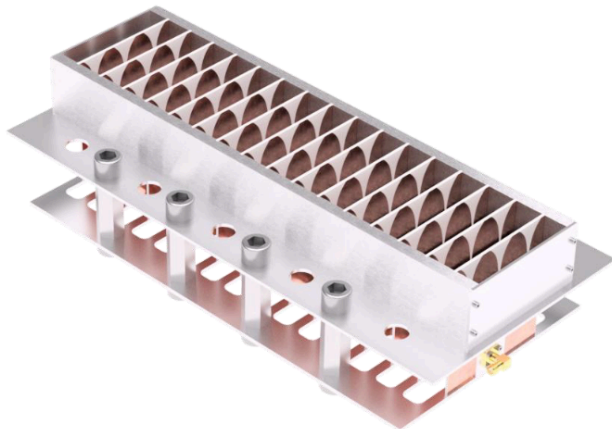
TU.60.3H31 – UWB 3dBi Terminal Mount Antenna covering 3.5-8GHz





4.3 Phased Array Demonstrator Overview

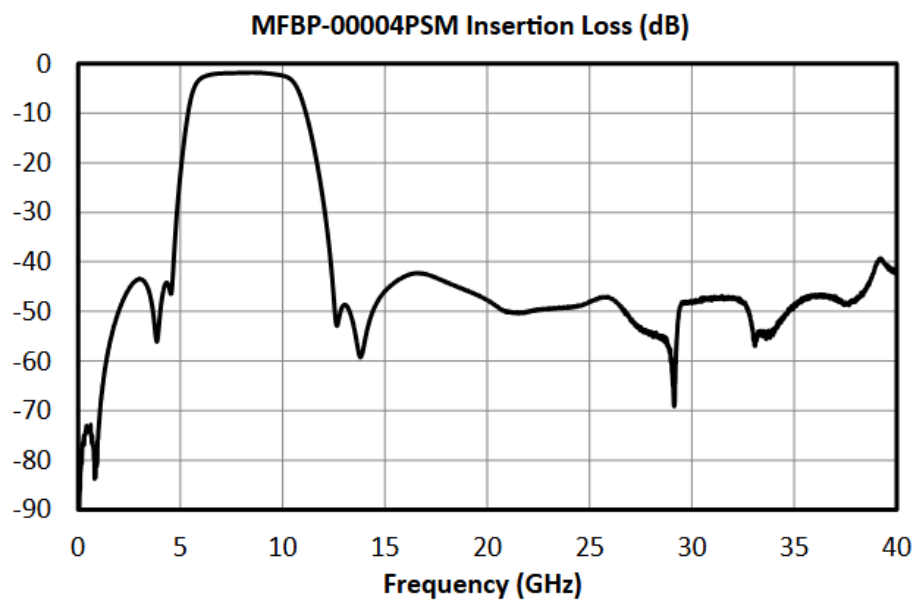
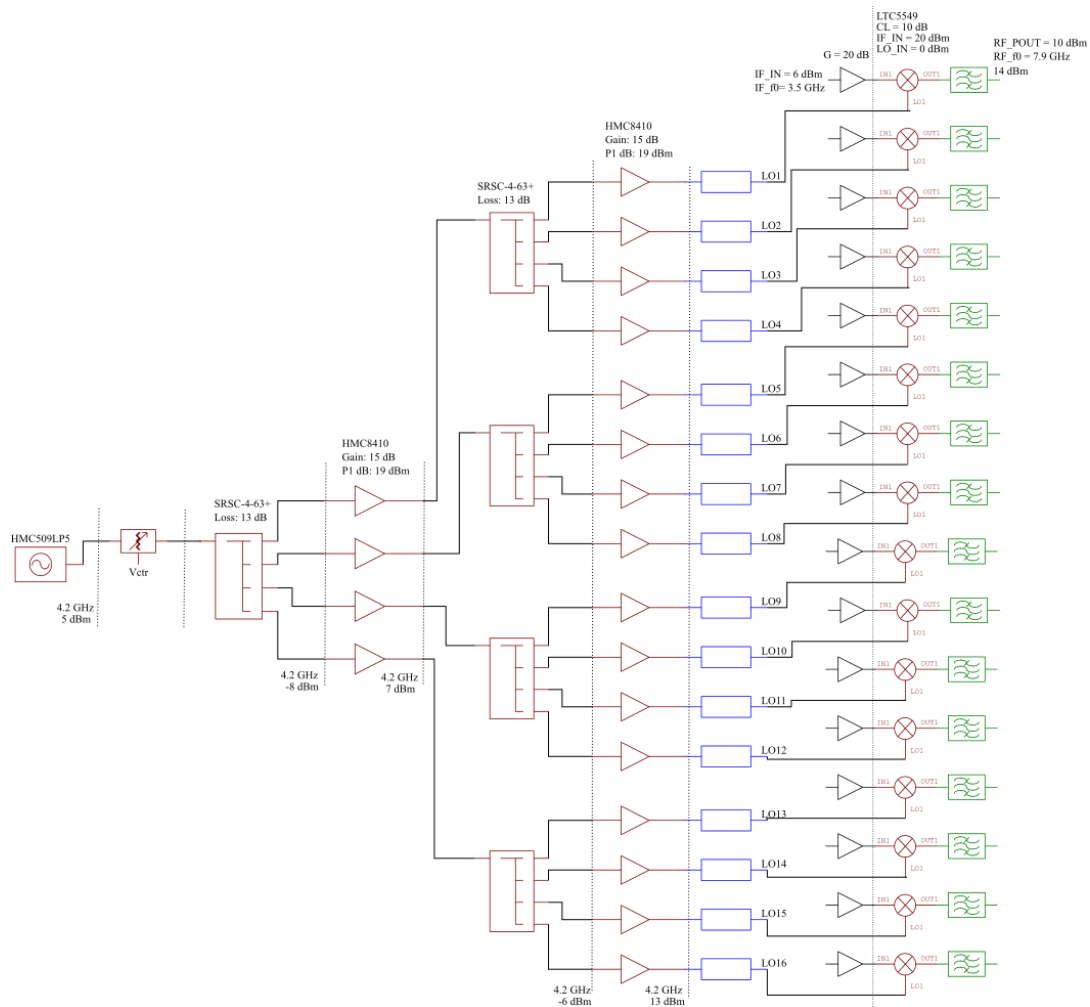
A custom 16 element phased array developed by the University of Colorado Boulder will be used for transmission. The array is a digital per element tapered slot array design. The array provides up to 22 dBi of gain in the broadside direction and is steerable over ± 40 degrees.



Broadside		7 GHz	7.5 GHz	8 GHz	8.4 GHz
	Gain	20.8	21.5	22.1	22.6
	Realized Gain	20.8	21.4	22.1	22.5
	HPBW (H)	6.4	6.0	5.5	5.2
	HPBW (E)	30.7	28.2	24.0	20.8
	SLL (H)	-13.5	-13.5	-13.5	-13.8
	SLL (E)	-14.3	-15.0	-13.6	-12.3
	Min. Return Loss (Active)	15.8	17.1	18.8	15.5
40° Scan		7 GHz	7.5 GHz	8 GHz	8.4 GHz
	Gain	20.3	20.9	21.0	19.5
	Realized Gain	20.1	20.8	20.8	19.5
	HPBW (H)	8.1	7.8	7.3	6.5
	SLL (H)	-12.2	-12.6	-12.2	-10.9
	Min. Return Loss (Active)	11.8	17.7	12.9	16.0

4.3.1 Phased Array Transmitter Details

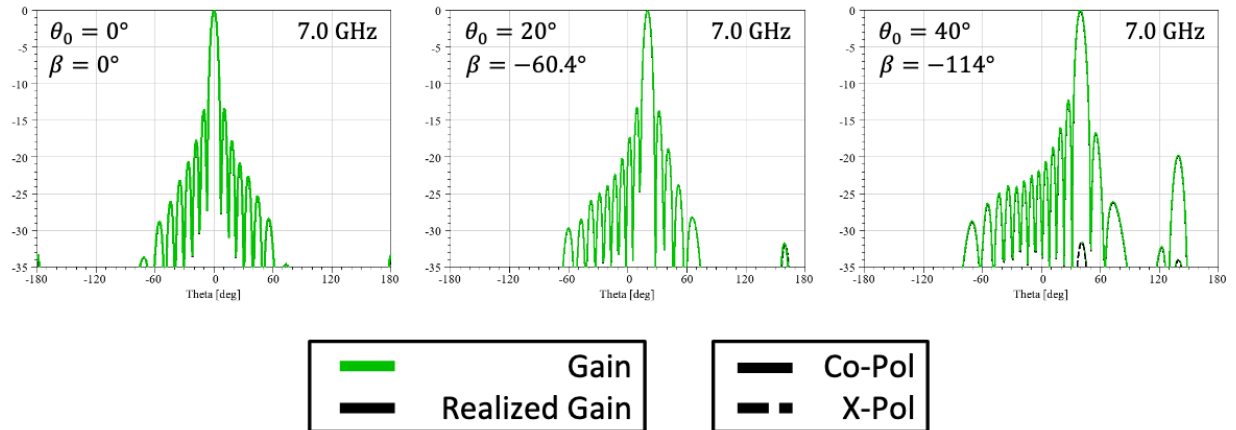
A custom RF upconversion design is used for array transmission. Signals are generated using the Analog Devices Quad-MxFE prototyping platform. This device uses the AD9081 chip and provides RF output at an IF of 3.5 GHz. This IF is used in combination with an amplifier stage and LTC5549 mixer and Marki Microwave MFBP-00004PSM RF filter to upconvert and output RF from each array element. The array has a usable frequency range of 7 to 8.4 GHz with 10 dBm of power per element. Total expected RF power is 22 dBm with a gain of 21 dBi at broadside and 17 dBi at maximum steering angle. The estimated total EIRP of the system is 43 dBm on broadside / boresight and 39 dBm at max steering angle. Estimated beamwidths are between 5 and 8 degrees with sidelobes typical -12 dB or better down from the primary beam. Frequency stability for the system will be provided by a GNSS locked OCXO.



4.3.2 Phased Array Antenna Pattern Details

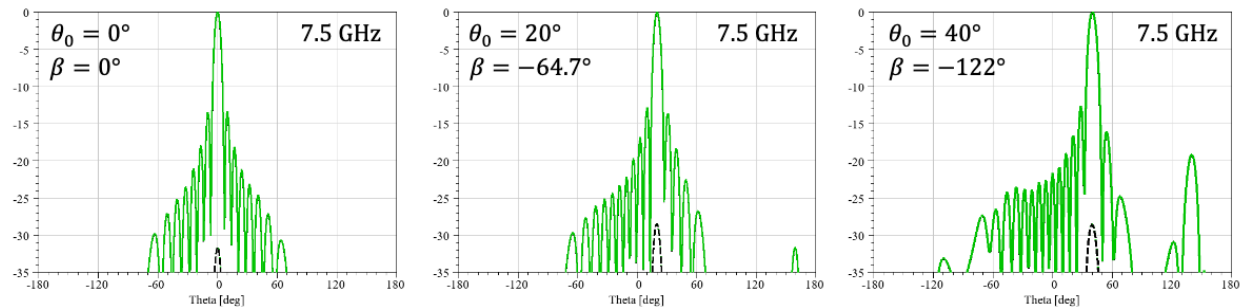
Radiation Patterns

H-Plane Normalized



Radiation Patterns

H-Plane Normalized



4.4 Propagation Transmitter Overview

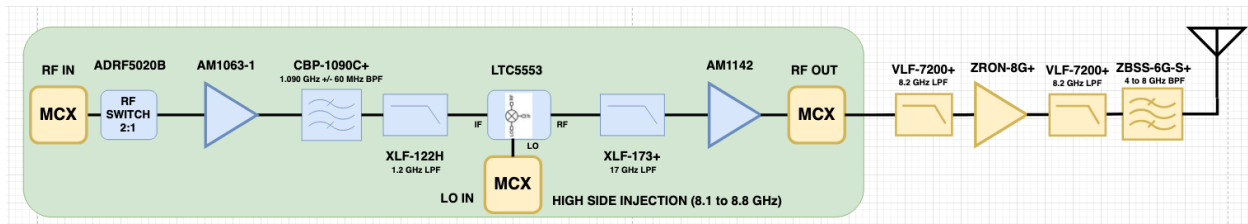


For the three fixed locations transmitting signals for the study of propagation, clutter, and troposcattering we will be using Ettus B210 software defined radios in combination with a custom upconverter. Two antennas will be supported including an omnidirectional monopole and a directional horn antenna. The horn antenna will be oriented towards

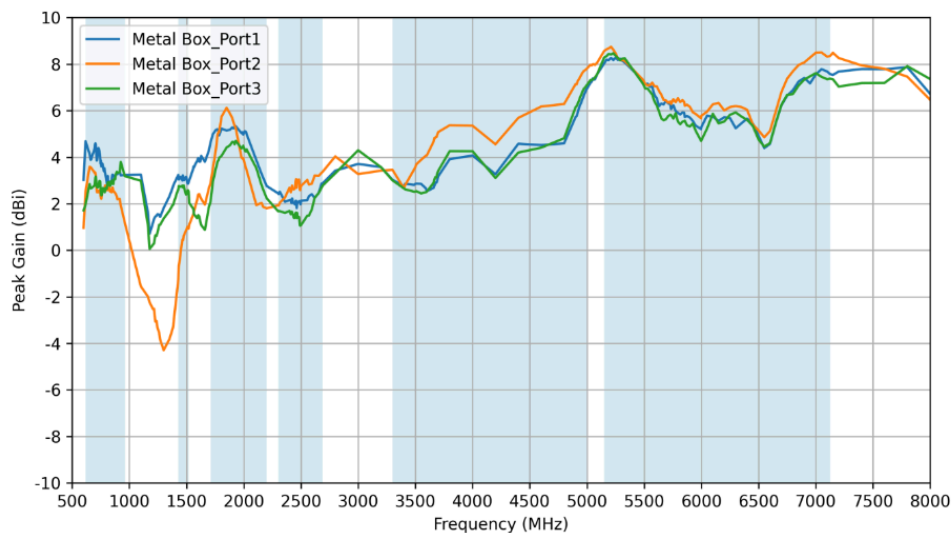
the horizon and directed towards MIT Haystack Observatory at each deployment site.

4.4.1 Propagation Transmitter Details

A custom PCB integrated upconverter will be used. This board converts a 1090 MHz IF to a selectable frequency using integrated components. The upconverter LO is provided by an external TI LMX2280EVM PLL/VCO. The final amplifier and filter stages use off the shelf minicircuits components appropriate for the frequency range, bandwidth, and transmitter harmonic suppression. Frequency stability for the system will be provided by a GNSS locked OCXO. The NI / Ettus B210 radio will provide for signal transmission on two separate channels.



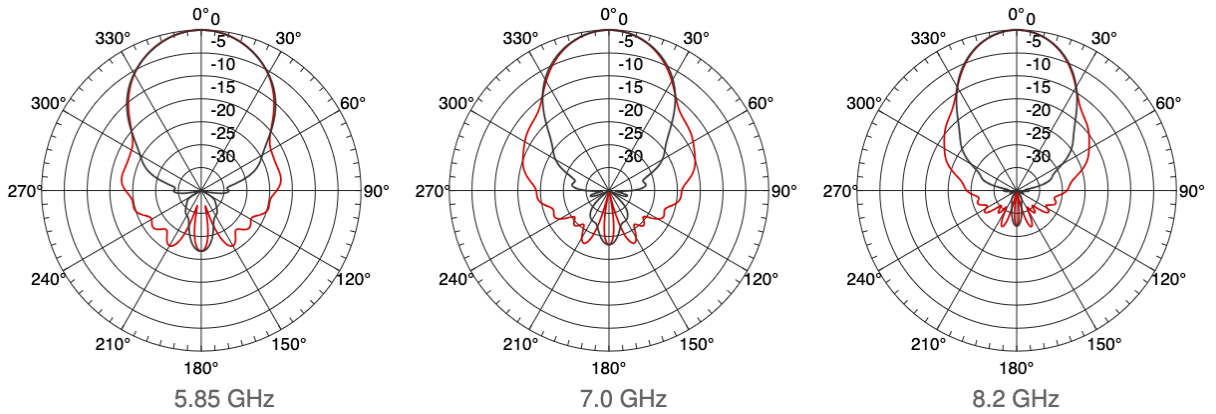
4.4.1 Propagation Transmitter Antenna Details



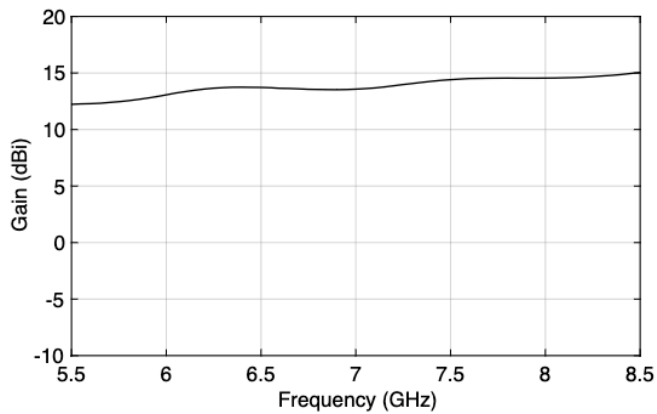
A Taoglas TU.60.3H31 – UWB 3dBi Antenna will be used for omni-directional transmissions. This antenna provides a peak gain of slightly under 8 dBi.

In addition to the small dipole antenna a EHA-WR137 horn antenna from Antenx will be used. This antenna provides approximately 14 dBi of gain in the lower 7 GHz band and beamwidths of approximately 40 degrees.

EHA-WR137 Normalized Radiation Patterns



EHA-WR137 Gain



5.0 RF Safety Information

The low transmitter power used for the experiments will intentionally help to ensure RF safety during all experiments. Worst case calculations for RF Safety are presented for each system. For the MEP experiments the highest gain antenna for the experiments is assumed. A broadside configuration for the Phased Array is assumed for a worst case EIRP level. Propagation transmitter safety estimates are presented for the horn antenna which has the highest overall EIRP.

5.1 Westford RF Safety Calculation

The Westford Telescope is safe at all physically accessible distances for the proposed transmission power levels. It is impossible to approach the antenna far field within 10 meters during operations or servicing. The telescope gimbal center is 13.7 meters above the ground.

WESTFORD Satcom Exhibit

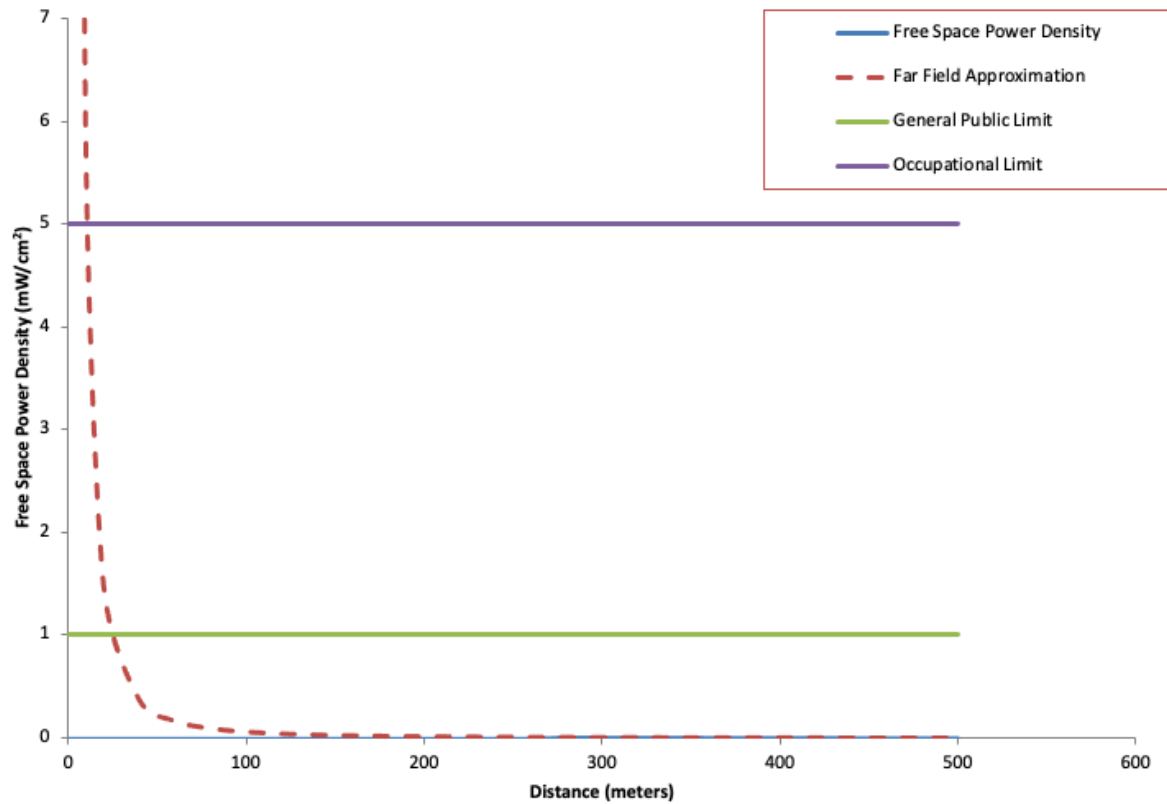
RF Safety Calculation

WESTFORD @ 7.130 GHz

Information Provided		Converted Values	
Frequency	7.13 GHz	7130 MHz	
Dish Diameter	720.4724 inches	18.3 m	
Transmit Power	1.00E-01 W	1.00E-01 W	
Antenna Gain	58.8 dBi	58.8 dBi	
Duty Factor	1	1	
Limits (S _i)		IEEE C95.1-2005/DoDI 6055.11 - 2009	
	General Public	Occupational	Action
(mW/cm ²)	1	5	1
			10
Parameter	Symbol	Formula	Value
Antenna Diameter	D	Input	18.3 m
Antenna Surface Area	A	$\pi D^2/4$	263.021995 m ²
Frequency	f	Input	7130 MHz
Wavelength	λ	$300/f$	0.04207574 m
Transmit Power	P	Input	0.1 W
Antenna Gain (dBi)	G	Input	58.8 dBi
Duty Factor	DF	Input	1
Average Power	P _{ave}	P*DF	0.1
Antenna Gain(factor)	G _{abs}	$10^{G/10}$	758577.575 N/A
Pi	π	Constant	3.1415927 N/A
Antenna Efficiency	η	$G_{abs}\lambda^2/(\pi^2 D^2)$	0.40631374 N/A
Distance to Far Field	R _{ff}	$0.6D^2/\lambda$	4775.5314 m
On-Axis Power Density at Far Field	S _{ff}	$G_{abs}P/4\pi R_{ff}^2$	0.0002647 W/m ²
			2.647E-05 mW/cm ²
Extent of Near Field	R _{nff}	$D^2/4\lambda$	1989.80475 m
Near Field Power Density	S _{nff}	$16.0\eta P/(\pi D^2)$	0.00061792 W/m ²
			6.1792E-05 mW/cm ²
Transition Region Power Density	S _t	$S_{nff}R_{nff}/R_t$	
Off Axis NF PD @ 1 Antenna Diameter	S _{ONF}	$S_{nff}/100$	6.1792E-06 mW/cm ²
Distance of Interest	R	Input	18.2 m
Power Denisty at distance R	R	$G_{abs}P_{ave}/4\pi R^2$	18.2241533 W/m ²
			1.82241533 mW/cm ²
		IEEE C95.1-2005	
		General Public	Controlled
Distance (meters) to which the power density is equal to the limit using Far Field*	R _L	24.56942907	10.9877827
		182.2%	36.4%
Percentage of Limit at distance R			
Note: Far Field Distance are not applicable if distance R is less than R _{ff}			

Distance	S	SFF	GP	Occ
Distance	Power Density	Far Field	General Public Limit	Occupational Limit
1	6.17916E-05	603.6568539	1	5
5	6.17916E-05	24.14627416	1	5
10	6.17916E-05	6.036568539	1	5
20	6.17916E-05	1.509142135	1	5
40	6.17916E-05	0.377285534	1	5
60	6.17916E-05	0.167682459	1	5
80	6.17916E-05	0.094321383	1	5
100	6.17916E-05	0.060365685	1	5
120	6.17916E-05	0.041920615	1	5
140	6.17916E-05	0.030798819	1	5
160	6.17916E-05	0.023580346	1	5
180	6.17916E-05	0.018631384	1	5
200	6.17916E-05	0.015091421	1	5
220	6.17916E-05	0.012472249	1	5
240	6.17916E-05	0.010480154	1	5
260	6.17916E-05	0.008929835	1	5
280	0.000439119	0.007699705	1	5
300	0.000409844	0.006707298	1	5
320	0.000384229	0.005895086	1	5
340	0.000361627	0.005221945	1	5
360	0.000341537	0.004657846	1	5
380	0.000323561	0.004180449	1	5
400	0.000307383	0.003772855	1	5
420	0.000292746	0.003422091	1	5
440	0.000279439	0.003118062	1	5
460	0.00026729	0.002852821	1	5
480	0.000256153	0.002620038	1	5
500	0.000245906	0.002414627	1	5
520	0.000236448	0.002232459	1	5
540	0.000227691	0.002070154	1	5
560	0.000219559	0.001924926	1	5
580	0.000211988	0.001794462	1	5
600	0.000204922	0.001676825	1	5
620	0.000198312	0.001570387	1	5
640	0.000192114	0.001473772	1	5
680	0.001305486	0.001305486	1	5
700	0.001231953	0.001231953	1	5
720	0.001164462	0.001164462	1	5
740	0.001102368	0.001102368	1	5

Calculated Free Space Power Density as a Function of Distance from Aperture



5.2 MEP RF Safety Calculation

The MEP is safe at all distances for the proposed antenna configurations and transmission power levels.

MEP Transmission Exhibit									
RF Safety Calculation									
MEP @ 7135 MHz									
Information Provided		Converted Values		Distance	S	SFF	GP	Occ	
Frequency	7.135 GHz	7135 MHz	1.0 m	Distance	Power Density	Far Field	General Public Limit	Occupational Limit	
Transmit Power	1.00E-01 W	1.00E-01 W		1	0.000363182	0.031680362	1	5	
Antenna Gain	16 dBi	16 dBi		5	0.000363182	0.001267214	1	5	
Duty Factor	1	1		10	0.000363182	0.000316804	1	5	
				20	0.000363182	7.92009E-05	1	5	
				40	0.000363182	1.98002E-05	1	5	
				60	0.000363182	8.8001E-06	1	5	
				80	0.000363182	4.95006E-06	1	5	
				100	0.000363182	3.16804E-06	1	5	
				120	0.000363182	2.20003E-06	1	5	
				140	0.000363182	1.61635E-06	1	5	
				160	0.000363182	1.23751E-06	1	5	
				180	0.000363182	9.77789E-07	1	5	
				200	0.000363182	7.92009E-07	1	5	
				220	0.000363182	6.54553E-07	1	5	
				240	0.000363182	5.50006E-07	1	5	
				260	0.000363182	4.68644E-07	1	5	
				280	7.71222E-06	4.04086E-07	1	5	
				300	7.19808E-06	3.52004E-07	1	5	
				320	6.7482E-06	3.09379E-07	1	5	
				340	6.35124E-06	2.74052E-07	1	5	
				360	5.9984E-06	2.44447E-07	1	5	
				380	5.68269E-06	2.19393E-07	1	5	
				400	5.39856E-06	1.98002E-07	1	5	
				420	5.14148E-06	1.79594E-07	1	5	
				440	4.90778E-06	1.63638E-07	1	5	
				460	4.6944E-06	1.49718E-07	1	5	
				480	4.4988E-06	1.37502E-07	1	5	
				500	4.31885E-06	1.26721E-07	1	5	
				520	4.15274E-06	1.17161E-07	1	5	
				540	3.99893E-06	1.08643E-07	1	5	
				560	3.85611E-06	1.01022E-07	1	5	
				580	3.72314E-06	9.41747E-08	1	5	
				600	3.59904E-06	8.8001E-08	1	5	
				620	3.48294E-06	8.24151E-08	1	5	
				640	3.3741E-06	7.73446E-08	1	5	
				680	6.85129E-08	6.85129E-08	1	5	
				700	6.46538E-08	6.46538E-08	1	5	
				720	6.11118E-08	6.11118E-08	1	5	
				740	5.78531E-08	5.78531E-08	1	5	
Note: Far Field Distance are not applicable if distance R is less than R _{ff}									

5.3 Phased Array Prototype Safety Calculation

The Phased Array prototype is safe at all distances for the array configuration under all steering angles.

SpectrumX Phased Array Prototype Exhibit

RF Safety Calculation

Array Prototype @ 7.13 GHz

Information Provided		Converted Values
Frequency	7.13 GHz	7130 MHz
Dish Diameter	18 inches	0.1 m
Transmit Power	1.60E-01 W	1.60E-01 W
Antenna Gain	21 dBi	21 dBi
Duty Factor	1	1

Limits (S)	MDPH	IEEE C95.1-2005/DoD1 6055.11 - 2009
	General Public	Occupational
(mW/cm ²)	1	5

Parameter	Symbol	Formula	Value	Units
Antenna Diameter	D	Input	0.1	m
Antenna Surface Area	A	$\pi D^2/4$	0.007853982	m ²
Frequency	f	Input	7130	MHz
Wavelength	λ	$300/f$	0.042075736	m
Transmit Power	P	Input	0.16	W
Antenna Gain (dBi)	G	Input	21	dBi
Duty Factor	DF	Input	1	
Average Power	P _{avg}	P*DF	0.16	
Antenna Gain(factor)	G _{abs}	$10^{G/10}$	125.8925412	N/A
Pi	π	Constant	3.1415927	N/A
Antenna Efficiency	η	$G_{abs}\lambda^2/(\pi^2 D^2)$	2.2582067	N/A
Distance to Far Field	R _{ff}	$0.6D^2/\lambda$	0.1426	m
On-Axis Power Density at Far Field	S _{ff}	$G_{abs}P/4\pi R_{ff}^2$	78.82628536	W/m ²
			7.882628536	mW/cm ²
Extent of Near Field	R _{nf}	$D^2/4\lambda$	0.059416667	m
Near Field Power Density	S _{nf}	$16.0\eta P/(\pi D^2)$	184.0152338	W/m ²
			18.40152338	mW/cm ²
Transition Region Power Density	S _t	$S_{ff}R_{nf}/R_t$		
Off Axis NF PD @ 1 Antenna Diameter	S _{offNF}	$S_{nf}/100$	1.840152338	mW/cm ²
Distance of Interest	R	Input	18.2	m
Power Density at distance R	R	$G_{abs}P_{avg}/4\pi R^2$	0.004839131	W/m ²
			0.000483913	mW/cm ²

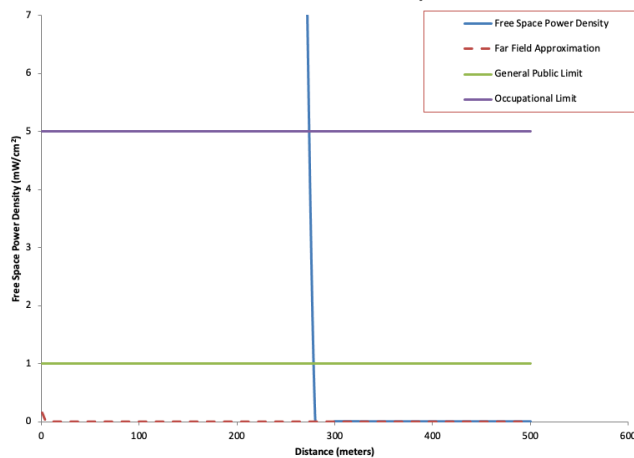
	MDPH	IEEE C95.1-2005
	General Public	Controlled
Distance (meters) to which the power density is equal to the limit using Far Field*	0.400364034	0.179048239
	0.0%	0.0%

Percentage of Limit at distance R*				
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Note: Far Field Distance are not applicable if distance R is less than R_{ff}

Distance	S	SFF	GP	Occ
Distance	Power Density	Far Field	General Public Limit	Occupational Limit
1	18.40152338	0.160291362	1	5
5	18.40152338	0.006411654	1	5
10	18.40152338	0.001602914	1	5
20	18.40152338	0.000400728	1	5
40	18.40152338	0.000100182	1	5
60	18.40152338	4.45254E-05	1	5
80	18.40152338	2.50455E-05	1	5
100	18.40152338	1.60291E-05	1	5
120	18.40152338	1.11313E-05	1	5
140	18.40152338	8.17813E-06	1	5
160	18.40152338	6.26138E-06	1	5
180	18.40152338	4.94726E-06	1	5
200	18.40152338	4.00728E-06	1	5
220	18.40152338	3.3118E-06	1	5
240	18.40152338	2.78284E-06	1	5
260	18.40152338	2.37117E-06	1	5
280	0.003904847	2.04453E-06	1	5
300	0.003644524	1.78102E-06	1	5
320	0.003416741	1.56535E-06	1	5
340	0.003215756	1.3866E-06	1	5
360	0.003037103	1.23682E-06	1	5
380	0.002877256	1.11005E-06	1	5
400	0.002733393	1.00182E-06	1	5
420	0.002603231	9.08681E-07	1	5
440	0.002484903	8.27951E-07	1	5
460	0.002376863	7.57521E-07	1	5
480	0.002277827	6.95709E-07	1	5
500	0.002186714	6.41165E-07	1	5
520	0.00210261	5.92793E-07	1	5
540	0.002024736	5.49696E-07	1	5
560	0.001952424	5.11133E-07	1	5
580	0.001885099	4.7649E-07	1	5
600	0.001822262	4.45254E-07	1	5
620	0.001763479	4.16991E-07	1	5
640	0.001708371	3.91336E-07	1	5
680	3.46651E-07	3.46651E-07	1	5
700	3.27125E-07	3.27125E-07	1	5
720	3.09204E-07	3.09204E-07	1	5
740	2.92716E-07	2.92716E-07	1	5

Calculated Free Space Power Density
as a Function of Distance from Aperture



5.4. Propagation Transmitter Safety Calculation

The Propagation Transmitter is safe at all distances for the array configuration using either the dipole or horn antennas.

SpectrumX Propagation Transmitter Exhibit

RF Safety Calculation

Propagation TX @ 7.13 GHz

Information Provided		Converted Values	
Frequency	7.13 GHz	7130 MHz	
Dish Diameter	6 inches	0.1 m	
Transmit Power	1.00E+00 W	1.00E+00 W	
Antenna Gain	15 dBi	15 dBi	
Duty Factor	1	1	

Limits (S _i)	MDPH		IEEE C95.1-2005/DoDI 6055.11 - 2009	
	General Public	Occupational	Action	Controlled
(mW/cm ²)	1	5	1	10

Parameter	Symbol	Formula	Value	Units
Antenna Diameter	D	Input	0.1	m
Antenna Surface Area	A	$\pi D^2/4$	0.007853982	m ²
Frequency	f	Input	7130	MHz
Wavelength	λ	$300/f$	0.042075736	m
Transmit Power	P	Input	1	W
Antenna Gain (dBi)	G	Input	15	dBi
Duty Factor	DF	Input	1	
Average Power	P _{avg}	$P \cdot DF$	1	W
Antenna Gain (factor)	G _{abs}	$10^{G/10}$	31.6227766	N/A
PI	π	Constant	3.1415927	N/A
Antenna Efficiency	η	$G_{abs} \lambda^2 / (\pi^2 D^2)$	0.567235877	N/A
Distance to Far Field	R _{ff}	$0.6D^2/\lambda$	0.1426	m
On-Axis Power Density at Far Field	S _{ff}	$G_{abs} P / 4\pi R_{ff}^2$	123.7516729	W/m ²
Extent of Near Field	R _{nf}	$D^2/4\lambda$	12.37516729	mW/cm ²
Near Field Power Density	S _{nf}	$16.0\eta P / (\pi D^2)$	0.059416667	W/m ²
			288.8908556	mW/cm ²
Transition Region Power Density	S _t	$S_{ff} R_{ff} / R_t$		
Off Axis NF PD @ 1 Antenna Diameter	S _{DNF}	$S_{ff} / 100$	2.888908556	mW/cm ²
Distance of Interest	R	Input	18.2	m
Power Density at distance R	R	$G_{abs} P_{avg} / 4\pi R^2$	0.007597092	W/m ²
			0.000759709	mW/cm ²

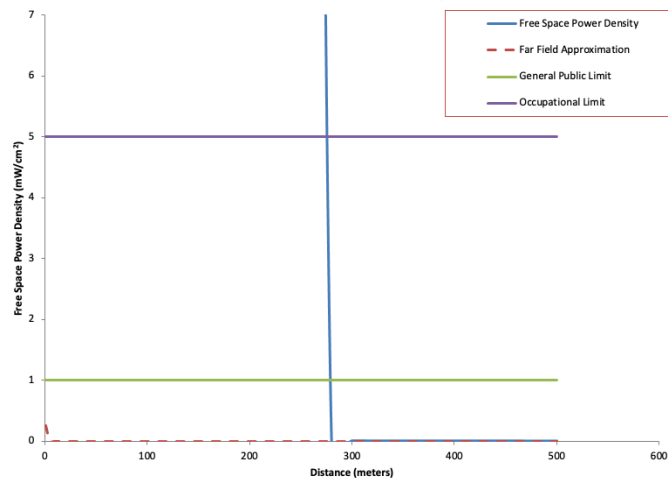
		MDPH		IEEE C95.1-2005	
		General Public	Controlled	Action	Controlled
Distance (meters) to which the power density is equal to the limit using Far Field*	R _L	0.501643356	0.224341729	0.501643356	0.15863356
		0.1%	0.0%	0.1%	0.0%

Percentage of Limit at distance R*

Note: Far Field Distance are not applicable if distance R is less than R_{ff}

Distance	S	SFF	GP	Occ
Distance	Power Density	Far Field	General Public Limit	Occupational Limit
1	28.88908556	0.251646061	1	5
5	28.88908556	0.010065842	1	5
10	28.88908556	0.002516461	1	5
20	28.88908556	0.000629115	1	5
40	28.88908556	0.000157279	1	5
60	28.88908556	6.99017E-05	1	5
80	28.88908556	3.93197E-05	1	5
100	28.88908556	2.51646E-05	1	5
120	28.88908556	1.74754E-05	1	5
140	28.88908556	1.28391E-05	1	5
160	28.88908556	9.82992E-06	1	5
180	28.88908556	7.76685E-06	1	5
200	28.88908556	6.29115E-06	1	5
220	28.88908556	5.1993E-06	1	5
240	28.88908556	4.36886E-06	1	5
260	28.88908556	3.72257E-06	1	5
280	0.006130333	3.20977E-06	1	5
300	0.005721644	2.79607E-06	1	5
320	0.005364041	2.45748E-06	1	5
340	0.005048509	2.17687E-06	1	5
360	0.004768037	1.94171E-06	1	5
380	0.004517087	1.7427E-06	1	5
400	0.004291233	1.57279E-06	1	5
420	0.004086888	1.42656E-06	1	5
440	0.003901121	1.29982E-06	1	5
460	0.003731507	1.18925E-06	1	5
480	0.003576027	1.09221E-06	1	5
500	0.003432986	1.00658E-06	1	5
520	0.003300948	9.30644E-07	1	5
540	0.003178691	8.62984E-07	1	5
560	0.003065166	8.02443E-07	1	5
580	0.002959471	7.48056E-07	1	5
600	0.002860822	6.99017E-07	1	5
620	0.002768537	6.54646E-07	1	5
640	0.002682021	6.1437E-07	1	5
680	5.44217E-07	5.44217E-07	1	5
700	5.13563E-07	5.13563E-07	1	5
720	4.85428E-07	4.85428E-07	1	5
740	4.59544E-07	4.59544E-07	1	5
760	4.35675E-07	4.35675E-07	1	5

Calculated Free Space Power Density as a Function of Distance from Aperture



6.0 Conclusion

We request permission to conduct an experiment at specific carriers in the 7.125 to 7.145 GHz and 7.3 to 7.7 GHz bands to enable the study of spectrum coexistence in the lower 7 GHz band. The transmissions will occur in the greater New England region and centered around MIT Haystack Observatory in Westford Massachusetts during the period of July 24th to August 26th of 2026. The experiment is planned as part of the NSF supported SpectrumX Center flagship project efforts. It will provide a valuable training opportunity for students, faculty, and staff of the Center. We expect that the data set collected will be made publicly available and will constitute co-existence related measurements relevant to the usage of the lower 7 GHz band. Quantitative information regarding potential use, impacts, and co-existence approaches will be of critical interest to the NSF, FCC, NTIA, DoD, DoE, NASA, and NOAA. Our effort is a key next step for study of coexistence approaches relevant to next generation wireless systems. Such studies are relevant for existing government users such as NASA and NOAA satcom and for passive services such as radio astronomy.