APPENDIX C

To the ARRL EMC Committee Report Doc #16

For the July 2024 Board Meeting

Analysis of Shortwave Modernization Coalition Experimental Licenses and Recorded Transmissions

Written by the ARRL Lab 7/17/24

SUMMARY

Members of the Shortwave Modernization Coalition (SMC) and other entities have operated numerous FCC issued Experimental licenses (CFR 47 Part 5) that have been used to create Ultra Low Latency networks (ULL) for the purposes of testing the feasibility of using HF spectrum to conduct High Frequency Trading (HFT) of commodities. SMC has petitioned the FCC for a change in rulemaking to the Part 90 spectrum (RM-11953), which includes the rules governing out-of-band emissions that would affect amateur allocations, claiming that their stations do not cause interference to other spectrum users, so therefore their proposed rule changes are not going to cause interference on the shortwave frequency bands.

Reporting: Because these stations do not identify their transmissions and no coordinated testing with other spectrum users has taken place, the lack of interference complaints cannot be taken as demonstrating a lack of interference.

Experimental Data: The SMC in their petition for rulemaking included data in support of their proposals that is factually insufficient for proving their arguments. The data consists entirely of computer model simulations of their transmissions and fail to include empirical data from the experiments they have been performing over the past 8 years. Currently the only data on SMC transmissions and their characteristics has been collected by individuals travelling to these sites and making recordings of the RF signals present. However, even this method does not guarantee that the signals present are transmitted by HFT stations as these companies often rent these transmitter sites and share the space with other users. It is also unknown what power these transmitters are operating at and to what degree these signals are attenuated. The signals that have been observed and recorded have had significant out of band[1] emissions across a wide bandwidth near the fundamental and have not been observed operating near the amateur band edges. The proposed rules would allow for signals that are significantly less attenuated than the observed transmissions which would pose an interference risk to amateur signals up to tens of kilohertz away from the band edges of spectrum adjacent to Part 90 allocations.

Technical Analysis: Members of the SMC have mischaracterized their broadcast equipment in their applications for experimental licenses which has allowed for them to avoid the ID requirement under Section 115. The equipment that has been publicly identified that is used by SMC members is capable of satisfying the Section 115 ID Requirements. In addition, the argument from the SMC relies on the assumption that a

[1] Out of Band Emissions are unwanted emissions that result from the modulation process and whose frequencies are immediately outside of the necessary bandwidth (47 CFR 95.303)

"listen before talk" scheme is sufficient to prevent all interference, however shortwave propagation is not necessarily bidirectional, and it is very easy to cause significant interference to a signal that is not audible at the transmit site due to various HF Propagation effects such as the presence of 'skip zones'[2]. These stations may also operate at a power level much higher than other stations, which can completely mask a transmission. There is also no consideration given to interference to signals outside the fundamental under this proposed listen before talk scheme which poses a danger to amateur radio signals in adjacent bands especially in the case of amateurs near an HFT site. It is for these reasons that the proposed rules outwardly constitute an interference risk to amateur radio.

Observed Signals: Using an SDR receiver, spectrum analyzer, and other test equipment, the ARRL Lab has visited and made recordings of 3 HFT sites: WI2XNX, WI2XXG, and WK2XJK. The signals recorded by the ARRL are exemplative of the types of signals that would be allowed by the SMC's petition. Observations show signals that are wide bandwidth with significant out of band emissions outside their fundamental frequency, far from the band edges of their allocated spectrum. Many of these signals if operated near the Part 90 band edges would create significant interference to adjacent amateur radio spectrum**.**

REPORTING

The SMC in large part relies on the lack of reports of interference from their stations to justify a permanent change in the rules. This should not be a compelling argument in part because their transmissions are unidentifiable due to the lack of any ID requirements. They could have also identified their experimentation using the FCC's Experiments Notification System website, which would not have required them to transmit their call sign, yet none of the SMC members' experimental stations have done so. Because their experiments lack documentation or identification it is unknown to what extent their stations have caused interference to other part 90 stations, but their claims of no interference are incorrect. The SMC experimental stations have not published any experimental results in their rulemaking petition. This section will lay out the experimental stations, their call sign identification requirement, and the status of their station's notification on the Experimental Notification System.

[2] A skip zone is a region between the outer limits of ground wave reception and the nearest limits of the sky wave reception. Within this region, no signal can be received as there are no radio waves to receive.

Call Sign	ID Required	Experimental Notification Status	Equipment	Location
WH2XVO	No	None	Redacted	Chicago, Secaucus, Homer, AL
WH2XWU	Yes	None	Experimental Unit	Chicago
WI2XAJ	No	None	NI USRP 200	Chicago
WI2XER	No (2018)	None	Redacted	Long Island, NY
WI2XNX	No	None	Trellisware 6210	Chicago
WI2XWV	No	None	Redacted	Chicago
WI2XXG	No	None	Barret 2050 SSB Transceiver, Experimental Unit	Johnsonburg NJ, Chicago IL,
WJ2XGD	No	None	Redacted	Chicago
WJ2XXI	No	None	Redacted	Chicago
WK2XJK	No	None	Experimental	Bergen, NJ
WK2XSY	No	None	Redacted	Chicago
WK2XTH	No	None	Redacted	Bergen, NJ
WL2XAB	No	None	Redacted	Chicago
WL2XEE	No	None	Experimental Unit	Chicago
WL2XFU	No	None	Redacted	Chicago, Seattle
WL2XYM	No	None	USRP X310	Seattle
WM2XHW	No	None	Experimental Unit	Chicago
WM2XTS	No	None	USRP X310	Chicago
WM2XZU	No	None	Prototype	Chicago
WN2XCR	No	None	Experimental Unit	Oxford Junction, IA
WN2XKQ	Yes/No	None	Redacted	Chicago

Table 1: Part 5 Experimental Licenses

*Stations Marked with a Yes/No identified on their application that their equipment could not identify but were not expressly granted a waiver of 5.115 in their license grant.

* Highlighted stations are HFT stations that have participated in rulemaking petitions with SMC members but are not members of the SMC

As can be seen from the table above, all of the SMC stations have gotten Section 5.115 Station ID requirement waived and none of these stations have used the Experiment Notification System to publicize the operating frequency and signal characteristics of their tests. This may be an acceptable standard for isolated experiments, but these tests should not be the basis for a sweeping rule change which have the potential to affect signals outside of the frequency bands being sought.

OBSERVED TRANSMISSIONS

WI2XNX:

ARRL's Digital RF Engineer, John McAuliffe, W1DRF, created recordings from ARRL Headquarters of many shortwave data transmissions and was able to correlate them, albeit without 100% certainty, to known recordings of certain SMC stations, notably WI2XNX, an HFT station in Chicago owned by 10Band LLC. Dave Wilson, AC4IU, did additional on-site and over-the-air testing.

The signal, as observed by Wilson on-site in Chicago, is 1 or 2 separate transmissions, each with a bandwidth of 50 kHz using OQPSK (Offset Quadrature Phase Shift Keying) modulation. Using the data provided by Wilson, McAuliffe was able to hear this signal at ARRL Headquarters and used these signals as an initial reference to understand the characteristics of the ULL data transmissions.

The following two images show a pair of signals originating from what is believed to be the WI2XNX station. Originally only the signal on the left was present, and there was an unknown data signal or radar transmission on the right in the area highlighted in green. McAuliffe started recording a few moments after the second WI2XNX signal started transmitting over the same frequency of the OOK signal. This transmission continued for over a minute before stopping. The OOK signal was still audible but had significant interference during the transmission, and this signal is usually present at that frequency during that time.

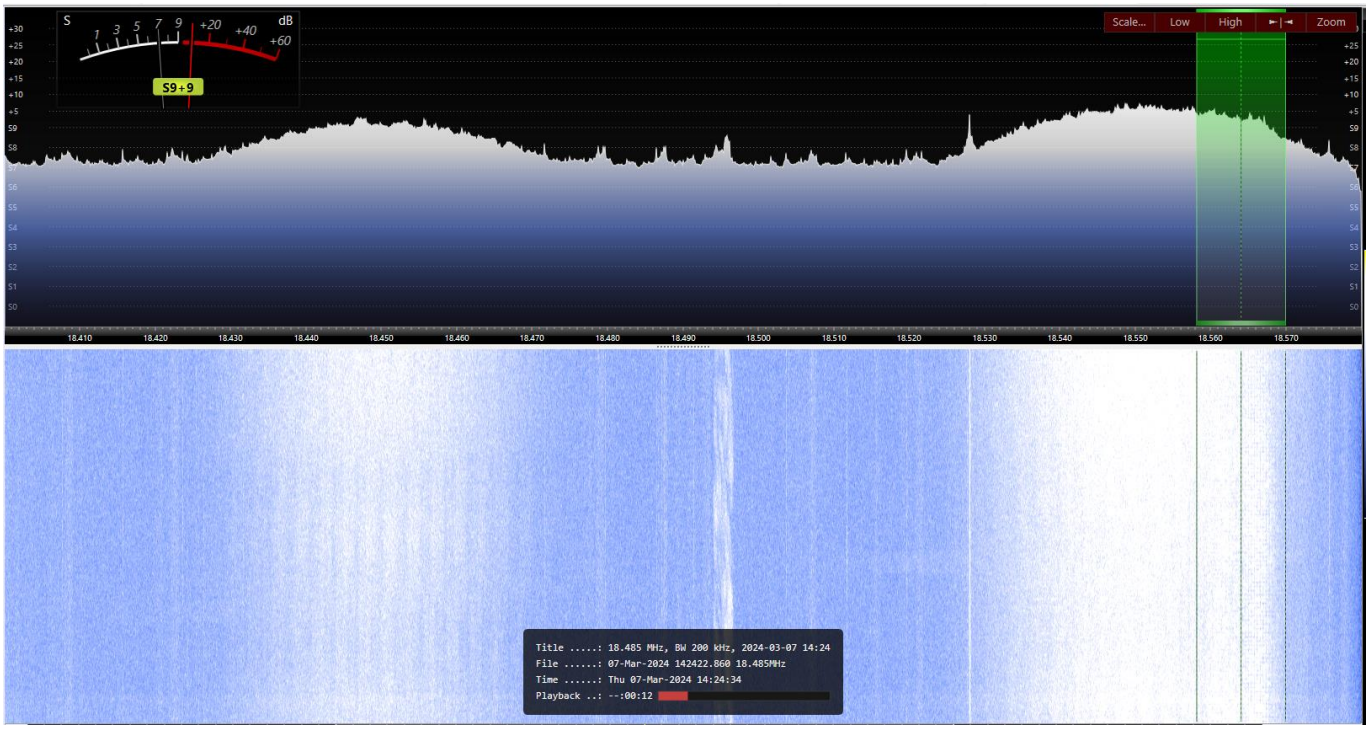


Figure 1: WI2XNX Interference During Transmission

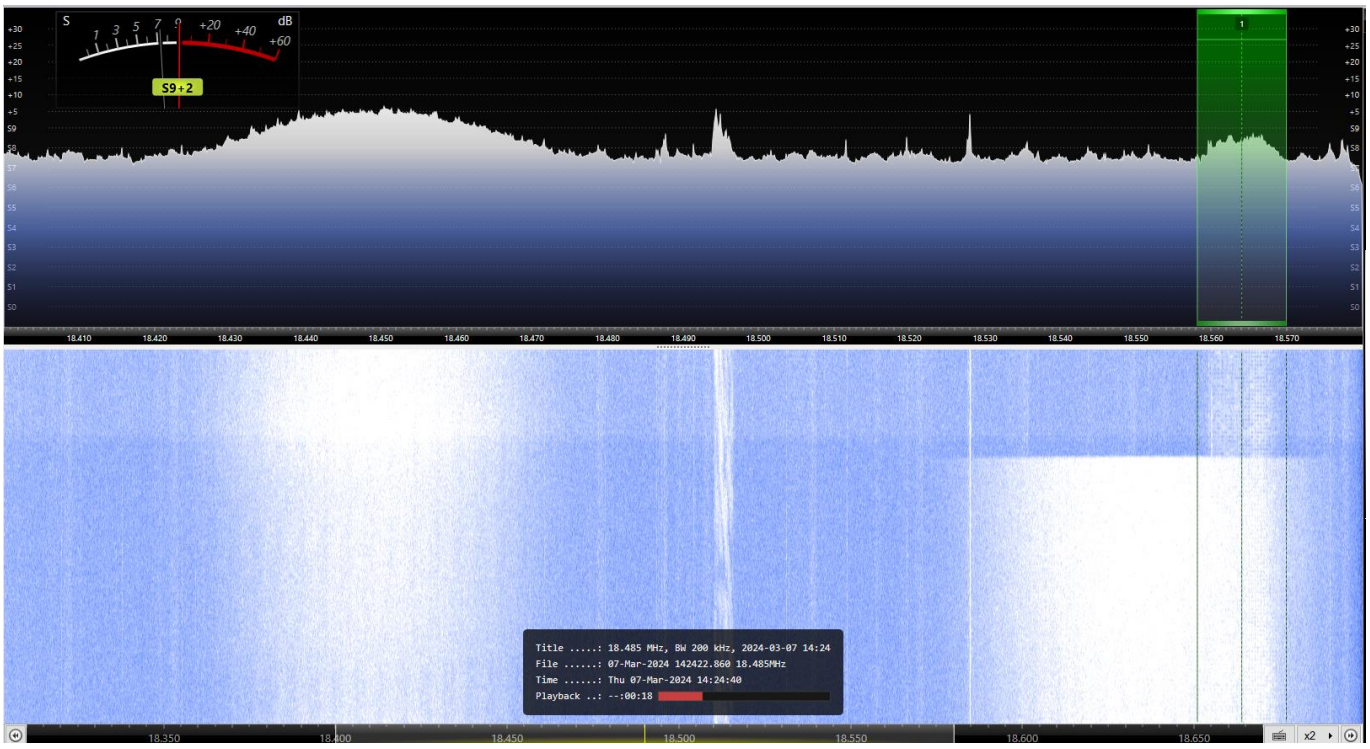


Figure 2: WI2XNX Signal After Halting Transmission

Although this interference was observed outside the amateur spectrum, it is exemplative of the type of interference that may happen within the amateur spectrum by transmitters operating near the amateur band edges. In this case the interference occurred within the fundamental frequency of the Experimental station and with high power which is why the transmitter changed frequencies, and it is unknown if this system would monitor for potential interference caused by its out of band emissions especially to low power transmissions such as those used in amateur radio.

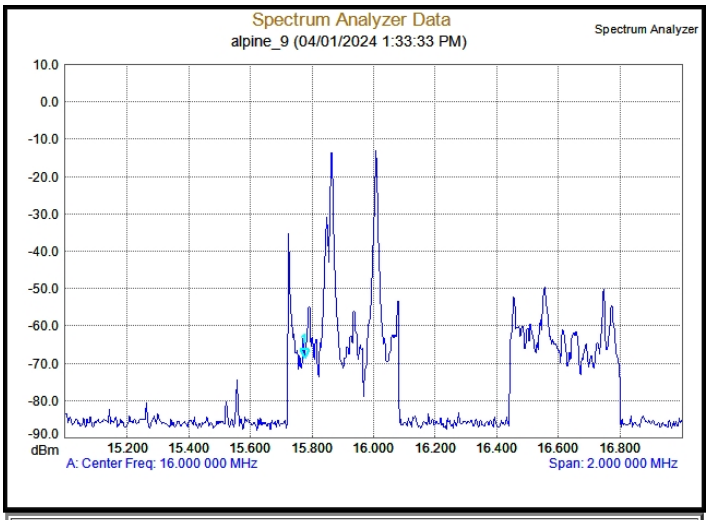
WK2XJK:

John McAuliffe, W1DRF, travelled to Alpine, New Jersey, to visit the WK2XJK station which is owned and operated by Research Capital LLC, a member of the SMC. The experimental site is a multi-use transmit station shared by FM broadcasters.

Figure 3: Photograph of one of the Towers at the Site WK2XJK

Figure 4: Satellite View of WK2XJK Experimental Site and Measurement Location with Distance

Due to the multiple high power transmissions present at the site it was difficult get direct measurements on the site's property, so measurements were taken a half mile down the road to eliminate interference caused by the reciever being overloaded. Measurements were taken using an RSP1a SDR Reciever, Anritsu Spectrum Analyzer, and an active receiving loop antenna.



Measurement Parameters			
		Trace Mode	Max Hold
Preamp	OFF	Min Sweep Time	0.066666 S
Reference Level Offset	0 dB	Input Attenuation	30.0 dB
RBW	1.0 kHz	VBW	1.0 kHz
Detection	Peak	Center Frequency	16.000 000 MHz
Start Frequency	15.000 000 MHz	Stop Frequency	17.000 000 MHz
Frequency Span	2.000 000 MHz	Reference Level	10.000 dBm
Scale	10.0 dB/div		

Device Information			
Serial Number	1605081	Base Ver.	V5.90
App Ver.	V7.15	Model	MS2720T
Options	9, 25, 31, 431, 709	Date	04/01/2024 1:33:33 PM
Device Name			

Figure 5: Spectrum Analyzer Capture of 2 WK2XJK Transmissions using Peak Hold

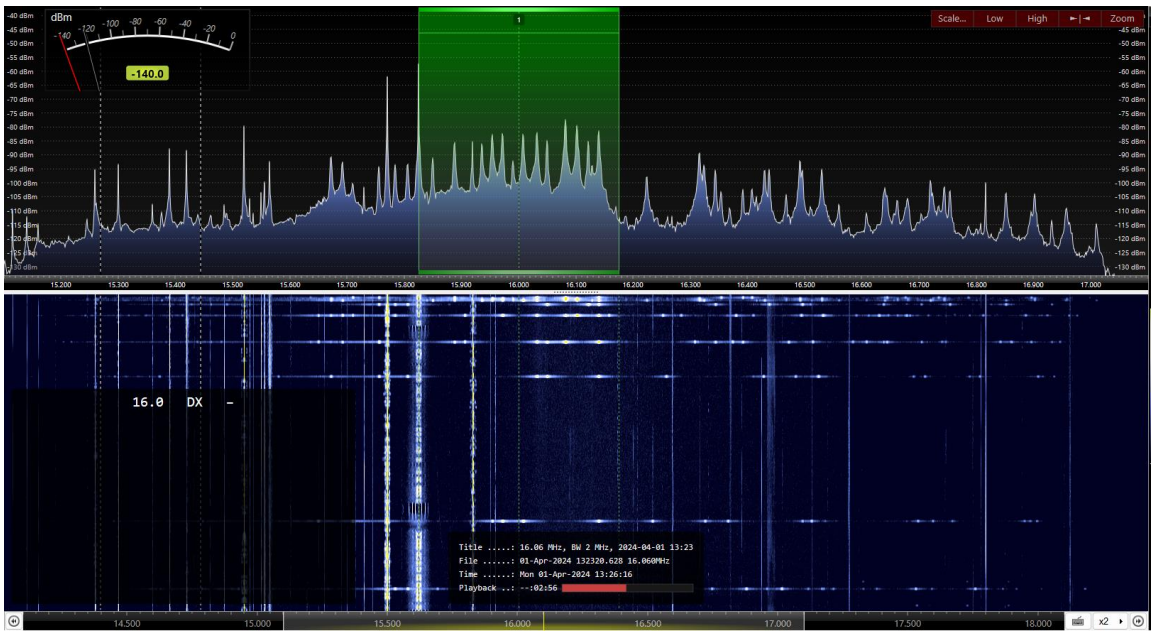


Figure 6: SDR Reciever Waterfall Capture of WK2XJK Transmission

The transmission observed was a 350+ kHz wide[3] Frequency Hopping Spread Spectrum Burst signal far from any amateur frequency allocation. Out-of-band emissions were observed as being both above and below the fundamental transmission at a power between 20 and 30 dB below the fundamental. The signal was observed transmitting over Shortwave AM broadcasters and data signals on the Part 90 spectrum that were clearly audible at the transmitter site.

WI2XXG:

Retired Laboratory Manager Ed Hare, W1RFI, travelled to Johnsonburg New Jersey to visit the experimental site WI2XXG which is owned and operated by 3DB Communications LLC. Measurements were taken approximately 1200 ft from the site which was as close to the site as possible without trespassing. Due to the distance and tree cover it was not possible to determine which of the antennas were used for transmission or in what direction the transmissions were being sent. Measurements of the transmissions were taken with an RSP1A SDR and an Anritsu Spectrum analyzer using an active receiving loop antenna. WI2XXG is not a member of the SMC but they have worked with SMC members to change Part 73 rules in the past and their type of transmissions are akin to the types of transmissions that would be allowed by the rules change.

Figure 7: Satellite View of Measurement Location and Test Site WI2XXG

[3] It is possible that the signal observed is from two separate Experimental transmitters located at the site, each narrower than 350 kHz.

Figure 8: Distance between Antenna Array and Measurement Location WI2XXG

Figure 9: Transmitting Antennas as seen from Test Site WI2XXG

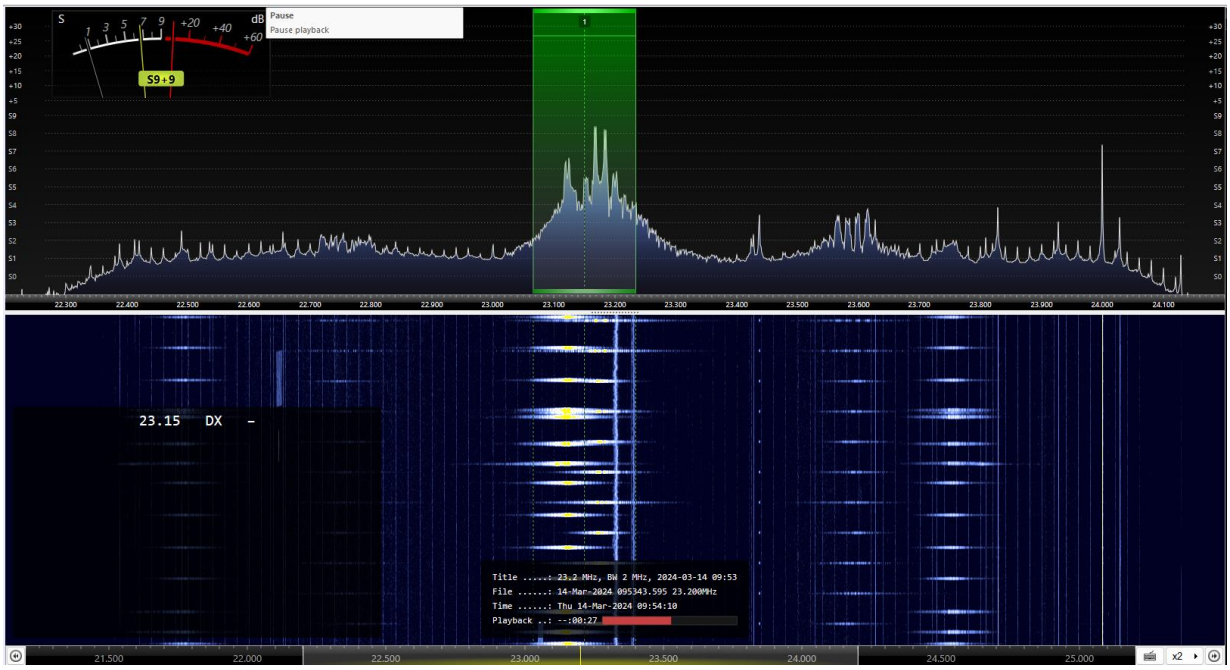
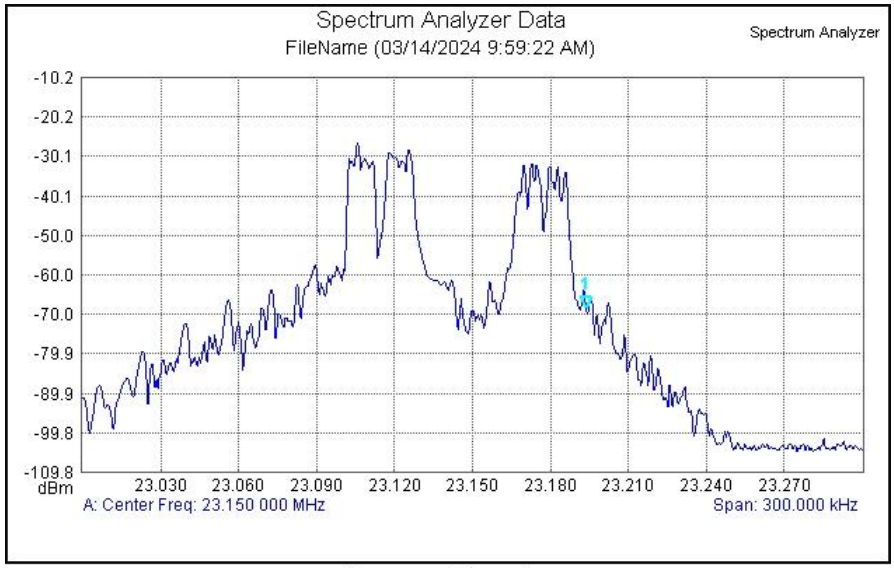


Figure 10: WI2XXG Transmissions on SDR Waterfall Display



Measurement Parameters

		Stop Frequency	23.300 000 MHz
Trace Mode	Max Hold	Frequency Span	300.000 000 kHz
Preamp	OFF	Reference Level	-10.200 dBm
Min Sweep Time	0.049999 S	Scale	10.0 dB/div
Reference Level Offset	0 dB	Serial Number	1605081
Input Attenuation	10.0 dB	Base Ver.	V5.90
RBW	1.0 kHz	App Ver.	V7.15
VBW	1.0 kHz	Model	MS2720T
Detection	RMS	Options	9, 25, 31, 431, 709
Center Frequency	23.150 000 MHz	Date	03/14/2024 9:59:22 AM
Start Frequency	23.000 000 MHz	Device Name	

Figure 11: Spectrum Analyzer Capture of WI2XXG signal using Peak Hold with Measurement Table

The measurement location chosen was as close as it was safe to park on the side of the road near the antennas. The signal observed at the site was a 100+ kHz wide signal[4] using burst transmissions to send data packets. The out-of-band emissions were observed both below and above the main transmission and were measured to be 25 dB below the fundamental transmission. The signal was observed to be transmitting on top of a full duty cycle PSK modulated data signal well within the fundamental transmission. The out-of-band emissions were not within the amateur band but were close to the lower band edge of the 12-meter amateur band.

Technical Analysis

For the experimental stations that are members of the SMC, all of them, with the exception of Skycast Services LLC WI2XER, have claimed that their equipment is incapable of Station Identification pursuant to Section 5.115. All of the SMC stations have obtained waivers of the Section 5.115 ID requirement. Most of these stations have asked for their equipment to be treated with confidentiality or are using some sort of prototype or experimental transmitter, and therefore the equipment capabilities of these stations are unknown. However, for the few stations that have identified their transmit equipment and in the cases where the equipment has documentation the statement that the equipment is incapable of self-ID is untrue.

WI2XAJ, WL2XYM, and WM2XTS have identified their transmitters as being NI USRP 200s, and NI USRP 310X. Both of these transceivers are a part of the National Instruments Software Defined Radio line and have similar technical characteristics for the purpose of this analysis. The National Instruments SDRs interface with PCs and use raw I/Q values with a defined center frequency and bandwidth to modulate a signal with an I/Q Modulator and transmit it. This I/Q data is generated by software platforms, a popular one being GNU radio.

The other identified radio used that is not experimental is the Barret 2050 SSB Transceiver, which is a standard transceiver not dissimilar to what many amateur radio operators would use. A photo of this transceiver from Motorola's website is attached showing it comes with a push to talk handheld microphone, and the specifications for this transceiver show that it supports USB and LSB voice and CW operation. This piece of equipment is capable of Station Identification Pursuant to Section 5.115.

[4] It is possible that the signal observed is from two separate Experimental transmitters located at the site, each narrower than 100 kHz.

Figure 12: Barrett 2050 SSB Transciever

The signals that have been observed by the ARRL have all been unique, using different modulation types, bandwidths, and having different magnitudes of attentuation of out of band emissions. There is no common standard used by the operators of these experiemental licenses.