Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Shortwave Modernization Coalition	)	RM-11953
Petition for Rulemaking to Amend the	)	
Commission's Rules to Allow Fixed,	)	
Long-Distance, Non-Voice	)	
Communications Above 2 MHz and	)	
Below 25 MHz		

Opposition of ARRL, The National Association For Amateur Radio

ARRL, The National Association for Amateur Radio, also known as the American Radio Relay League, Incorporated (ARRL), submits this Opposition to RM-11953, a Petition for Rulemaking filed by the Shortwave Modernization Coalition (SMC) seeking amendments to Part 90 of the Commission's Rules.[1] Adoption of the rules proposed by SMC would authorize high-power and wide-bandwidth digital transmissions on Part 90 spectrum between 2 and 25 MHz.

Many of the subject Part 90 bands are immediately adjacent or very near to spectrum bands that are allocated to the Amateur Radio Service on a primary basis. These bands are very heavily used for worldwide communication by Amateur Radio licensees employing significantly less power than that proposed by SMC for purposes that include vital support during disaster recovery and mitigation, technical and scientific experiments, and propagation studies.[2]

[1] This Opposition is being filed within two days of the Commission's Order denying Skywave Networks LLC and FlexRadio Systems Motions for Extension of Time, DA-23-649 (July 31, 2023), *see* 47 C.F.R. § 1.46(b).
[2] The adjacent bands are identified in the attached ARRL Analysis at Table 1, p. 3 of 11.

ARRL commissioned a technical analysis to determine if the rules proposed by SMC would affect operations on the bands allocated to the Amateur Radio Service that are inter-mixed with the Part 90 bands in the subject spectrum. The analysis was prepared by Mr. Ed Hare, a recognized expert in the analysis of radio frequency interference, who recently retired as Manager of the ARRL Laboratory after 37 years spent analyzing spectrum interference that included both situations related to Amateur Radio and those related to potentially harmful interference to and among other services.[3] The ARRL Analysis authored by Mr. Hare is attached to this Opposition.

ARRL's analysis concludes that Part 90 operations as they would be permitted under the proposed rules would not just threaten to cause harmful interference to Amateur communications, but would cause widespread disruption to Amateur and other communications services on multiple spectrum bands. The proposed rules are seriously flawed, and would adversely impact other services as well as the Amateur Radio Service. If the Part 90 HF spectrum is to be used for a service of the type proposed, the rules must reflect the realities and peculiarities of HF propagation and be limited to power levels and bandwidths that, with appropriate requirements for suppression of out-of-band emission (OOBE) and spurious emissions, will reasonably protect neighboring and adjacent services from harmful interference.

[3] Mr. Hare is a spectrum veteran with deep experience in the field of radiofrequency interference. He has served as the IEEE EMC Society Vice President for Standards, on the ANSI-ASC C63 Committee on Electromagnetic Compatibility (EMC) and chair of its Subcommittee 5 (RF Immunity), as a member and Secretary of the IEEE EMC Society Standards Development and Education Committee, a member of the IEEE EMC Society Standards Development and Advisory Committee, a member of the IEEE EMC Society Working Group on Power-Line Noise, and a member of multiple related IEEE EMC Society technical committees.

THE RULES PROPOSED BY SMC WILL RESULT IN HARMFUL AND EVEN DESTRUCTIVE INTERFERENCE TO AMATEUR COMMUNICATIONS

Multiple Part 90 bands from 2-25 MHz immediately abut Amateur HF bands. This results in the Amateur bands being especially vulnerable to harmful interference from OOBE and spurious emissions from the adjacent Part 90 bands. Rather than proposing at least the protection levels consistent with those that have proven effective in other services, SMC instead proposes in its petition to ***lessen*** the applicable protections that already reside in Part 90 and other Commission rules to minimize the potential of harmful interference to adjacent and neighboring licensees and services. The predicted harmful interference potential is exacerbated by the proposed broad bandwidth, digital modulation, and high power. The result is that, if adopted, the new high-power digital operations inevitably will cause significant harmful interference to many users of adjacent and nearby spectrum, including operators in the Amateur Radio Service.

Part 90 HF operations today are limited by rule to a maximum signal bandwidth equal to a voice communications channel.[4] SMC proposes a much wider signal bandwidth, one that would range up to 50 kHz. As explained in the attached ARRL Analysis, the increase in bandwidth would create the potential for harmful interference across a much wider adjacent frequency range than the narrower voice-bandwidth transmissions currently permitted. This is because the area of undesired emissions outside the intended bandwidth is proportional to the signal bandwidth.

The OOBE limits proposed by SMC are much less protective than existing requirements, covering a frequency range of ±250% of the bandwidth of the digital transmissions. Specifically,

[4] *See* 47 C.F.R. § 90.266(f).

adoption of SMC's proposal would permit digital modulation sidebands to be greater than the current Part 90 HF limits on spurious emissions and intrude as much as 100 kHz into Amateur bands that themselves are only 300 to 450 kHz in total width.

Digital modulation compounds the potential for out-of-band interference absent Commission rules to ensure that the digital transmitting system designs used in this spectrum incorporate the necessary shaping of the transmitted signals sufficient to meet OOBE limits capable of protecting adjacent and neighboring operations. Practical post-design hardware filtering is not sufficient to provide the attenuation needed to protect adjacent and neighboring spectrum users.

SMC's request to substantially increase from 1000 watts to 20,000 watts the power limits for wideband Part 90 HF digital transmissions and to define the limit as ***average*** power rather than peak envelope power (PEP) further compounds the potential for out-of-band interference. The increase of at least 13 dB in power and the change from PEP to average power can be even more for some digital transmission techniques. Such significant increases in power would create a much greater potential for harmful interference than the existing Part 90 HF limit of 1000 watts PEP for 3 kHz SSB transmissions.

Incredibly, notwithstanding the significant increase in potential interference that would result from using digital schemes with 50 kHz bandwidths and 20,000 watts of power, SMC also proposes to substantially lessen the protections required to protect adjacent and neighboring licensees. SMC proposes OOBE limits that offer less protection than the existing Part 90 limits and would actually permit no attenuation (0 dB) at the edge of adjacent allocations, many of which are bands allocated to and heavily used in the Amateur Radio Service.

Consistent with lessening protections while increasing the potential for harmful interference, SMC also proposes a lower limit for spurious emissions. SMC would reduce the existing protection of -73 dB for the applicable 1000 watt power limit to just -50 dB protection for their proposed 20,000 watt limit. Due to the much wider 50 kHz proposed bandwidth, the resulting interference would penetrate deep into the adjacent Amateur bands.

The Quadra Partners "Coexistence Report" (Quadra Report) submitted with SMC's Petition follows the same pattern of minimizing or underestimating the likelihood for harmful interference. For example, the Quadra Report counts in the average times of use for a particular frequency the hours during which a frequency will not support long-distance communication and therefore will not be employed. Furthermore, users of the HF spectrum – high frequency traders, radio amateurs, and other users – can be expected to use specific areas of the spectrum only during the hours that distant propagation is supported by the ionospheric conditions. Including the hours that the frequency is unlikely to be used by anyone because of the lack of propagation unrealistically minimizes Quadra's predictions of interference.

Another tool used in the Quadra Report to unrealistically minimize predicted interference is its consideration of only signals propagated by the ionosphere. On one hand the Quadra Report inflates the hours that a frequency will be used, and on the other hand it excludes consideration of groundwave signals that will propagate for considerable distances even when the ionosphere will support more distant communication. The signal strength of such groundwave signals typically can be expected to be 50 or more dB above noise levels for several miles from the transmitting location.

It is apparent from these and additional factors set out in the attached ARRL Analysis that the predictions of interference in the SMC Petition and the Quadra Report significantly

understate the harmful interference that is not just likely, but certain, if the rules proposed by SMC are adopted. It is noteworthy that SMC's proposed rules would provide less protection than the much-lower power Amateur Radio transmitters are required to provide Part 90 HF users.

THERE WAS NO REPORTED TESTING WITH AMATEUR OR OTHER AFFECTED STATIONS

The impact that the Part 90 changes would have on spectrum allocated to and used by Radio Amateurs would be significant. SMC employs semantics to suggest that its members used their experimental licenses to test the proposals in the real world, and that no interference was found. Having an experimental license and transmitting at unknown times is hardly any sort of valid test. It is in no way a relevant test to transmit at unknown hours and frequencies with no observers to document the effects of the signal on spectrum neighbors. SMC submits no information that suggests that any sort of operation was ever conducted that could be called a test for interference with observers of any sort.

We also want to note that the experimental licenses of SMC members that we reviewed include authorizations to use technical parameters that are not reflected in the proposals made in SMC's petition. Consequently the essential details are unknown of any experimental transmissions claimed to demonstrate a lack of interference, including such essential information as actual transmit powers, effective radiated powers (ERP), transmit bandwidth, type of data transmission, and propagation conditions. We found no reports in SMC's petition or in the Commission's experimental license files suggesting that any tests were ever conducted and documented at which third parties were used to observe whether interference was being caused to spectrum neighbors.

We note in particular the Comments filed by the Dayton Group, on page 5 of which is reproduced a spectrum capture of a signal apparently transmitted under experimental license

WI2XXG.[5] At the time of capture, the HFT experimental station was transmitting only a 20 kHz wide signal located 25 kHz above the Amateur band edge, yet harmful interference is clearly observed for tens of kHz inside the Amateur band. In fact, the observed power radiated into the upper end of the Amateur band was more than most Radio Amateurs use for their primary transmissions on those frequencies even though the experimental signal was employing the equivalent of a guard band. This is the sole report of an observation that we found, and it confirms the findings in the attached ARRL Analysis.

CONCLUSION

The ARRL constrained its review and analysis to the interference potential represented by the technical rules proposed in the SMC petition. During the process it became clear that despite the statements and rhetoric in the Petition, no actual test results relevant to harmful interference to spectrum neighbors have been provided by the petitioners. The proposed rules requested by SMC offer substantially less protection to the licensees who would be its spectrum neighbors than protections adopted by the Commission in multiple other services, including the Amateur Service. It also became apparent that destructive interference would result if operations commenced using anything close to these rules.

[5] Comments of the Dayton Group (filed July 28, 2023).

Accordingly, the ARRL respectfully requests that the petition be dismissed or denied.

Respectfully submitted,
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Analysis of Shortwave Modernization Coalition Petition to Permit High-Speed Digital Transmissions on Part 90 HF Spectrum

Prepared by: Ed Hare, W1RFI for ARRL, The National Association for Amateur Radio®

SUMMARY

The Part 90 rules proposed by the Shortwave Modernization Coalition (SMC), if adopted, will result in significant interference to adjacent-channel users and to adjacent radio services such as amateur radio.

- **Bandwidth:** Part 90 rules limit bandwidth between 2 and 25 MHz to that required for analog voice communications. SMC proposes a significant increase in bandwidth, up to 50 kHz, that poses the potential for harmful interference across a much wider frequency range than the voice-bandwidth transmissions currently permitted. Any new rules must specify the measurement bandwidth for spurious and out-of-band emissions (OOBE).
- **Adjacent Spectrum:** Nine of the subject Part 90 bands from 2-25 MHz immediately abut or overlap seven amateur HF bands, resulting in these bands being especially vulnerable to OOBE.
- **Power:** SMC seeks to increase the power limits for wideband Part-90 digital transmissions to 20,000 watts *average* power. This is an increase in power of at least 13 dB (or more for some digital transmission techniques) over the existing limit of 1000 watts PEP for SSB emissions. Such an increase in power would create a much greater potential for interference than the existing Part 90 limits for SSB transmissions.
- **Out-of-Band Emissions (OOBE):** SMC requests providing substantially less OOBE protection, including 0 dB of attenuation at the edge of the occupied communications channel. This will cause severe interference extending many kHz on both sides of the digital transmission.
- **Spurious emissions:** SMC seeks to significantly lower existing protections from spurious emissions. It would lower the existing limit of -73 dB for existing 1000-watt transmitters to a limit of just -50 dB for 20,000-watt transmitters. Such a change would significantly increase the potential for interference.
- **Coexistence Report:** The Coexistence Report significantly underestimates the likelihood of interference by including times that a particular frequency will not support long-distance communication and therefore not be used.
- **Interference to noise ratio (I/N):** The Coexistence Report uses the residential noise floor as defined in ITU-R P.372-16 (P.372.16) as its benchmark. This represents a noise increase of 3 dB. No more than a 1 dB increase normally is used as a benchmark by regulators. To achieve that customary benchmark, noise would need to be 6 dB lower than existing noise levels to have an insignificant impact on existing communications.
- **Impact on Local Communications Not Considered:** The Coexistence Report considered only signals propagated by the ionosphere. Signal field strength several miles from a typical 20,000 watt station typically would be 50 or more dB greater than the noise levels described in P.372.16.
- **Mitigation.** It is not practical to mitigate radio frequency interference (RFI) from 50-kHz digital signals because the OOBEs are an actual part of the digital modulation. Practical post-design hardware filtering is not sufficient to provide significant attenuation close to the desired signal. It therefore is absolutely vital that regulations require that the design of the transmitting system include the necessary shaping of the transmitted digital signals to meet stringent OOBE limits.

IMPACT OF THE PROPOSED CHANGES ON AMATEUR RADIO

Bandwidth

If this petition is granted, the impact of the proposed changes on spectrum immediately adjacent to the digital transmissions will be significant. The Part-90 bands are immediately adjacent to amateur bands in the 2-25 MHz range. The nature of interference from digital signals is typically much worse than the interference from SSB transmissions, as explained below.

The proposed increase of bandwidth to 50 kHz poses a much greater risk of interference into the Amateur bands under the rules proposed by SMC because the proposed OOBE limits are much less protective over a frequency range of ±250% of the authorized bandwidth of the digital transmissions. Adoption of SMC's proposal would permit digital modulation sidebands to be greater than the Part 90 limits on spurious emissions for as much as 125 kHz into the amateur bands.

SMC also is proposing to relax the spurious limits to -50 dB for its 20,000-watt transmitters even outside of the 250% necessary bandwidth. This would provide less protection than the much-lower power amateur radio transmitters are required to provide Part 90 receivers against spurious emissions.

The measurement bandwidth for spurious emissions and OOBEs must be specified in the rules. The bandwidths for the HF range used in C63 and CISPR standards are an appropriate starting point.

Power

The existing Part 90 power limit for 2-25 MHz SSB operation is 1000 watts peak envelope power (PEP). SMC seeks to increase the current 1000 watt limit for SSB to 20,000 watts "RMS" (sic),[1] an increase of 13 dB. SMC offers no technical justification for why this increase is needed, even though modern digital modes are typically able to communicate at transmission power levels substantially below those necessary for SSB transmissions. A significant increase in power, with its accompanying significant increase in interference potential, is not warranted by any information presented by SMC.

SMC also requests that the power limit be changed from a PEP limit to a limit based on average power. Some digital transmission technologies use pulse or multicarrier technology. In such cases, PEP could be significantly higher than average power, thereby effectively underestimating the real power increase being requested.

Adjacent Spectrum

Nine of the commercial Part 90 bands between 2 and 25 MHz are immediately adjacent to or co-channel with seven different amateur bands within the 2-25 MHz range. SMC proposes no attenuation – 0 dB – for OOBE at the immediate adjacent band edge. Zero dB is obviously not sufficient to protect the communications of adjacent spectrum and radio services, even if those adjacent services were permitted to use equivalent power.

[1] SMC may have intended "average power." Although it is mathematically possible to take an RMS measurement of the power of a modulated RF envelope, the result is essentially without technical meaning or use.

Amateur Radio Frequency Allocations vs Adjacent Part 90 Private Fixed Allocations

Amateur Band (kHz)	Part 90 Private Fixed Band (kHz)	Immediately Adjacent?
1800-2000	2000-2065	Yes
3500-4000	3230-3400 4438-4650	No No
5330.5-5406.4	5250-5450	Co-channel
7000-7300	6765-7000 7400-8100	Yes No
10100-10150	9900-9995 10150-11175	No No
14000-14350	13870-14000 14350-14990	Yes Yes
18068-18168	18030-18068 18168-18780	Yes Yes
21000-21450	20010-21000 21850-21924	Yes No
24890-24990	23350-24890	Yes

Table 1: Nine of the of the commercial Part 90 bands are immediately adjacent to the amateur bands. One band is collocated with amateur spectrum. Seven different amateur bands are impacted by this proposal.

SPURIOUS AND OUT-OF-BAND EMISSIONS

SMC seeks to simultaneously increase the permitted power levels while significantly decreasing the protection afforded to users of adjacent spectrum. The decreased protection from OOBEs at some frequencies represents as much as a 77 dB degradation from the protection currently provided by Part 90 OOBE and spurious emissions requirements.

Spurious emissions

The existing Part 90 rules for 2-25 MHz operation require that spurious be reduced to a level that is 43+10log(W) below the transmitter power level. So, for a 1000 -watt transmitter, the rules require attenuation of spurious emissions to a level of -73 dB. SMC proposes that spurious emissions suppression from the proposed 20,000-watt transmitters be limited to 50 dB of necessary attenuation. **This is a decrease of protection for other users of 36 dB** (23 dB from the proposed limit change and 13 dB from the proposed power-limit increase). There is no justification for increasing the absolute levels of spurious emissions by 36 dB and allowing this would cause massive interference to neighboring amateur operations.

Proposed Spectral Mask Rules Changes for Out of Band Emissions

SMC is requesting that the following changes be made to Part 90 rules governing spurious and OOBEs.

(n) Emission Mask N.

For fixed non-voice transmitters in the 2-25 MHz Band, the power of any emission must be attenuated below the unmodulated carrier output power (P) as follows:

(1) On any frequency removed from the center of the authorized bandwidth by 50 percent to 100

*percent of the authorized bandwidth: At least **83*log(2*f_d/B) dB** where f_d is the displacement from the center frequency in kHz and B is the authorized bandwidth in kHz;*

*(2) On any frequency removed from the center of the authorized bandwidth by 100 percent to 250 percent of the authorized bandwidth: At least **31.5*log((2.5*f_d/B)^2)** dB where f_d is the displacement from the center frequency in kHz and B is the authorized bandwidth in kHz;*

*(3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: **At least 50 dB**.*

SMC proposed two formulas to calculate the allowable OOBEs, based on the proposed bandwidth of 50 kHz. The formulas specify that at the band edge of the authorized transmission, the required suppression is 0 dB, with a gradual increase to 50 dB at 250% of the authorized bandwidth removed from the center of the signal. This results in a significant degradation from the mask for existing Part 90, 3-kHz wide SSB transmissions. For example, at 2 kHz into an adjacent service, the required suppression is only 1.8 dB. At 10 kHz penetration, suppression from a 20,000-watt transmitter is only 12 dB. The portions of the petition that analyze the impact of -35 dB of OOBE suppression fail to address this serious incursion into amateur (or other) spectrum. The impact of this is illustrated in Figures 1 and 2 below.

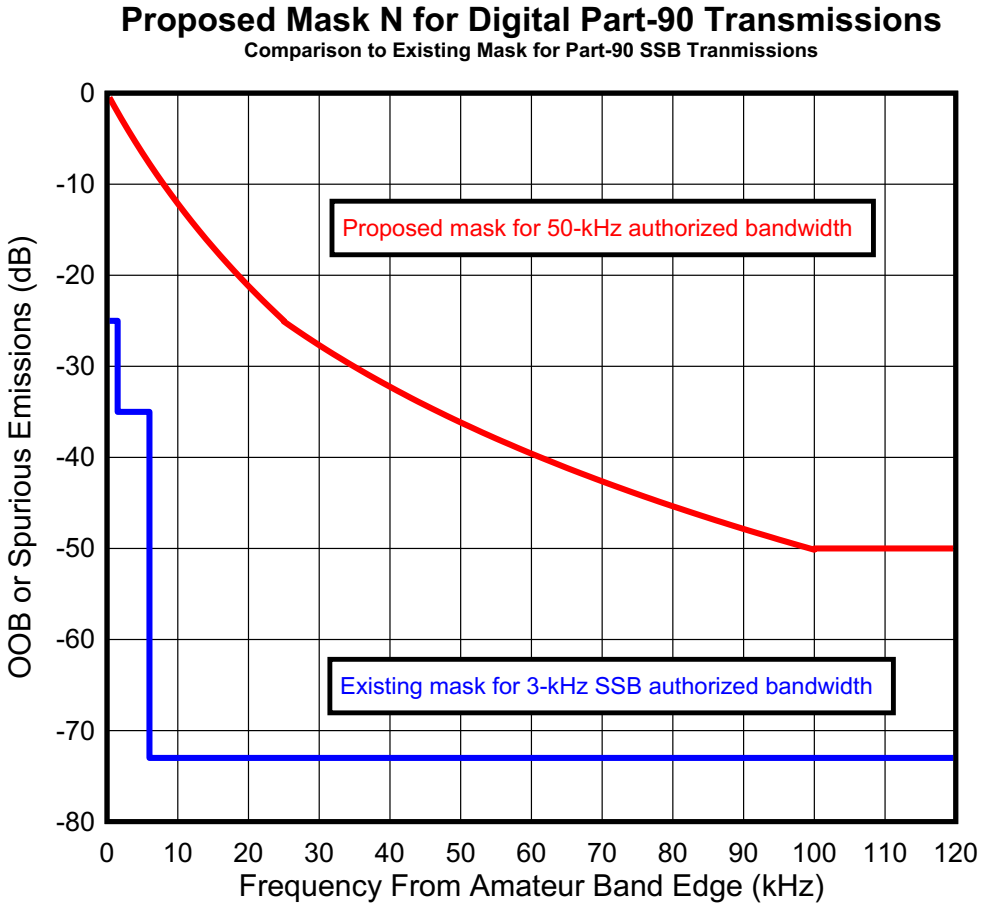


Figure 1. This compares the proposed rules for the 20,000-watt digital transmissions to the existing level of protection from 3-kHz wide SSB Part-90 transmitters. This does not account for the 13 dB difference in power level between the proposed 20,000 -watt transmitters and existing 1000-watt transmitters.

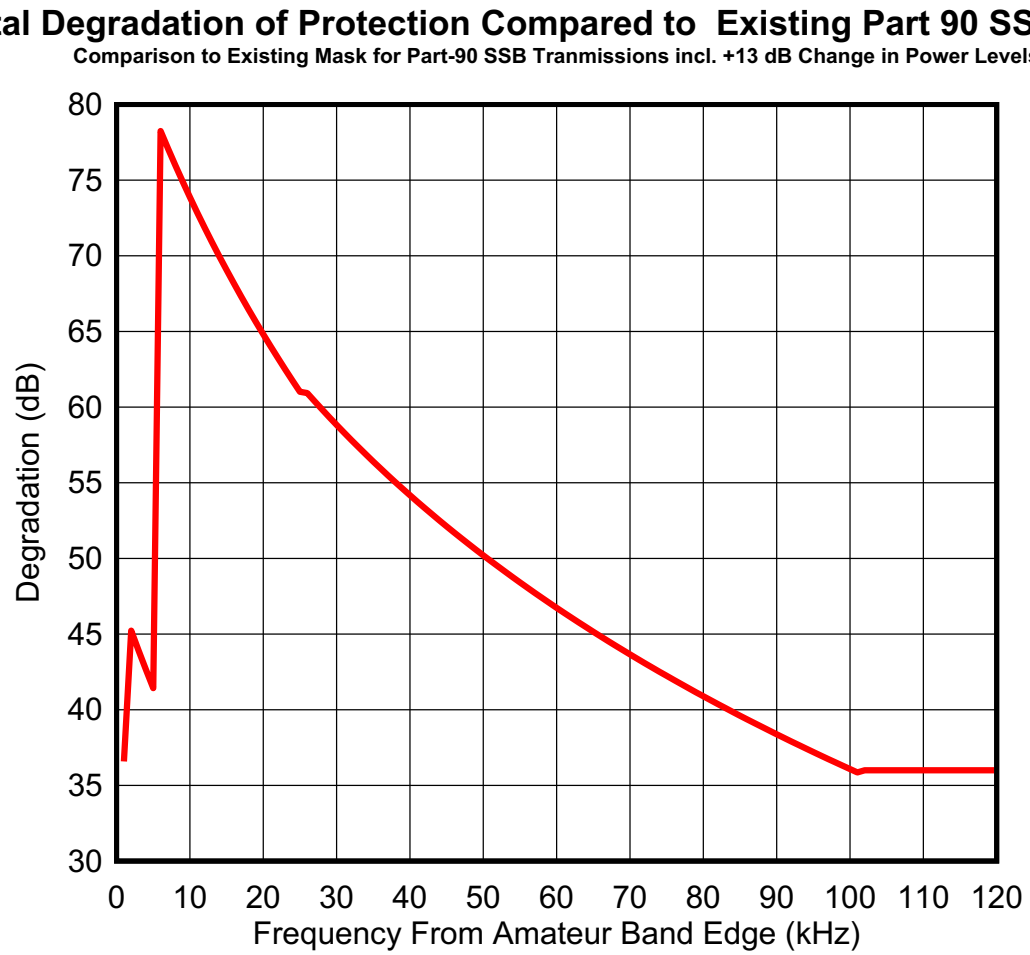


Figure 2. This shows the total difference between the absolute levels for OOBE as proposed in the rules compared to the existing protection in the Part 90 mask for 3-kHz wide SSB transmitters. This graph does include the 13 dB difference in power levels between a 1000-watt transmitter and the proposed 20,000-watt transmitters.

Table 2 shows the total amount of additional degradation from existing Part 90 SSB rules, including the change in OOBEs, spurious emissions and the increase in power level. The rules as proposed are as much as 77 dB less protective than the current Part 90 rules for SSB transmissions.

Table 2: Degradation of Communications Outside the Authorized Bandwidth

Parameter	Part 90 Limits for SSB	Part 90 proposed limits for digital operation	Degradation including power increase
Power (watts)	1000	20,000	+13 dB
Bandwidth	3 kHz	50 kHz	--
Modulation	SSB	Digital	--
Protection at 1 kHz from edge of channel	-25 dB	-1.2 dB	-36.8 dB
Protection at 3 kHz from edge of channel	-35 dB	-4.1 dB	-43.5 dB
Protection at 8 kHz from edge of channel	-73 dB	-10 dB	-77 dB
Protection at 25 kHz from edge of channel	-73 dB	-22 dB	-64 dB
Protection at 100 kHz from edge of channel	-73 dB	-50 dB	-36 dB

Table 2: This table summarizes the additional degradation of communications outside the authorized bandwidth that will result from the proposed rules changes as written.

INTERFERENCE TO AMATEUR STATIONS NEAR PART 90 DIGITAL STATIONS

The data in In Figure 3 were calculated using EZNEC antenna modeling software using the NEC-4 calculation engine. The field strength was calculated at a height of 60 feet, representing a typical height for a nearby amateur station. The frequency of 14.2 MHz was chosen, to represent the most popular amateur band in the frequency range being considered. The transmitter power is set to 1.6 W/Hz to match the transmit power levels used in SMC's Coexistence Report. The noise level at a distance of 5 miles from a Part 90 digital transmitter operating as described in the SMC petition will be 73.1 dB over the ambient noise level in a residential environment as described in ITU-R P372.16.

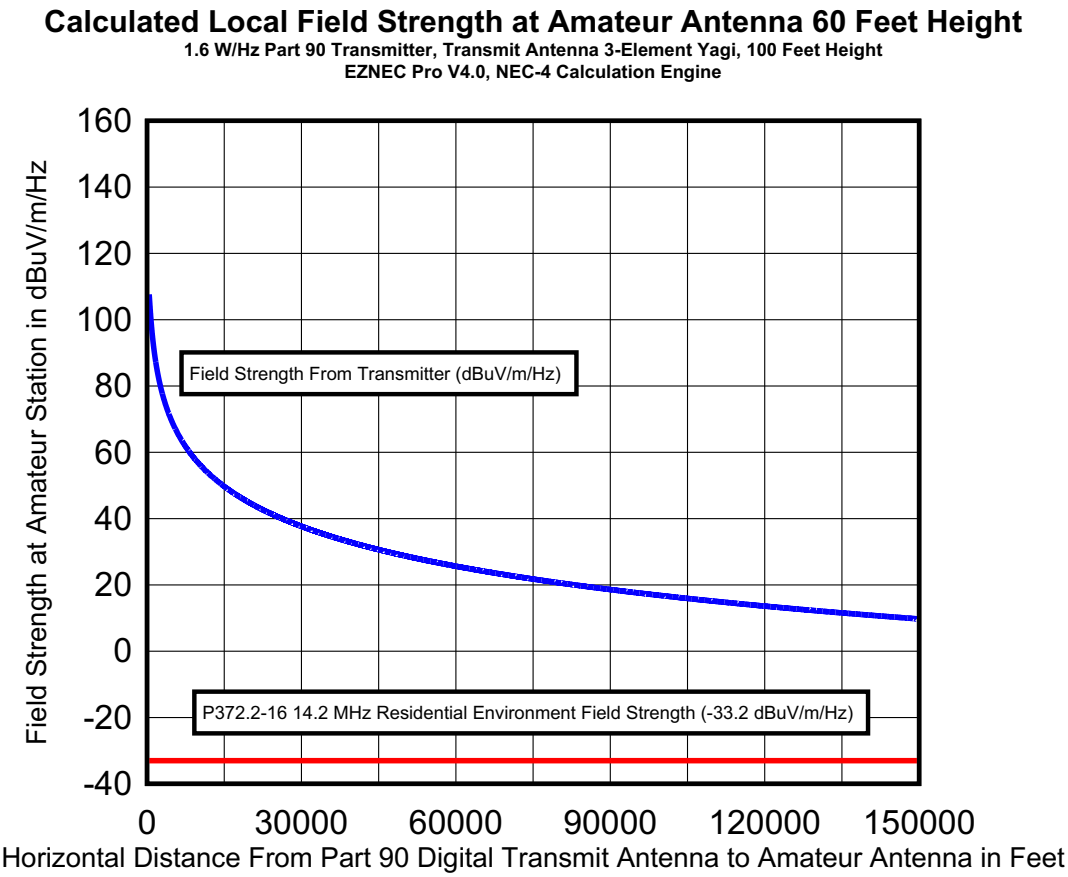


Figure 3: This shows the E-field strength that will result from a 1.6W transmitter operating into a 3-element Yagi antenna at 100 feet height. The field strength was calculated at a height of 60 feet to represent typical amateur radio installations. The results show the field strength in dBuV/m per Hz. The red line shows the electric field strength in dBuV/m per Hz that is the median value of human-made noise described in ITU-R P.372-16.

ERRORS OF ASSUMPTION AND OMISSIONS

There are a number of issues discussed in the Coexistence Report that are not proposed as limits in the rules. These include:

- Antenna Azimuth Patterns
- Antenna Elevation Patterns and Height
- Receive Antennas
- Inclusion of times when bands are closed as part of probability of interference calculations

Antenna Patterns

The Coexistence Report did not stipulate what directional antenna was used for the analyses it reported, but from the antenna patterns described, with a -10 dB beamwidth of 60 degrees, the four lobes described “above 10 MHz” for the vertical pattern and the stipulated 10 dBi of gain, it is evident that the antenna is a 3-element Yagi (or equivalent log-periodic array) at a presumed height of 120 feet. The 10 dBi of gain is more than a 3-element Yagi would exhibit but is less than the NEC-4 antenna-analysis software estimates for a 3-element Yagi over real ground. If the various elevation angles of antenna

radiation pattern are going to be analyzed, this can only occur with an antenna over ground. The modeled gain of a 3-element Yagi over ground of typical conductivity is 12.2 dBi, adding another 2 dB to the errors in assumption of the model.

The proposed rules include *no* stipulation about the type of antenna that can be used, so the only appropriate analysis would include all possible angles, both azimuth and elevation, because all possible angles of radiation from a non-specified antenna are possible. Again, from an adjacent 50-kHz-wide signal, in the direction of a directional antenna, at whatever angle that antenna happens to radiate, interference to multiple amateur radio users will range from likely to inevitable. An analysis of interference that includes elevation-pattern nulls that may or may not exist is seriously underestimating the interference potential from different antennas or heights than were used in the analysis.

Receive Antenna

The Coexistence Report stipulates that the antenna used at the victim receiver is isotropic. Although some amateur antennas may have a gain of approximately 0 dBi, most amateur HF stations use antennas with significant gain. Any gain antenna used by an amateur station will increase the amount of OOBE signals picked up by the amateur station if the Part 90 digital station is located within the beamwidth of the actual receive antenna. This could easily result in as much as a 10 dB or greater underestimation of the interference potential from the Part 90 digital station. Even a simple wire dipole antenna used by many amateurs exhibits 2.15 dB of gain over an isotropic antenna (dBi) and over ground, these simple antennas commonly exhibit 6-10 dB dBi of gain.

Closed Bands and Probability of Interference

The conclusions drawn from these conditions about the probability of interference are incorrect. The Coexistence Report included times and conditions where propagation did not exist to many parts of the country and, in some cases, when the frequency being analyzed was not open for anything beyond ground-wave communications. These times that the band would not be open to some parts of the country were counted in determining the percentage of time that there would be interference. Rather than analyzing the interference potential to areas where the frequency being used would propagate signals via the ionosphere, the Coexistence Report concludes that the probability of interference was low because it included times and distances that would not be used at all because propagation did not exist.

The bottom line is that frequencies will be selected based on the premise that ionospheric propagation actually exists and to areas where the frequency supports communication at that time.

When frequency and operating times are chosen to optimize propagation, interference is not “unlikely,” it is certain. Figure 4 below shows the I/N ratio that will result in 1.6W of noise signal per Hz being fed to an antenna with 10 dBi of gain, assuming a 3-element Yagi and ground gain. Because antenna pointing is not specified in the rules, it is reasonable to use an omnidirectional pattern, showing that in whatever direction a gain antenna is pointed on this 14 MHz analysis, 15 January at 2000 UTC, strong interference is to be expected. At the 1- or 2-dB OOBE suppression level that will occur from adjacent channel operation near an amateur band edge, all but the strongest of amateur signals will be obliterated. This will happen again and again at frequencies, times, seasons, and sunspot numbers when a particular selected band is open. To achieve an I+N/N ratio of 1 dB, and to account for variables such as ripple in the passband of the OOBEs from a digitally modulated signal, 50 dB of suppression *per Hz* would have to be the regulatory limit.

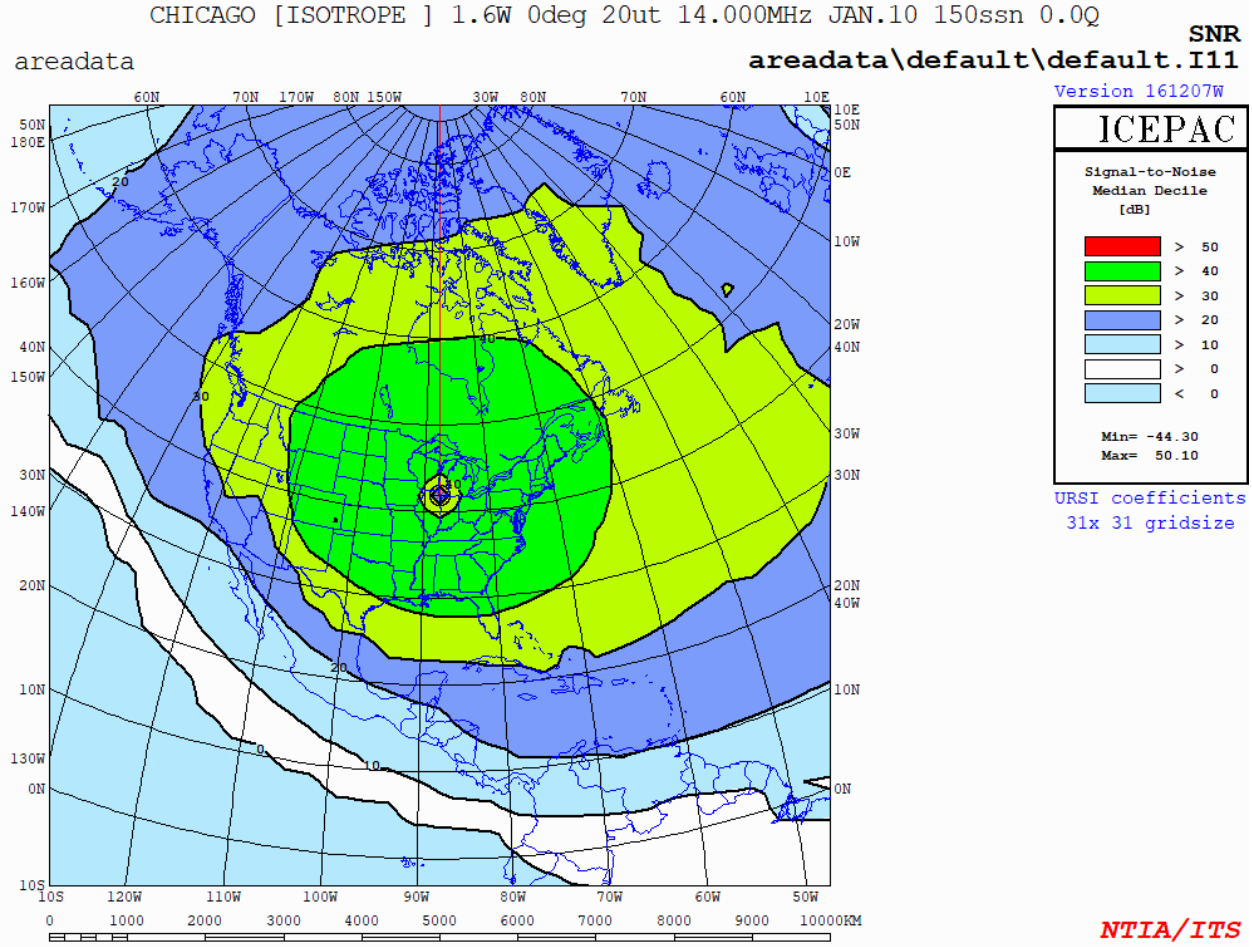


Figure 4 – This shows the level of S/N degradation from a transmitter transmitting 1.6 W/Hz to the ambient noise level on 14 MHz, 10 January, SSN 150, 2000 UTC.

Other Errors

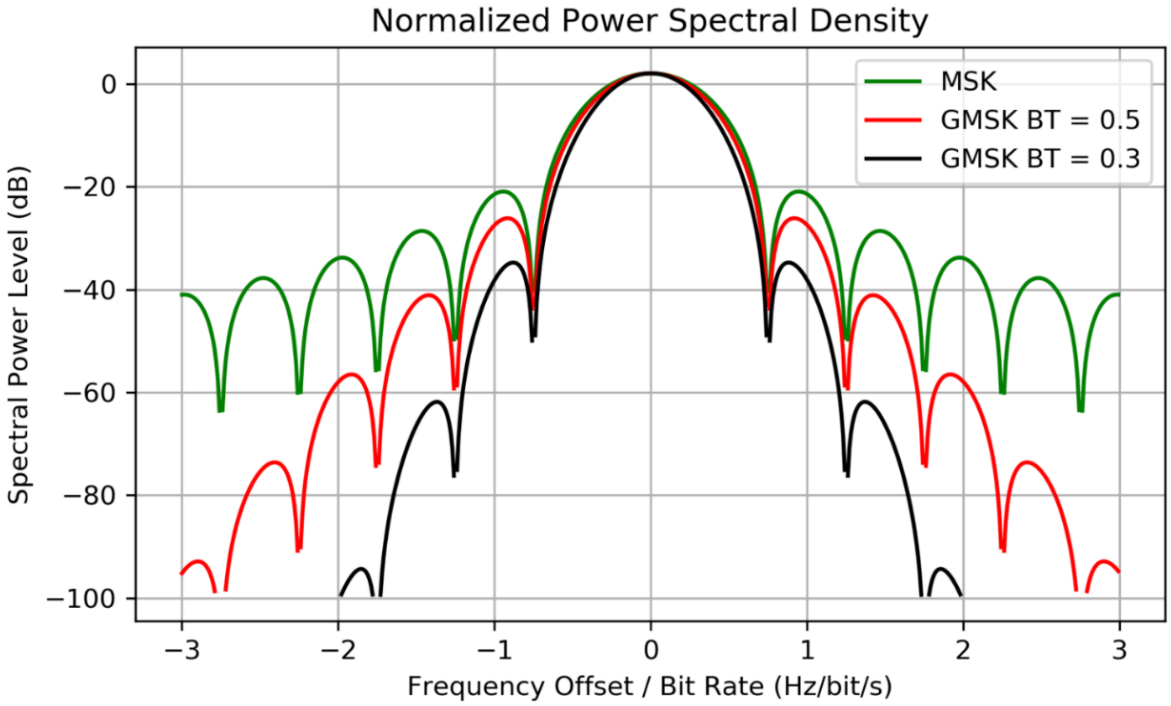
There are a number of errors of assumption that are part of the Coexistence Report. They include:

Assumption	**Estimated Error**	**Notes**
Digital modulation uniform vs frequency, modulation modes	3 dB min	
0 dB I/N radio assumed	6 dB	The term "I" should be -6dB relative to noise to achieve an increase of noise of no more than 1 dB
Residential environments assumed	6 dB or more	As discussed in the Coexistence Report, many amateur stations are located in rural or even quiet rural locations
Total	**15 dB**	

Digital Modulation Is Not Uniform vs Frequency and Modulation Modes

The Coexistence Report estimated that the Part 90 digital station would be using 10 kHz of bandwidth. It therefore reduced the 20-kW transmitter power by 40 dB, to account for the way VOACAP analyzes I/N using a 1 Hz bandwidth. Although this is correct for VOACAP estimates of I/N ratios, it must be noted that

digital modulation is *not* uniformly distributed at the data rates that would reasonably fit into a 10 kHz bandwidth. The following figure shows the actual distribution of several types of digital modulation:



The lobes shown in this figure are *not* intermodulation or distortion, but the actual digital-modulation sidebands, and a part of the information being transmitted. Note that these sidebands are not uniformly distributed but are higher on some frequencies than others. A flat “40 dB” adjustment does not account for the peaks and valleys and does not account for the fact that within the 3 kHz of bandwidth that would be typical of an amateur station, multiple instances of these lobes would be present, with a peak-envelope power that is higher than the average power present in spectrum adjacent to the Part 90 digital transmitter. At a minimum, considering only the shape of the spectral distribution, the power at the peak of one of the lobes would be at least 3 dB greater than the -40 dB correction applied and the peak power in the bandwidth of the receiver being affected could be as much as 10 dB higher. The -40 dB factor used in the Coexistence Report contains yet another error in the wrong direction to support the conclusions of the report.

The proposed rules do not specify minimum or maximum data rates or modulation modes, so the error or assumption could range from 0 dB to 6 or more dB, depending on the modulation mode and data rate chosen by the system designer.

0 dB Interference-to-Noise Ratio Assumed

The Coexistence Report also bases its interference analysis on a 0 dB Interference to Noise ratio (I/N). This is not appropriate spectrum engineering. A 0 dB I/N ratio increases noise by 3 dB, essentially doubling the noise in that environment. Good spectrum management generally evaluates interference against a 0.5 dB or 1 dB increase in noise level, which would result in the 1-dB case from an I/N ratio of -6 dB. This changes the entire premise of how much protection of adjacent spectrum is needed by 6 dB in and of itself, representing a major flaw in the analysis.

Station Location and Environments

The Coexistence Report analyzes the geographical distribution of population, to determine urban, residential, rural, and quiet rural areas. The existing ambient noise levels are much quieter in rural and quiet rural areas. The report, however, analyzes OOBE noise only against residential environments. This is a flawed premise because many amateur HF stations are intentionally located in RF-quiet environs, for a number or technical and social reasons. The proposed limits are not sufficient to fully protect residential noise environments, so they fail significantly to protect against the quieter environments where many existing amateur stations are located. It is technically incorrect to include areas and times when propagation does not exist and set a level of only the residential noise levels, to determine that the interference potential from the proposed changes is low. In reality, especially in the rural and quiet rural environments, in the areas and times when propagation actually exists, when the band is open, at the proposed levels, the likelihood of harmful interference that limits amateur operation is essentially 100%.

MITIGATION

If harmful interference does occur, the operator of the offending transmitter is required to take action to correct the interference. SMC's proposed limits essentially require no filtering of immediately adjacent spectrum but are simply set at the levels that result from the digital modulation process. Mitigation is absolutely essential. How will this be accomplished? The listen-before-talk (LBT) protocols that are described in the Coexistence Report and in the statements of individual petitioners are of no use to protect amateur users in adjacent bands. It will not be possible to easily identify which Part 90 station is responsible when interference is caused by the proposed Part 90 digital transmissions unless periodic station identification using an open and known protocol is required for that purpose.

Under SMC's proposed rules, harmful interference is almost inevitable to amateurs in areas where propagation from a Part 90 digital station is strong. The only solution is to have sufficient protection built into the rules. The rules as proposed by SMC simply fail to protect amateur signals from harmful interference. Interference from OOBEs that may occur from digital transmitters cannot be filtered after the fact but must be part of the design of the transmitter by using internal digital processing techniques that reduce OOBEs. Based on the formula that SMC requested it appears that even this basic filtering is not planned. This protection must be required in the rules.

The Coexistence Report discusses listen-before-talk (LBT) protocols. These protocols obviously won't help protect adjacent-channel amateur operations.

AUTHOR PROFESSIONAL EXPERIENCE

- Member ARRL Laboratory Staff, Laboratory Manager, retired, 37 years experience.
- Past IEEE EMC Society Vice President for Standards
- Past ARRL Representative on ASC C63, Chair of Subcommittee 5 (immunity)
- Past Member and Secretary of the IEEE EMC Society Standards Development and Education Committee
- Past member of the IEEE EMC Society Standards Development and Advisory Committee
- Past member multiple IEEE EMC Society Technical Committees
- Past member of ARRL EMC Committee, ARRL RF Safety Committee
- Member of IEEE EMC Society Working Group on Power-Line Noise
- Licensed amateur radio operator since 1963

CERTIFICATE OF SERVICE

I hereby certify that on August 2, 2023, I transmitted a true, correct, and complete copy of the foregoing Opposition by electronic mail to counsel for Petitioners at the below-noted email addresses.

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