Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of Amendment of Parts 2, 15, 80, 90, 97, and 101 of the Commission's Rules Regarding Implementation of the Final Acts of the World Radiocommunication Conference (Geneva, 2012)(WRC-12), Other Allocation Issues, and Related Rule Updates	)))))))	ET Docket No. 15-99

COMMENTS OF JOHN H. DAVIS REGARDING PROPOSED SERVICE RULES FOR THE AMATEUR RADIO SERVICE IN THE 2200 AND 630 METER BANDS

INTRODUCTION

1. Comments of the undersigned are submitted in regard to FCC 15-50, section VI. NOTICE OF PROPOSED RULEMAKING (WRC-12 NOTICE), and in particular, paragraphs 159-182 addressing the topic of Amateur 2200 Meter (135.7-137.8 kHz) and 630 Meter (472-479 kHz) Bands. Paragraph numbers cited herein are from that document unless otherwise noted.

2. Since 1966 I have held a First Class Radiotelephone Operator license, and now its successor, the General Radiotelephone certificate. My occupational experience in AM, FM, and television broadcast transmission includes facilities planning, preparation of application exhibits, station construction, and equipment tests and measurements. I am a member of the Institute of Electrical and Electronic Engineers, and a member of the IEEE Broadcast Technology Society, Antennas and Propagation Society, and Circuits and Systems Society .

3. I am also currently licensed in the Amateur Radio Service as KD4IDY, Technician Class; a member of the American Radio Relay League; and have participated for many years in activity at 160-190 kHz under provisions of Part 15 of FCC Rules. In my capacity as an editor of the Long Wave Club of America newsletter, *The LOWDOWN*, I am in regular contact with other

such experimenters as well as licensees of Part 5 Experimental Service stations operating below 500 kHz. Our members are in near unanimous support of the new LF and MF amateur allocations, although the opinions and specific recommendations below are based on my own observations and experience and should not be regarded as an official club position.

PHYSICAL SEPARATION AS THE CORNERSTONE OF SPECTRUM SHARING

4. The Commission at paragraph 168 establishes physical separation between amateur stations and power transmission lines as the cornerstone of its proposed new rules, in conjunction with limits on EIRP and tower heights. Amateur operators seem in broad agreement that separation and EIRP limits will assure coexistence between themselves and PLC systems, and many concur that a 1 km separation distance is reasonable. There are some additional considerations, however, which I believe may be helpful when setting and enforcing the separation requirement.

5. <u>Separation needed to protect PLCs from amateur signals</u>. The 1 km separation most widely mentioned is based on an ARRL analysis submitted in the ET Docket 12-338 proceeding. At 169, the Commission notes that analysis was based on a 1985 NTIA study, and enquires whether there have been subsequent changes that could affect the outcome. One would hope that the power utilities will not argue that they have been installing *less* robust control and monitoring systems since that time. However, considering that there have been no observed problems whatsoever from extensive operation by Part 5 stations with authorized powers greater than 1 W EIRP, and often at distances less than 1 km from transmission lines, it would appear that modern PLC systems are at least as robust as their predecessors, perhaps more so.

6. In fact, based on both calculation and actual operating experience, several licensees in the Experimental Service suggest shorter separation distances might be appropriate. While I find

some merit in their arguments, I will leave it to them to state their cases in their own comments. Probably the most meritorious idea offered by some is the thought that, if a coordination mechanism existed between the utilities and the amateur community, amateur operation could be authorized closer than 1 km to transmission lines which do not employ PLCs in or near the band of interest. If this could indeed be implemented without excessive administrative cost or regulatory burden to anyone involved, I would urge its consideration by the FCC as an alternative that might be made available in addition to the general separation requirement. That is, an amateur could simply choose to locate a minimum of 1 km away from any transmission line, or could attempt to coordinate operation at a specific location that is closer, provided the coordination ascertained that no PLC would be affected.

7. If the Commission does find a shorter separation distance to be appropriate, either based on a technical re-evaluation of the 1 km proposal, or in specific cases where closer operation can be adequately coordinated, I suggest that it still might be desirable to impose a minimum separation of at least the radius of the near field induction zone (wavelength divided by 2π; or, 350 meters/1150 feet for the 2200 m band, and 100 meters/330 feet for the 630 m band). Within that zone, as distances from the antenna decrease, field intensities increase more rapidly than outside, first in proportion to the inverse of distance squared, and then eventually to the inverse of distance cubed, and so on. From the standpoint of reliably estimating field strength, it is therefore desirable to keep any systems which need to be protected outside the transmitting antenna's inductive near field region. In addition, an amateur would not want such a large conductor intercepting power from his near field and thereby affecting his transmitter tuning.

8. <u>Separation to protect amateurs from PLCs.</u> At 171, the Commission also asks what impact PLC operation would likely have on amateur stations. Surprisingly, over the last dozen

years, there seems to have been little reported interference **to** amateur or Part 5 activities on 2200 meters, even among those of us who regularly monitor for amateur signals originating from Europe, western Canada, and Japan. A few probable PLC carriers can be heard at modest levels in different parts of the country on 2200 meters, but not as many as used to be commonly found affecting Part 15 operation in the 160 - 190 kHz band. To their credit, the utilities seem to maintain these signals with a high degree of frequency stability, so the Experimental licensees have been able to simply tune to an unused frequency, as is normal amateur practice. (Would that switching mode power supplies in home appliances and industrial equipment were so stable.) Amateurs in Canada and overseas have been more than willing to find clear spots for their signals to be monitored here in the States, as well. At 630 meters, I cannot find any reports of apparent PLC activity at all! Thus, I believe any separation distance which is adequate to protect PLC systems will also be sufficient to protect amateur stations and promote sharing.

9. <u>Ensuring that the separation distance can be maintained reliably.</u> Whatever separation distance is finally established, it clearly must be maintained in order for the desired protection to be conferred. This is an issue with multiple aspects on which additional input has been sought, and they appear so interrelated that I shall undertake to address them more or less together here.

(i.) Permanent fixed locations. At 168, and in the proposed wording of § 97.303 (g) (1) in Appendix F, the Commission considers limiting amateur operation in these bands to permanent fixed locations only. I respectfully urge that such a strict requirement **not** be imposed, because it is not necessary for ensuring that adequate separation will be maintained. In the earlier Docket 12-338 proceeding, UTC objected that mobile amateur operation would introduce too many variables, and I agreed with them in my response. In addition, I pointed out that mobile transmission at 2200 meters would be extraordinarily difficult and is therefore unlikely in the

first place. It could conceivably be attempted at 630 meters, though, which has since been added to the discussion, with the same potential to be disruptive to any nearby PLCs. Therefore, I still support a prohibition on mobile operation in both bands. However, implementing that prohibition does not require fixed-location-only unless a full formal coordination requirement is also being imposed, which does not currently appear to be the case. Instead, I urge the Commission to allow fixed-portable operation for such typical amateur purposes as ARRL Field Day or DXpeditions, provided that the operator first undertakes the same site survey as would be required for his primary location. If that is done and documented, there is no reason why fixed-portable operation should not be just as safe as operation from any permanent site. As I propose to demonstrate below, this determination is within most amateurs' abilities and resources.

(ii.) Identifying transmission lines will not be difficult for amateurs. The largest transmission lines are conspicuous because of their tall steel towers and massive insulators, but as the FCC observes at 176, medium voltage transmission lines sometimes employ wooden poles and otherwise resemble heavy duty distribution lines in appearance. It will not be necessary for amateurs to have to identify particular insulator types or construction techniques, however, in order to distinguish between them. By definition, distribution lines distribute power directly to customers; transmission lines do not. If a given line has service connections to homes, farms, or businesses, it is a distribution line. Otherwise, if an amateur sees none of these, he must regard it as a transmission line. And of course, if a row of poles contains both a set of wires that has customer connections, plus another set of wires that doesn't, then it must be assumed that the one without customers is a transmission line and must be protected to the separation distance.

(iii.) Resources available to the amateur for determining separation. Mapping software is widely available for determining the distance between any two points on the ground with very

good accuracy. Even without aids such as GPS, Google's satellite view and some of its competitors now deliver such high resolution images of features on the ground that someone without much map reading experience can pinpoint their own position by visual inspection well enough to determine separation to another point with reasonable accuracy. (This is only true for visually confirmed locations, not searches by address, which can be off by hundreds of feet; or, in some instances, many miles.) After one has identified the intended location of his own antenna on such a map, the trick then becomes to reliably identify the location of any and all possible transmission lines in order to determine the shortest distance to them. While aerial views will generally reveal deforested rights-of-way or even the shadows of individual transmission towers, it's not always clear that such features are indeed transmission lines. It is also possible to miss seeing transmission lines from above, and the satellite views may be as much as two or three years outdated at any given time. While they can be used to determine distance to a feature once it is spotted, maps and aerial photos are not enough to be certain that they are present! For most amateurs, this will require legwork and/or driving.

(iv.) Using "ground truth" to verify adequate separation. By standing at two different corners of my farm, I can obtain unobstructed visibility of a mile in one direction and up to two miles in all others, and thereby visually ascertain that the only power line in all that territory is the 7.2 kV single-phase distribution line of the rural electric cooperative. Obviously, however, that approach will not work from my back yard in town, where there are trees, houses, and other structures. Nor will it work from a wooded or hilly rural area. There, the approach would be to accurately plot the position of one's antenna on a good map (meaning a topographic chart, county highway map, or a large and highly detailed city street map), use a compass to draw a circle having a radius of the specified separation (assumed to be 1 km in this example), and then

hike or drive any available paths that enclose the smallest practical area lying completely outside the 1 km radius circle. (In my home town, that outer path required less than a 6 mile journey to identify the modest-sized transmission line leading to our town's substation 1.37 km away, and was easily completed in under an hour. In more rugged areas with fewer roads, it could take considerably longer.) Using the test given previously in subparagraph (ii), one would look for and mark the location where any transmission line crossed that outer perimeter, then use any combination of aerial mapping and on-ground inspection necessary to determine whether it also crosses the 1 km circle. If it doesn't, the location and the nearest distance to it should be recorded and retained for future reference; but if it does, then the intended antenna site cannot be used. Of course, if no transmission line crosses the outer perimeter at any point, then it will not cross the inner circle either, and all is well. This approach may be time-consuming in some cases, but the technique is fundamentally simple and it is well within the capability of dedicated amateurs. It is also certainly adequate to maintain the required separation between an amateur and a transmission line, even for portable operation, if an amateur is willing to perform a site survey like this and maintain records to verify every location where he wishes to operate.

(v.) Of course, if another method to determine location of applicable transmission lines becomes available in cooperation with the power utilities, that might be a less labor intensive alternative for amateurs, and perhaps even be a way for system operators to have more confidence in the determination of separation distance.

10. <u>Method of specifying separation distance.</u> At 177, the Commission seeks comment on whether separation distance should be determined by the slant range method or by simple horizontal separation between an amateur station and transmission line. The horizontal method is preferable for its simplicity and seems wholly adequate in this case. In those situations where

slant range is more commonly used, the distance between power conductors and the observer is generally measured in tens of meters at most, while the relative elevations of the line (often low tens of meters) and the measurement point only a meter above ground can result in a significant angular difference. However, where the required separation distance is likely to be a kilometer, or the better part thereof, both the horizontal distance and slant range methods will yield results that are quite close to each other. Where there is any difference at all, geometry shows us that the horizontal distance will always be the shorter of the two because the slant distance is the hypotenuse of a triangle, so specifying minimum separation in the form of the horizontal distance provides a more conservative number with marginally better protection.

CONCERNS FOR SPECTRUM SHARING AND FUTURE POWER LINE EXPANSION

11. At 172, the Commission anticipates that a separation distance requirement could become problematic if it inhibits either construction of new transmission lines or the growth of the amateur service. The question is raised, "Should our rules explicitly prohibit utilities from deploying new PLC systems in these bands?" I see no alternative to such a prohibition if sharing is to work. It is *not* sharing if either user of a given spectrum segment can force another user off in order to further its own expansion. The amateur community already expressed its willingness not to force existing PLC systems out of the band in the earlier proceeding (ET Docket 12-338), and the FCC has made it clear at paragraph 26 of the current Notice that: "Amateurs will not be able to use their allocation status to force unlicensed PLC operations out of the band, and utilities will have no cause to abandon or incur large costs to modify existing PLC systems." This is fair and reasonable, but only if the principle is also applied in reciprocal fashion.

12. A rule prohibiting new PLC systems in the proposed bands should be worded to allow existing systems now operating there to continue. In particular, I suggest explicitly allowing

replacement of existing PLCs in the 2200 meter band as needed, but only with the same frequency, power, and modulation types presently used, and only along the same transmission line routes where they are currently used. This way, a system operator would not have the expense of re-engineering the PLC for another frequency, no amateur would have to cease operation or relocate, and if any form of quasi-coordination had been employed to determine a safe operating location for any particular amateur station, that process would not have to be repeated just because hardware is being replaced.

13. At 630 meters, I also endorse allowing any existing system to continue operating until it needs to be replaced, and no new systems or routes. However, since there appear to be so few (if any) currently operating within the 472 - 479 kHz band, perhaps consideration should be given to encouraging migration to another frequency when replacement is needed. With the caveat that my knowledge of power generation and transmission is now seriously dated, I seem to recall one reason that so few PLCs ever operated at the top end of the available frequencies is that they were necessarily confined to shorter range than their lower frequency counterparts; both due to increased attenuation in the lines, and the fact that the higher frequencies tend to radiate more efficiently than lower frequencies, causing concerns for compliance with radiated emission limits. It would seem desirable for any PLCs remaining at that end of the band to relocate in frequency anyway when their useful life comes to an end. However, I do <u>not</u> advocate that as a regulatory requirement at present, hoping instead that it could be done voluntarily over time and the question be revisited in the future. (If, perchance, there already is **no** PLC operation in the 472 – 479 region at this time, then prohibiting future use there would immediately ease separation requirements in the 630 meter band.)

14. Prohibiting installation of new PLCs within the 2200 meter and 630 meter amateur bands need not cause undue burdens for the power industry. It will not affect existing PLCs at all. As for planning of new installations, not only do these two bands represent only a small portion of the spectrum available to PLCs, but the ongoing decline in the number of long wave aeronautical beacons over the past two decades means more of that spectrum is now of potential use to PLC operators than it was previously. Further spectrum may be freed for new PLCs over substantial inland areas if the government goes ahead with recently announced plans to shut down three-quarters of the National Differential GPS reference stations.

15. In addition to that spectrum availability, it should be remembered that new construction does not necessarily have to mean new PLCs. While retrofitting existing transmission lines with other technologies to replace PLCs may not be deemed practical by much of the industry, that option nonetheless does remain available for new construction. In the previous proceeding on Docket 12-338, I cited the example of the Municipal Electric Authority of Georgia, whose SCADA system now monitors and controls 200 substations serving 49 partner cities, principally by buried fiber optic cable. Actually, MEAG did not wait for new construction, but undertook retrofitting of its 1300 miles of transmission lines with buried fiber optic cable on existing easements in the 1990s. They no longer depend upon RF devices that can be disrupted not only by external interference, but also by physical damage to the very lines over which they work. They also have excess bandwidth available as a potential revenue source.

16. At 173, the Commission raises the issue of other future changes to the electric system, including the recent IEEE standard 1901.2-201.3 for smart grid applications below 500 kHz. Development of a possible new use for RF on a distribution line, acknowledged to be governed by all the normal Part 15 restrictions, should not impede implementation of any allocated and

licensed radio service. Unlike PLCs, which have rightly been accorded special status because of their frequency inflexibility, criticality to the operation of the grid, and historical ubiquity, any new technology which bills itself as "smart" really also needs to be adaptable to its RF environment, long before it becomes widespread and potentially burdensome to others. No new technology should be considered for special status based on the (dissimilar) precedent of PLCs, but should instead be expected to comply with Part 15 in all respects, including § 15.5. If it is not already sufficiently adaptive, then it should not be deployed for critical applications. If it cannot be made adaptive but is still deemed vital to meeting a critical need, then its users should seek allocated and licensed status to receive the protection afforded to other spectrum users.

TRANSMITTER POWER LIMITS AND ANTENNA HEIGHTS

17. Along with physical separation requirements as the cornerstone of the Commission's regulatory framework for these bands, the other key structural component must be the radiated power limits. Meeting those limits, in turn, necessarily depends on what transmitter power limits and antenna restrictions are imposed. With regulations little more elaborate than a statement of the internationally recognized EIRP radiated power limits for these bands, many nations of the world have encountered no apparent interference problems at all. With the need to accommodate PLCs, however, it is recognized that the situation may be more complex here.

18. The Commission has asked for comments on whether antenna height and transmitter power limits should be imposed to ensure that these limits are met. In general, there have been two philosophies expressed thus far. Some have suggested various specific limits, sometimes based on actual operating experience, as a way of ensuring compliance even when a given operator may not have the means to make accurate power determinations of his own. Meanwhile, others point out that not all amateurs have access to locations where efficient

antennas can be constructed, but some do have the means to make actual field strength measurements, and therefore the experimental nature of operation in these bands would best be served by not imposing limits below the 1,500 W PEP and 200 foot/60 meter limits that apply in amateur bands not otherwise restricted to lower powers. I find merit in both arguments.

19. Fortunately, a one-size-fits-all approach need not be adopted. Realizing that there will be a wide range of experience levels and equipment among the various amateur operators, but recognizing that other users of the bands must be thoroughly protected, I believe the Commission can best promote sensible utilization of these bands by making a number of alternative power determination methods available, each one sufficient to ensure compliance while not needlessly restricting potential applications of the band. The operator would be responsible for documenting the method used to determine power, and would keep that determination as part of the station records, similar to what is required for the amateur 60 meter band. Determining power by any one of these requirements would be deemed compliant:

- *Actual field strength measurements.* Some of the amateurs holding existing Experimental Licenses do have the equipment and the experience to perform these measurements, and have done so to determine compliance with the terms of their licenses. It is worthwhile to keep this as a valid option for those so qualified, as it enables them to experiment with a greater variety of antenna types, not all of which may be adequately quantifiable by relatively simple formulae or antenna analytical software.
- *An antenna engineering analysis by the operator.* This could take the form of determining antenna efficiency by actual measurement of RF resistance at the antenna terminals (by RF bridge, vector impedance analyzer, substitution method, or a combination thereof), including the resistance of the base inductor if a vertical antenna,

and also calculating the radiation resistance of the antenna with NEC-type software or formulae from standard references for the type of antenna employed; with radiated power then determined as the product of transmitter power, calculated antenna efficiency (radiation resistance divided by total terminal resistance), and pattern gain. Pattern gain, in this case, would mean the 2.15 dB gain of a dipole over the isotropic case for a loop, or the 5.15 dB gain of a monopole over isotropic for a vertical antenna. [Alternately, it is not necessary to first determine the loss resistance if one can actually measure RF current at the antenna base, then apply the formula $\mathbf{p = i^2 r}$ where **r** is the calculated radiation resistance only, and multiply that result by the pattern gain.] Many amateurs are capable of this type of analysis, although it would be limited in scope to comparatively simple transmitting loops or vertical masts. To allow for the calculated radiation resistance being an approximation, the Commission could require a safety factor, setting a slightly lower EIRP when this method is employed.

- *Fallback position.* If unable to do either of the above, an operator would be permitted to employ a combination of antenna height and TPO limits enumerated in a set of tables within the rules, sufficient to allow the specified EIRP to be attained in principle under ideal conditions over excellent ground, but which will not allow it to be exceeded under any condition. Although most real-world stations would end up with less than the full EIRP this way, all amateurs could use this method without difficulty if the alternatives were not practical for them.

In this way, amateurs of different skill levels can be accommodated, while amply protecting other users. Other commenters are likely to submit technical information that will be useful in implementing the options above, so I would like to address a few additional factors for consideration when establishing antenna size and power limits. Some of these relate to the different usage the bands will experience, some relate to the differences in wavelength between them, and some arise from the types of antennas amateurs now use at these frequencies.

20. Operational differences between 2200 meters and 630 meters. While it is still correct to consider operation in both bands much more experimental than, say, the HF amateur bands, some differences are gradually emerging between them. Both among amateurs overseas and experimental licensees here in the U.S., the 2200 meter band continues to be mostly a "proving ground" for equipment, transmission methods, and antennas, and observation of propagation, with little or no routine communication. The extreme difficulty of radiating useful amounts of signal and the tiny amount of bandwidth available in this band will always limit its appeal to the most serious experimenters, which in turn means there will continue to be little or no equipment manufactured for it, further confining its appeal to serious-minded and well prepared amateurs. On the other hand, while 630 meters largely remains experimentally oriented at this time, I am aware of a number of licensed amateurs who are eager to give the band a try for communication once the rules are in effect. In Europe and Japan, there is a modest cottage industry providing transverters and low power exciters for amateurs to use at 630 meters. Here in America, Elecraft has already announced a 630 meter option for their radio. Thus, it is reasonable to anticipate more activity in the 472 – 479 kHz region than at LF and more routine communication, although it is still unlikely to ever become a crowded band because it is such a technical challenge to radiate and receive an adequate signal there compared to HF. From my monitoring of European email groups, it is apparent that after an initial influx of interested parties to the new band, activity settled down and a nucleus of the most dedicated individuals now account for most of the current activity. It seems probable that same pattern will hold here as well. If so, the

differences in usage of the two bands might have some bearing on how antenna size and transmitter power are regulated, and almost certainly will be relevant in deliberations over emission types, authorized bandwidth, and operator requirements.

21. Technical differences between 2200 meters and 630 meters. At 179, the Commission asks, "Should the transmitter power limits differ between the 135.7-137.8 kHz band and the 472-479 kHz bands?" I am convinced that they must differ. Not only will the two bands likely be authorized different EIRP, but the difference in wavelength between them is particularly relevant to discussions of antenna and power limits. All antennas that will be used in these bands inevitably fall under the definition of electrically small (their largest dimension is physically less than an eighth of a wavelength), and that makes their efficiency sensitive to wavelength.

22. In the case of an electrically small vertical radiator, the radiation resistance is proportional to the square of the effective height expressed as a fraction of a wavelength. If a short antenna of a given height has a radiation resistance of 0.5 ohm at its intended operating frequency (roughly typical for a 50 foot mast with a moderate amount of top loading at 475 kHz), doubling that height does not double the radiation resistance, but quadruples it to 2.0 ohms. That means, if there is no appreciable change in loss factors such as ground system resistance, the antenna becomes four times as efficient by doubling its height, not just twice. That needs to be taken into account when formulating tables of permissible power versus antenna height in a given band, of course; but it also means that an antenna of a given fixed physical height also becomes a greater percentage of the wavelength as the frequency increases and wavelength shrinks. Unless the loss factors also change with frequency (which they will to some small extent) the same antenna becomes more efficient in inverse proportion to the square of the ratio of the wavelengths. The ratio between 2200 meters and 630 meters is approximately 3.5:1,

and the square of that ratio is about 12.2:1. Consequently, a vertical antenna of a given height will radiate about 12 times better at 630 meters than it does at 2200 meters; or conversely, only about a twelfth as well at 2200 meters as it does at 630.

23. The greatest variability in performance of electrically short vertical antennas at different sites arises from the combined effects of ground system resistive loss, RF resistive loss in the base loading inductor (for cancellation of the short antenna's inherent capacitive reactance), and interaction with any other partially conductive objects within the antenna's near field region. Ground system loss varies widely between sites because of differences in soil conductivity, number and length of buried radials that can be installed at a given site, and so on. It also varies with frequency, because the skin depth of a conductor is greater at low frequencies than at higher ones, and the RF currents may or may not encounter poorly conductive rock in the subsoil at any given site. Based on decades of Part 15 operation by scores of experimenters in the 160 – 190 kHz band, it seems reasonable to expect ground losses to vary widely. My own ground system measures about 3.5 ohms at 185 kHz with antenna reactance nulled and the measured RF resistance of the coil subtracted, which itself is considerably greater than the ground resistance. That's an atypical result achieved with 33 buried radials of 100 feet or greater length, in high conductivity prairie soil, supplemented with applications of magnesium sulfate (Epsom salt). Most Part 15 installations were considered good if the ground system could be brought down to 10 or 20 ohms, plus similar losses in the loading coil; while by contrast, operators afflicted with sandy or rocky soil had to be content with scores of ohms' loss. At 630 meters, my system's loss is lower (slightly below 3 ohms), and at 2200 meters it is greater (somewhat over 4 ohms), but these also should also be considered atypical. It has been reported by operators of Experimental Service 630 meter stations that around 15 ohms total loss seems

more common, but I do not have an adequate sample of data to confirm that. It should also be noted that my own results show little influence of environmental losses other than the ground, because the farm location enables the antenna to be well away from obstructions that might extract power from the induction zone. Most amateurs won't be so fortuitously situated. Since the extent of an antenna's near field varies in proportion to wavelength, most amateur stations employing vertical radiators at 2200 meters could expect to encounter more loss from nearby vegetation and structures than they will at 630 meters. Also, since loading coils are necessarily larger at the lower frequencies, their resistive losses will be greater than for most 630 meter installations. Thus, in most cases, operators at 2200 meters can expect to encounter more losses than will be accounted for by the effect of wavelength on radiation resistance alone, and possibly should have greater flexibility in their transmitter power limits.

24. While most of the discussion to date has assumed the use of vertical antennas, the trend among Part 5 licensees on 2200 meters, especially in residential settings in the Northeast, has been toward transmitting loops. These will also need to be considered when preparing tables of antenna size and power limits, since it is not just a question of antenna height alone any more. Well built loops have the advantage of stable characteristics and less interaction with conductive objects in their vicinity, such as trees. They have the disadvantage of extremely low radiation resistance, necessitating high RF current levels, and therefore require relatively massive conductors to minimize resistive losses. Yet, if an amateur is willing to undertake the effort, this type of antenna can be quite effective at LF, and therefore is likely to be around for a while. From my own experience monitoring the Northeastern experimental stations over recent winters, it is clear that their performance is quite consistent, and therefore should be easier to characterize for regulatory purposes than vertical antennas.

25. The WD2XES loop antenna appears to have been well tested, and may serve as a good example by which to gauge real-world loop performance. My understanding is that the conductor encloses an area of close to 1,000 square feet, and an applied transmitter power of 500 watts yields measured field intensities corresponding to 1 W ERP. However, since the ITU specification is for 1 W **EIRP**, a scaled-back transmitter power of 300 watts can reasonably be assumed to produce 1 W EIRP from a 1,000 square foot single-turn loop of good construction at 2200 meters. Radiation resistance of an electrically small loop is proportional to the square of the area, so a loop of 500 square feet area (which might be the most an amateur on a small lot could construct) would have a quarter of the radiation resistance and roughly half the resistive loss, since the latter usually varies in direct proportion to the perimeter. Because of this, efficiency of a loop made with a given conductor varies in proportion to the enclosed area (within reason); and thus, a transmitter power of 600 watts would be appropriate to achieve 1 W EIRP with the smaller version. (Now, it should be noted that a given loop's radiation resistance varies inversely with the <u>fourth</u> power of the wavelength, but loss resistance follows a different relationship, so more care would be required when modeling how a given loop antenna's efficiency would scale between 2200 and 630 meters. Also, efficiency of a loop with multiple turns is less certain. Radiation resistance is proportional to the square of the number of turns, but instead of loss resistance varying linearly as it does with area, interaction between turns increases the RF loss to an extent that is harder to predict. However, single turn transmit loops are sufficiently challenging to erect, and appear to be the norm.)

26. <u>Antenna height limitations</u>. In the preceding discussion, I have only addressed antenna height as it relates to an antenna's ability to produce field strengths corresponding to the desired EIRP limit for each band. I note, though, at 178 the Commission also contemplates that

antenna height restrictions could assist in spectrum sharing "by limiting the number of transmission lines that would potentially be in direct line-of-sight of amateur station antennas." I would respectfully point out that a line-of-sight path makes little difference to signal propagation at these frequencies, unlike VHF or UHF. Shielding against line-of-sight would only become a concern if the transmission line were actually close enough to the antenna's inductive near field to intercept some of the stored reactive energy, a different matter from radiated energy. The inductive near field region is small compared to the proposed separation distance, however, and proximity of transmission lines to the near field is something that we want to avoid in any case (see comments at my paragraph 7). Sufficient physical separation, in conjunction with the limited EIRP that will be authorized, is therefore adequate to ensure successful spectrum sharing.

EMISSION TYPES AND BANDWIDTH SPECIFICATION

27. I note that there have been a few comments filed suggesting elaborate plans to divide both bands into various tiny segments restricted according to bandwidth, operator license class, and other criteria. These bands will not receive enough use to justify such needless complexity, nor would arbitrarily segregating operators into different parts of the band be conducive to spectrum efficiency, international compatibility, or sharing with other radio services. At 2200 meters, simple *ad hoc* band plans are already in place that ensure non-interference between operators in Europe, Asia, and the Americas attempting long distance weak-signal work. Both foreign amateurs and U.S. experimental licensees have respected that informal arrangement with good results. At 630 meters, different digital techniques are tested in mutually agreed narrow frequency slots that are honored by other operators internationally. The amateur community is evolving these band plans as a natural matter, and there seems no need at this time to impose additional restrictions.

28. At 2200 meters, I am generally inclined to agree with the ARRL position in the *WRC07 NPRM* that setting limits narrower than the full 2.1 kHz band would not be conducive to experimentation with digital modes that may be developed in future. However, individual commenters in this current proceeding have correctly pointed out that the modes most successful at LF thus far are the ones that require the narrowest bandwidths. My own experience in January 2014, as the Kansas receiving point for a daytime groundwave test by the operator of WE2XEB and WG2XRS/4 in New York, illustrates that point. After determining that his signal was more than adequate for the most typical LF slow modes which require seconds or minutes to send a single character, but not quite strong enough to decipher standard Morse code keying amongst the routine background noise, we agreed to attempt one of the narrower bandwidth keyboard modes. The only mutually compatible software we possessed for that purpose was PSK31, which is considered a robust and spectrum-efficient method by HF amateur standards, but proved only marginal for the kind of signal levels we were working with. The usual narrower modes employed at LF were far more effective. From this experience, I conclude that most operators who are willing to take the trouble to work in this band are likely to gravitate toward the narrowest bandwidth techniques on their own. However, if the FCC does choose to establish specific bandwidth limitations at 2200 meters, I recommend that they be sufficiently narrow and applicable to modes such as RTTY and CW Morse as well, because these can be highly disruptive in a band where signals of very narrow bandwidth are often intentionally clustered together within 0.5 Hz of each other.

29. At 630 meters, the greater usage I anticipate for this band may justify bandwidth restrictions from the beginning. Although I have no specific numbers to offer, I do encourage the Commission to consider leaving at least part of the band accessible for experiments with

narrow digitally compressed real-time voice, if that seems feasible. It is a promising field, but I recognize that such experimentation may best be left to other bands for now.

30. Related to spectrum utilization, and therefore also spectrum sharing, is the question raised at 180 of automatic control. That was a concern I voiced in the earlier proceeding. I have no objection to automatic control apart from being uncomfortable with software that can choose its own transmitting frequency without operator confirmation. One such technique sends its coded signal on a given frequency for a set number of minutes, then repeats the sequence during the next cycle on a different frequency that may be many hertz away from the first. It is my opinion that spectrum sharing, both between services and within the amateur service itself, is best served if an operator initiates transmissions on a definite frequency that he himself has determined, not just an arbitrary one within a general range, so he can verify it is clear for use.

OPERATOR REQUIREMENTS

The Commission also asks for comments on what operator licensing requirements would be appropriate. This time I note that two respondents heavily favor Extra Class, but without providing justification to show how this would promote spectrum sharing. Most respondents appear to endorse the earlier ARRL position that the bands should be fully available to General, Advanced and Extra Class licensees. I also agree, but with one addition.

At 180, the Commission says: “In particular, we note that ARRL states that it would be consistent with Commission policy to make this frequency band available to Amateur Extra, Advanced, and General Class licensees.” This argument can be made effectively for 630 meters since it is an MF band with a few traits in common with the other ARS MF band, 160 meters.

However, at 2200 meters, I maintain that it would **also** be consistent with Commission policy to make that band available to Technician Class. Furthermore, it is entirely consistent with the goal of promoting spectrum sharing.

There is sometimes a tendency in the amateur community to casually equate Technician with Novice. But it should be remembered that above 50 MHz, Technicians share **all the same privileges** that General, Advanced and Extra Class have—and **all the same responsibilities** to comply with power limitations, geographical restrictions, and general frequency sharing requirements as a secondary service in all UHF and microwave bands! Technicians who exercise their privileges in these bands are already well accustomed to having to familiarize themselves with specific rules pertaining to each spectrum segment in which they operate. Such rules will be no more complex at 2200 meters.

So far as technical proficiency is concerned, Technicians are already in the same boat with Amateur Extra, Advanced and General Class licensees in bands above 50 MHz, just as they would be at LF. As the frequency increases, the availability of equipment manufactured specifically for the amateur decreases. Technicians who seek to work there must do **the sam**e **self-training** as Amateur Extra, Advanced, and General Class in order to construct or modify previously-unfamiliar types of hardware. This is exactly what will also be necessary at LF.

The highly experimental nature of 2200 meters is directly comparable to amateur activity at UHF and microwave frequencies, where Technicians and higher classes already operate side by side. Therefore, it is entirely consistent with Commission policy to authorize operation at 2200 meters by all classes of license from Technician through Amateur Extra.

There is also precedent in other countries where 2200 meters has been authorized much longer. I’ve not found a CEPT country that excludes any of its amateurs from 2200 meters by license class. In fact, I am informed by British amateurs that Ofcom, the UK radio regulatory agency, makes 2200 meters available to all three of their license classes, including the beginner Foundation Class. By contrast, Ofcom does restrict 630 meters to their two higher classes. The view seems to be that LF operation is a self-limiting process because of its very challenging nature; only those with the necessary preparation and experience will even attempt it.

CONCLUSION

I continue to believe that amateur radio and PLC operation can coexist successfully in the proposed new LF and MF amateur bands, just as they have done thus far on experimental basis. Along with many other amateurs, I thank the Commission for the time, attention and diligence that has been put forth toward making that coexistence a real possibility.

Respectfully submitted,

John H. Davis
PO Box 66
Oswego, KS 67356

August 31, 2015