In the Matter of
Amendment of Part 97 of the Commission's
Amateur Radio Service Rules to Permit Greater
Flexibility in Digital Data Communications **RM-11708**

To: The Chief, Wireless Telecommunication Bureau

Comments of Andrew T. Flowers, PhD[1]

The Petitioner argues that current symbol rate limit in §97.305 and §97.307 is a relic of past technology that today encourages inefficient use of spectrum and hampers technological innovation. The Petitioner proposes that the symbol-rate limitation be replaced with a bandwidth limit since this was the original intent of the old rule as it applies to HF communications. The Petitioner makes a very understandable mistake its interpretation, but a closer reading of the Commission's statements in context will show that *the rule was primarily about compliance and self-regulation, not limiting bandwidth*. This is an extremely important point, because the Petitioner believes it is "filling the vacuum" of the old rule with the new one by proposing an explicit bandwidth limit. As I will demonstrate, it does not, and if adopted as is, *is likely to have imminently disastrous effect on the Amateur Service's ability to self-regulate.* While I do not believe the current regulatory framework will accommodate all that the Petitioner intends even if the proposal were adopted *in toto*, there are merits to the petition that would be beneficial to the Amateur Service and they deserve a fair hearing. While a bit unorthodox, I have chosen to discuss this in a historical narrative in sections II and III because this approach will clearly illuminate the specific issues around Pactor-4 as well as frame the concept of "spectral efficiency" in context. (It will also point the way to some further deregulation, which I believe is in everyone's interest). Finally, I will try to show how the Commission may be able to salvage the kernel of what is valuable and practical without leaving the scope of the Petition. I beg the

[1] Background and credentials are provided at the end of my comments.

Commission's patience, as such a seemingly small request as this really does require seeing the forest through the trees. I thank the Commission's time for reading what I have to say and hope that it is helpful in reaching an informed decision that is in the best interests of the Amateur Radio Service as a whole.

I. "Spectrum efficiency" in the Amateur Radio Service

Before we dig into the premises of the Petition, I should point out that the Commission has never been principally concerned with the spectral efficiency insular to the Amateur Radio Service *per se*. Spectral efficiency (whether defined as technical, economic, or functional) has been proposed as a useful rubric for spectrum allocation among services that come under auspices of the FCC and NTIA, and that appears to be the value to which the Petitioner is appealing. A review of the relevant literature shows that this concept is one that is generally applicable to services that serve a third-party beneficiary (the "consumers" of some service). The concept of spectral efficiency is very clearly applied to those services whose purpose is to provide a deliverable good or service to the general public—for example broadband wireless internet or personal communications, or to cite a non-profit case, public safety networks whose purpose is to deliver safety to the public. By using spectral efficiency as rubric (though not necessarily the only measure) policy options among these often highly-regulated services can be weighed by a more objective criterion that approximates the public good.

The Amateur Radio Service is unique in that the licensed users of the radio service are themselves the primary beneficiaries of the service, not a third party "public". In other words, the primary public interest *itself* is served directly by the very act of establishing a radio service that is open to members of the public to pursue an "interest in radio technique solely with a

personal aim and without pecuniary interest."[2] In fact, the Petitioner itself has argued that the standard of spectral efficiency should generally *not* apply to the Amateur Service in the same way as other services due to its unique "public right of way" or "public park" nature.[3] By appealing to "spectral efficiency" in the current petition, the Commission is now being asked to use information rate as a cudgel to prioritize the actions of individuals within the Amateur Service: *he who can send the most information the fastest within some arbitrary bandwidth wins*.[4] That may be a good model for regulating wireless ISPs, mobile telephone services, and awarding spectrum auctions, but the unique, balanced, diverse and ultimately *public* interests that make up the Amateur Service today will not be well served sleeping in that Procrustean bed.[5]

When the Commission has spoken of spectrum efficiency through its proceedings with respect to the Amateur Radio Service, it has been in the context of whether or not the allocated frequencies as a whole are being used in accordance with the enumerated purposes of 47 C.F.R

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[2] See the definition of "Amateur station" in 47 USC §153(3). Note the characteristics used to describe the service where it is defined for the purpose of distinguishing it against all other services (Common Carriers, Public Safety, etc.) that fall under the jurisdiction of the Commission.

[3] The Petitioner has made the appeal to the *direct public benefit of licensees* when defending against impediments to Amateur Radio operations: "A metaphor for the use by radio Amateurs of its small spectrum segments is that of a public park. The park is available to all who choose to use it by becoming licensed in the Service, and it is used for the benefit of the public." (Petitioner's comments *In the Mater of Emergency Communication by Amateur Radio and Impediments to Amateur Radio Communication*, GN Docket 12-91).

[4] The Petitioner's definition of spectral efficiency seems to be a *very* limited one in this context, and one crafted to suit its argument: bits/sec*Hz. This has been played out by other services who wish to discount opportunity costs involved in order to favor a particular position. In this case, it simply privileges those who are interested in sending high-speed data between computers, since real-time communication between humans does not require high information rates, nor is it typically in a form that would possible to measure in like quantity. The Commission is no stranger to these arguments (see Report of the Spectrum Efficiency Working Group of the Federal Communication Commission Spectrum Policy Task Force (2002), p. 9).

[5] We should also note that the FCC's own Technical Advisory Council draft whitepaper regarding Spectrum Efficiency Metrics does not even include Amateur Radio under its analysis, and warns against using any such measure for comparing heterogeneous services (or we might say, "purposes", like the ones enumerated in §97.1), while at the same time often calling into question the relationship between Spectral Efficiency and public interest even in the target services themselves. See http://transition.fcc.gov/oet/tac/tacdocs/meeting92711/Spectrum_Efficiency_Metrics_White_Paper_by_TAC_Sharing_Working_Group_25Sep2011.doc (retrieved 16 December 2013).

§97.1.[6] Thus efficiency, if one must call it that, is ultimately measured by whether or not the specified purposes are being met in some optimum manner. The Petitioner has noted this necessarily broad meaning of "value" in proceedings directly regarding spectrum policy.[7] Rather than focus on the minutiae of how licensees in the Amateur Service themselves communicate, the Commission has instead rightly focused its attention on the appropriate and balanced *use* of the privileges granted to licensed amateur radio operators and to ensuring that the amateur service is protected from the encroachment of interests that properly belong in other services.[8] This has been especially true in respect to digital communications and in particular to unattended digital stations, which the petitioner considers to be a critical component the current petition.[9] Following this pattern, the Commission should focus its attention on whether or not the proposed rules and likely future effects support a balance of the enumerated purposes in §97.1(a-e), not the equivocal "efficiency" from which the Petitioner argues. In other words, I respectfully ask the Commission to keep its eye on the ball.

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[6] For example, reallocating spectrum in the 7.0-7.3 MHz in 2004 (ET Dockets 04-139, 04-140), mentioned an increase of "spectral efficiency" that would result from the proposed changes, but only as a result of Broadcasters vacating the 7.1-7.2 MHz region to allow more space for a common band among amateurs *worldwide*. The increase in "spectral efficiency" was backed by an increase in international goodwill per 97.1(e), not prioritizing the speed or amount of information in that bandwidth. We will see later on that the original intent of the "regulation by bandwidth" NRPM in Docket 20277 also followed this pattern, contrary the Petitioner's interpretation.

[7] For such "public" uses, information rate is a very poor variable for measuring value because it is essentially economic in nature. The Petitioner has in fact noted publicly before the NTIA that economic values are a poor measure: "Unless the concept of 'value' is general enough to encompass the concept of public interest, convenience, and necessity, it tends to devalue or ignore uses of the spectrum that do not have economic components. Non-profit uses of the spectrum, such as Amateur Radio, serve the public interest by providing a voluntary service that could not be duplicated by a commercial or government service." (American Radio Relay League, Comments in In the Matter of United States Spectrum Management Policy for the 21st Century, Docket No. 040127027-4027-01 (2006), response to Question 10).

[8] See *In the Matter of Don Rolph, Petition for Rulemaking to Amend Part 97 of the Commission's Rules Governing the Amateur Radio Service to Provide for Encrypted Communications*, DA 13-1918 (at 7): "[W]hile the proposal could advance one purpose of the amateur radio service…it would undermine other characteristics and purposes of the service."

[9] See Section IV of the Petition.

II. The symbol rate limit was about self-regulation, not bandwidth

The fundamental premise of the Petition is that the symbol rate limit was acting as a *de facto* bandwidth limitation for digital transmissions because, under the current technological assumptions in 1980, the Commission equated symbol rate with the bandwidth of the emission.[10] The Petitioner misunderstands the whole of the Commission's intent when the Commission stated, "[R]ecognizing that the use of **slower speeds** is likely to be the norm, we have, in order to provide maximum flexibility, decided to permit speeds up to 300 bauds between 3.5 and 28 MHz…."[11] The Petitioner interprets this statement as, "[T]he Commission thought it was achieving [the objective of limiting bandwidth of transmissions], because it equated the symbol rate with the bandwidth of the data emission."[12] Perhaps it did have the effect of limiting bandwidth of individual transmissions and was understood by the Petitioner in this manner at the time, but this is true only under the assumptions that the Amateur operators themselves were not largely interested in experimenting with state-of-the-art, high-speed digital communication techniques—*something the Commission pointed out in the same proceeding*. Any bandwidth limitation was one of choice, as it is to this day, and while bandwidth of individual transmissions may have been a concern of some of the commenters, it seems that the Commission was simply noting that it believed the commenters concerns would be met by virtue of the expected practice as voiced by the commenters themselves. What I suggest, and what will be demonstrated in the following discussion, is that the historically accurate reading of the Commission's reasoning was this: rather than limit the specific symbol rates that amateurs would be interested in using *en masse* to enable worldwide communication, *the Commission decided to allow all symbol rates up*

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[10] See Petition at 8.
[11] *Third Report and Order*, Docket 20777, FCC 80-35, 46 Pike & Fischer Radio Regulation 2d 1435 (1980); quoted by Petitioner at 7.
[12] Petition at 9.

to a well-understood practical limit that would still allow global transparency of the message content. The key understanding is that the symbol rate limit, in conjunction with the requirement for *specified codes* on HF (which at the time only included Baudot and later ASCII), guaranteed distant stations on suboptimal HF paths had a reasonable chance of seeing the content of the communications. This requires some explanation because it is not obvious unless you understand the state-of-the-art HF communications at this time the rule was established.

A symbol rate of 300 symbols-per-second has a symbol *period* of a little more than three milliseconds. It had been well established long before the aforementioned *Third Report & Order* in 1980 that faster symbol rates (and thus shorter symbol periods) require exceptional HF paths due multipath time delay effects caused by the ionosphere. That the 300 symbols/s limit was a practical limit for HF communication is evidenced by the concurrent academic literature and now several subsequent decades of actual innovation in HF communication. The following from Nicholas Maslin—*published seven years after the establishment of the symbol rate limit*—is illustrative:

> "When a signal propagates by more than one mode, intersymbol interference can result….Taking worst case multipath of 8ms then the symbol plus guard band time comes to about 10 ms so that the maximum symbol rate would be 100 symbols per second….
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> *Unless it is known that only a single mode of propagation exists*, FSK transmission should be limited to below 300 bit/s, and in practice much less, due to multipath interference.[13] (Emphasis mine.)

Maslin goes on to clarify that higher information rates than 100 or 300 bit/s are possible by using M-ary FSK or multicarrier systems—all methods of increasing information rate in a fixed bandwidth while working within the symbol-rate speed limit that is determined by the ionosphere. Thus, it is unambiguous that the practical limit is symbol rate and not information

[13] Maslin, Nicholas. *HF Communications: A Systems Approach*, Pitman Publishing (1987), p. 136. Note that the practical limit of 300 bits/s is equivalent to 300 symbols/s in a binary FSK signal.

rate. The implication is clear: the content of messages utilizing symbol rates faster than 300 symbols/s can only be ascertained under very specific channel conditions with single modes of propagation (a relatively rare phenomenon at HF). Thus utilizing higher symbol rates would make it difficult for a third party to read the content of the message unless these very specific conditions were met. The Commission knew exactly what it was doing by specifying *symbol* rate as opposed to information rate as the limit; it certainly did not conflate the terms. In fact the Commission, by specifying *symbol* rate, left the door open for radio amateurs to experiment with other, more modern modulation methods in the future, which as the Commission stated, was real goal of the whole "regulation by bandwidth" initiative in the original 1976 NPRM in the first place.[14]

Further evidence comes from the subsequent practice of new digital techniques. The Pactor-III waveform suite—one of the most widely used methods for transferring email over HF channels—uses a maximum symbol rate of only 100 symbols/s per channel, *despite being designed 22 years later (2002) for the commercial market in which no such symbol rate restriction exists*.[15] Ironically, the Petitioner notes the lower symbol rate of Pactor-III compared to earlier generations of Pactor, but perhaps does not understand how the lower symbol rate is actually evidence that it is *not* the "inefficient" technological anomaly it is believed to be.[16] Maslin was right all along.

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[14] The Petitioner would have us read this series of events as "failure" to regulate the bandwidth of individual transmissions, but that was never an end in itself. The whole underlying intention of regulating by bandwidth was fulfilling the amateurs' "proven ability to contribute to the radio art" per §97.1(c,d); it was never about "spectral efficiency" in the sense the Petitioner is using it and is in no way a precedent for the current petition. See *Second Report & Order* in Docket 20777, FCC 78-588, 43 P&F Radio Regulation 2d 1622, 1623 (1978), quoted by Petitioner at 5). As evidenced by future practice and discussion today this goal was realized—just not by the means originally proposed.

[15] See description of Pactor III in ITU-R M.1798-1, pp. 39ff.

[16] Petition, footnote 17.

Perhaps the Petitioner is arguing that the symbol rate limit forced a *class* of supposedly "inefficient" multicarrier techniques of which Pactor-III is an example, but multicarrier techniques have *always* been a method of attaining bandwidth efficiency under the natural symbol-rate constraint of the ionosphere. One of the earliest to have commercial implementation was the Kineplex system—a 20-tone (sometimes more), four-phase PSK waveform—essentially a mechanical implementation of OFDM.[17] Please note the date of the reference. OFDM and other more refined multi-channel techniques could also be cited that were already in widespread use by the time Docket 20777 began, as the Commission surely knew at the time. Advances in technology since then—particularly digital signal processing to replace discrete components and more efficient coding of the information—have allowed multicarrier techniques to reduce their occupied bandwidth, but we have the same ionosphere with the same constraints today as we did in 1980. Simply put, advances in technology could not "effectively divorce symbol rate and bandwidth"[18] in the way the Petitioner claims because Mother Nature never allowed the marriage when it was supposed to have occurred.

The important point of this discussion is that the 300 symbols/s limit really had little to do with bandwidth directly (i.e., bandwidth limitation may have been a side effect under other assumptions), but rather provided a reasonable guarantee that operators could self-police by ensuring that they could read each other's messages and identify abuses.[19] Given the volatile nature of global politics and the continual presence of nations that grant less freedom to their citizens than we ourselves enjoy, *this transparency cannot be undervalued*. International

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[17] *Transactions of the American Institute of Electrical Engineers, Part I: Communications and Electronics*, Vol. 76/6, January 1958. Note that this was a way of *conserving bandwidth* over binary "single channel" telegraphic techniques, contrary to the implication of footnote 16 in the Petition.

[18] Petition at 9.

[19] This may explain the otherwise cryptic phrase in the *Third Report & Order* of Docket 20777: "…inasmuch as operation within such maximum specified limits is very easily ascertained (*thus facilitating compliance*)." (Emphasis added.)

goodwill is an enumerated and *unique* purpose of the Amateur Service (§97.1(e)) that is directly served by the open nature of the communications that take place within it, particularly on HF where worldwide radio propagation is the norm.

III. Serial-Tone Modems, self-regulation, and "The Pactor-4 problem"

Breaking the natural "symbol rate barrier" was a subject of tremendous of research during the 1980's, shortly after the symbol rate rule went into effect. By the end of the decade this research resulted in *serial-tone modems*[20] that did in fact allow faster symbol rates to be used on normal HF channels. The method that was used to accomplish this was aided by advances in signal processing and computational power unavailable in 1980, but how exactly this came to be is not really relevant to our discussion. What is relevant are methods used, as it has direct bearing on the self-policing nature of the Amateur Service.

To overcome the natural limit discussed above, the transmitter would scramble the information to be sent by using what is *functionally equivalent to symmetric-key encryption*. It is the "shared key" between transmitter and receiver that allows the receiver to estimate the distortion of the ionosphere, and then construct an *equalizer*—a corrective lens—in the receiver's software thus undoing the distortion of the ionosphere and allowing the higher symbol rate.[21] Rather than send multiple narrow-bandwidth channels of slower data, the newer serial technique uses one channel of wider bandwidth and faster, *scrambled* data. The scrambling with a randomized key is the lynchpin that allows the faster symbol rates; it cannot work without it. Whether or not these serial techniques offer an advantage over parallel techniques in measures of "spectral efficiency" (as the Petitioner claims and defines the term) appears to be an open

[20] This term is used in opposition to *parallel-tone* modems, which describes the multicarrier techniques we just discussed.

[21] This corrective lens is often referred to as an "equalizer" or "equalization technique" because it "equals out" the effect of the ionosphere.

question,[22] nevertheless, it is in fact the serial-tone equalization technique that is generally prevented by the current symbol rate rule—although this is only true if your interest is sending higher speed data.[23] Leaving this issue aside, the crucial point for this discussion is this: *because of the close relationship between equalization techniques and cryptography, these "serial-tone modem" techniques present some challenges to the self-regulatory nature of the Amateur Service should the symbol rate limit simply be removed as proposed.*

The declassified NATO STANAG 4285 specification serves as a good example to illustrate the issues involved.[24] This code uses 176-bit "random scrambling sequence" to encode the information being transmitted.[25] The appendix of the specification shows the algorithm used, which any undergraduate engineering student will immediately recognize a symmetric-key block cipher. If you were not given this key and asked to find it, you would have to find the correct key in 2^{176} possibilities. This is equivalent to having to pick the correct number between 1 and 1-followed-by-53-zeros, and is in fact much stronger encryption than 128-bit encryption commonly used on the internet today (and this was 1989!). *In other words, without documentation of the coding algorithm itself serial-tone techniques can be effective as any encryption technique*. This is of course why it was (and continues to be) so attractive for classified communications among NATO allies in the first place: it solved both the ionospheric

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[22] The field seems to have many misconceptions regarding the advantages and disadvantages to each, and some eminent experts are not willing at this point to offer up which technique is more spectrally efficient. See discussion in recent publication: Johnson, et al., *Third-generation and Wideband HF Radio Communications,* Artech House (2013), pp. 28ff.

[23] Of course, you can apply this same technique at lower symbol rates as well. It appears that the STANAG 4285 specification defines a 1200 symbols/s mode which is has always been allowed on the 28.0-29.7 MHz band. This specification was declassified two decades ago, but I am not aware of any experimentation with it in the Amateur Service, nor does the Petitioner cite any.

[24] See the declassified standardization agreement for *Characteristcs of 1200/2400/3600 bits per second single tone modulators/demodulators for HF radio links,* http://www.n2ckh.com/MARS_ALE_FORUM/s4285.PDF (retrieved 16 December 2013). I am purposefully citing a personal website of an amateur radio operator to make the point that there is some interest within the Amateur Service regarding these technologies, and those voices are important. Again, my principle concerns revolve around the intended uses of the technology within the bounds of the Amateur Service.

[25] Ibid., Appendix A (pp. 11-12 of the referenced PDF document).

distortion problem and kept communications private! Surely both the Petitioner and the Commission would agree that the spirit and intent the requirement that codes used on HF be publicly documented would include this essential piece of information like this (see §97.309(a)). Moreover, the Commission addressed the issue of "publicly documented codes" in 1995[26] and argued as recently as this year that the ability of amateur stations to *understand* the communications of other amateur stations is an integral part of ensuring that the amateur service remains a non-commercial service and self-regulates.[27] The record is unambiguous: the amateur service must have necessary and sufficient technical specifications to be able to watch the content of communications without undue burden.[28]

The Petitioner apparently believes that Pactor-4 meets this requirement; to my knowledge, and at the time of this writing, it does not. It is worth quoting the creator of Pactor-4 at length: [29]

> The high speed protocol PACTOR-4 (P4), is THE HF-Data protocol of the 4th generation, using the most modern methods of *adaptive channel equalization*, *channel coding and source compression. […]*
>
> The *channel equalizer* operates using an iterative method, and *compensates for distortion caused by multi-path propagation* up to a delay spread of 8.8 ms…. *In comparison to OFDM methods*, selective fading does not produce an irreducible noise floor…
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> (emphasis in italics added, CAPS original)

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[26] This is not the first time this has been addressed. See *Use of CLOVER, G-TOR, and PacTOR Digital Codes,* DA 95-2106 Federal Register Vol. 60, No. 211, Rules and Regulations 55485 (1995). At the time of this rule, "PacTOR" refers to first-generation Pactor, i.e., "Pactor I" cited by the Petition in footnote 17 of the Petition—there was no other at the time. We may all be better served by eliminating specific examples of codes that are now 20 years old, opting instead for clarifying the intent of the rule so that we do not need to revisit the issue.

[27] "To ensure that the amateur service remains a non-commercial service and self-regulates, amateur stations must be capable of understand the communications of other amateur stations." See DA 13-1918 (2013) at 6.

[28] I would suggest that this burden could not only be technical, but also financial in nature. The Amateur Auxiliary that acts as the interface between the FCC's enforcement division and the Amateur Service relies on unpaid volunteers through the Petitioner's own Official Observer program. Obviously the Petitioner would be in a better position to comment on the tools its volunteers have with regard to modern digital communications.

[29] See http://www.pactor4.com/en/PACTOR-4.html (retrieved 14 December, 2013).

Thus it is clear from the manufacturer's own publication that the equalization techniques are used—as opposed to multi-carrier (i.e., OFDM) techniques—for the purposes of compensating the distortion of the ionosphere. It is therefore certain that data-randomization similar to symmetric key scrambling in the STANAG 4285 example is involved, since it is a pseudo-randomization of the data that makes the process possible. Even more problematic, it appears that the sole manufacturer of the modem does not even provide a method of decrypting a Pactor-4 communication between two other parties using its own equipment.[30] This situation could be rectified on the part of the manufacturer should it choose to make it compatible with the Amateur Service, but we should also note that it is self-evident that the choice of whether or not to sufficiently document the code is the prerogative the intellectual property owner.[31] While the current rules specifically prohibit "encryption for the purpose of obscuring communication"[32] it is very clear that historically these techniques have served a dual purpose by design. In cases like this, where the target market (and its intended use in the Amateur Service) is email communication over HF radio in other services that are not required to be as transparent as the Amateur Service, it is reasonable conjecture that in fact this is part of the intent and a reason to keep the key secret. This clearly stands at odds with the longstanding principle that there is no expectation of privacy in the Amateur Service. Note that because the code could be sufficiently complex to reverse engineer, simply revoking any expectation of privacy (e.g., by the creator publicly granting a "license to reverse engineer the code" or simply holding a trade secret

[30] I apologize for not being able to obtain all the information regarding Pactor-4 in such a short period for comments. The point I wish to convey is that that there is a fundamental pillar of the Amateur Service as a public, open, and non-commercial service that has the potential to be violated as a result of the Petitioner's intent.

[31] In other words, there is an ethical danger here: that by allowing "under-published" codes we encourage the reverse engineering of intellectual property through the very act of self-policing. An unscrupulous person could observe a particular code being used in the Amateur Radio Service and then use that as a foil for reverse engineering without the consent of the creator. Surely this is the kind of gray area from which §97.309(a) is supposed to protect everyone.

[32] See 97.113(a)(4).

without explicit legal protection) is likely to never be enough to allow viewing the content of the message.[33] The code by its very nature, unless the algorithms are published with necessary and sufficient detail, creates an expectation of privacy in those who use it. This is, after all, how cryptographic keys work in the first place. *Therefore, requiring publication of the necessary and sufficient technical specifications solves this dilemma in a way that protects both the Amateur Service and the intellectual property holders, both today and in the future.* Again, this principle is already contained in §97.309(a); the Commission only needs to clarify along these lines for the benefit of all parties since it is obviously a point of confusion.

Finally, I do not expect this to be a common situation. Unfortunately it is one that is imminently before us, and as the Commission is no doubt aware by now, one that is causing a tremendous amount of noise that may be distracting from the more noble aspects of the Petition. I believe that most if not all of the declassified MIL-STD and declassified NATO STANAG specifications upon which most are based are sufficiently documented in this regard to be compatible with the spirit of §97.309(a), although I have not done an exhaustive investigation.[34]

IV. Summary and Further Issues

I have demonstrated that the current petition misunderstood the *whole* intention of current limit symbol rate limit: that in conjunction with the requirement for specified codes it provides a guarantee that the content of messages is open and viewable to other amateur operators around

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[33] To put this in perspective, the STANAG 4285 specification would take, on average, seven billion computers (one for each person on earth) on the order of a trillion-trillion-trillion years to find the correct key, assuming each computer could test one possible key per second. Moreover, this assumes that you already know the length of the key!

[34] There is also the further issue that some (by no means all) of the waveforms mentioned in the petition may fall under the technical definition of Direct Sequence Spread Spectrum (DSSS), which under the letter of the current rules is not allowed on the HF frequencies in the current petition. A cursory reading of STANAG 4415 indicates a DS spread waveform that spreads a 75 baud data rate out to about 2.8 KHz with a 2400 base baud rate. It looks like the intent of this spreading is to provide a more robust data transmission through an exceptionally distorted HF channel, but arguably a simple change to the symbol rate rule as proposed would not fulfill the intention of allowing all of the STANAG specifications that the petitioner intends.

the world. This directly bears on the non-commercial nature of the Amateur Service, as well as promotes international goodwill in accordance with the enumerated purposes in §97.1. The proposal to simply replace the current symbol rate limit with a bandwidth limit does not fully fill the vacuum that would be created. While I do agree that it would be wise to allow experimentation with higher-speed serial techniques, it is clear that we have not addressed some very fundamental dangers presented by the technology. These are not insurmountable at all, and I have tried to provide some guidance as to how the vacuum could be filled while accomplishing most of the implied interests represented by the Petition. But the bottom line is this: if the Commission is truly interested in preserving the "public park" and allowing us to be the custodians, the Commission must provide us with clearly defined tools to do so.

At this point it should be fairly clear that the underlying intention in the Petition is not about the occupied bandwidth of individual radio transmissions or experimentation; it is about finding a way to allow higher speed data transmission on HF with a minimal possible fuss. I understand this pragmatism from the point of the Petitioner, although I disagree with it. Unfortunately, the noble quest for deregulation in the public interest is often not best accomplished incrementally, no matter how much we would like to avoid the difficult issues. To be certain there are difficult issues that would be exacerbated by granting the Petitioners request as is, however I think they are best addressed in my reply comments, or directly with the Petitioner for those that may be considered out of scope in the current context. We should remember that the long process in Docket 20777 did eventually accomplish its purpose to the benefit of all, just not by the method originally proposed. Given the Commission's focus not on how Amateur Radio operators communicate but on the appropriate use of the Amateur Service with regards to its balance of purposes, along with the Commission's understandable reluctance

to put the genie back in the bottle once he has been let out, I *strongly* suggest a conservative approach in weighing the current petition. The rule has served us well enough for 33 years; if necessary it can stand a little while longer so that these issues can be addressed properly.

Furthermore, the petitioner's request for a bandwidth limit does not seem unreasonable in my judgment. This can be accomplished without modifying the current symbol rate limit and simply adding the bandwidth cap. That will alleviate one of the Petitioner's concerns regarding equitable sharing of a limited resource. Given that current practice uses occupied bandwidth up to 2200 Hz, we would hinder nobody with this limit and maximize the Petitioner's desire to make room for the ever growing number of people to enjoy the public benefits of the Amateur Service. The rather strange appeal to 2.8 KHz seems to be a based on a limit that was requested by the NTIA when establishing the shared allocation at 5 MHz, as the Amateur Service is effectively reusing its original channel structure and spacing to share the band with incumbent services. It is not representative of amateur practice anywhere else in the HF spectrum. If there is a tangible need for the larger bandwidth limit the Petitioner does not state it directly. It is worth noting that in all these years without an explicit bandwidth limit the self-regulating nature of the Amateur Service seems to have been very effective in keeping actual occupied bandwidth much lower than the requested one. To request something significantly higher seems incongruous with the stated intentions of the Petitioner to allow more people to reap the benefits of the service.

V. A Postscript

I must note that this Petition has generated an inordinate number of frivolous (my judgment, the Commission may make its own) comments that is hindering my ability to cross reference other parties who may have substantive content that is worthy of addressing. I am an

amateur, so to speak, and I do not have a staff to sort through the stack. Given the explosion of nearly 500 comments over the weekend of December 14-15 with similar themes and wording, I was able to find several posts on various sailing-related websites and forums where people were encouraged to comment on the petition to "allow Pactor-4". The authors of the messages appear to be related to organizations separate from the Petitioner, and should the Commission find it pertinent they may follow the references I have provided. [35,36] I do not wish to have this detract from the issues I've discussed, other than to point out that there exist outside special interests that wish to use Amateur Radio as a means for cheaper (and perhaps more private) email. These interests do not represent the Amateur Radio community nor (I presume) the Petitioner. I am in no position to judge the magnitude of this threat, but it should illustrate to the Commission that abuse of the Amateur Radio Service is not merely existential. I can address specific issues directly in my reply comments to other parties, but for the time being I will simply suggest to the Commission that it consider the protection of the Amateur Service that is provided by §97.113(a)(5) and how it may relate to outside interests that would benefit from the current petition if adopted, especially with regard to automated operation which is ostensibly a crucial aspect of the current petition. Again, I *strongly* suggest a conservative approach to this petition.

VI. Commenter's Background

I currently hold the FCC issued Amateur Radio license K0SM and have been an FCC licensed radio amateur for 22 years. I am a member of the American Radio Relay League (the Petitioner). I hold a BA in Music from Carleton College, MN (2002) and a PhD in Music

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[35] See http://www.cruisersforum.com/forums/f13/support-pactor-4-act-quickly-116927.html (retrieved 16 December 2013). Particularly troublesome is the intention to pass the message on to "parties who may no longer be using Winlink". The implication here is that some sailors have chosen other more appropriate services (Part 80, satellite, etc.). The date of the posting is December 12.

[36] See http://www.sailnet.com/forums/general-discussion-sailing-related/111746-us-citizens-urged-support-fcc-rm-11708-a.html (retrieved 16 December 2013). Note the appeal to "make Pactor 4 available to cruisers in the US" and the note that this service directly competes with "SailMail", a Part 80 service that provides email to maritime interests in the Part 80 HF allocations using the same equipment.

Theory from the University of Rochester, NY (2013), where my research involved information theory and models of machine learning applied to music notation. I have published both independently and in ARRL (the Petitioner) publications with regard to bandwidth of digital signals, and in fact have encouraged the manufacturers of amateur radio equipment to implement some of the suggestions (with some success). If the academic credentials come as a surprise to the reader in light of the discussion above, let me humbly suggest that these comments, and even to a large extent the academic credentials themselves, are a testament (imperfect as it is) to the kind of lifelong education that can be provided through twenty-two years in the Amateur Radio Service when its enumerated purposes are pursued *and protected*. Please understand that I have a great debt owed to the opportunities provided to me by the service itself, and I hope that I am acting as a voice for thousands in the next generation, including my own children, who will benefit in the ways that I have.

Respectfully Submitted,

Andrew T. Flowers, PhD
19 December 2013