**Before the**
# FEDERAL COMMUNICATIONS COMMISSION
**Washington, D.C. 20554**

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| **In the Matter of** | ) | |
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| **TECHNOLOGICAL ADVISORY COUNCIL** | ) | **ET Docket No. 16-191** |
| **NOISE FLOOR TECHNICAL INQUIRY** | ) | |
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**To: The TAC Spectrum and Receiver Performance Working Group and The Chief, Office of Engineering and Technology**
**Via: ECFS Electronic Filing**

## COMMENTS OF ARRL, THE NATIONAL ASSOCIATION FOR AMATEUR RADIO

ARRL, the national association for Amateur Radio, formally known as the American Radio Relay League, Incorporated (ARRL), by counsel and pursuant to the *Public Notice* (the Notice), DA 16-676, released June 15, 2016[1], hereby respectfully submits its comments in response to the wide-ranging series of questions asked in the Notice. These questions, and ARRL's responses thereto, are intended to assist the Commission's Technological Advisory Council (TAC) in an investigation of changes and trends to the radio spectrum noise floor; its determination as to whether there is an increasing radio frequency (RF) noise problem; if so, the scope and quantitative evidence of the problem; and finally, how a noise study should be performed by the TAC. For its comments and input to the TAC, and representing the interests of Amateur Radio operators in this critical investigation, ARRL states as follows:

### I. Introduction and Background

1. ARRL is most grateful for the leadership on this issue of Dr. Greg Lapin, ARRL's representative to the TAC and co-chair of the TAC Spectrum and Receiver Performance

[1] See, *Office of Engineering and Technology Announces Technological Advisory Council (TAC) Noise Floor Technical Inquiry*, released June 15, 2016 in the captioned docket proceeding. These comments are timely filed.

Working Group; and of Lynn Claudy, the National Association of Broadcasters' representative to the TAC and the other co-chair of the Spectrum and Receiver Performance working group. Indeed, this effort is both long overdue and yet more timely than ever before, and Dr. Lapin and Mr. Claudy are each eminently qualified to lead this effort. Additionally, it is gratifying that the TAC and the Commission have done a good job of framing the complex conceptual and practical technical issues in the conduct of the study in the list of questions contained in the Notice. ARRL is of the view that licensees in the Amateur Service can provide great assistance to the TAC in the gathering and submission of data from the field in different RF environments. It is important, however, that the data gathering be done in accordance with consistent methodologies.

2. On December 11, 1998, the Commission created the TAC to provide technical advice and to make recommendations on the issues and questions presented to it by the Commission. [2] On May 26, 1999, the Commission *requested that the TAC study the noise floor* and propose new approaches to spectrum management based on emerging and future technologies.[3] In making this request, the Commission noted that electromagnetic noise levels had not been studied for more than twenty years prior thereto.[4] The request also noted that the "commercially viable range of radio frequency devices has significantly expanded" and that, although these devices were previously limited to the 30 MHz to 3 GHz range, "communications now utilize spectrum up to and including the oxygen absorption bands to 70 GHz." FCC staff summarized the importance of the TAC's efforts as follows:

> The regulatory limitations the Commission places on intentional and unintentional emissions are premised on long-standing assumptions about the relevant ambient environmental noise. Given the dated nature of the Commission's knowledge underlying those assumptions, as new and innovative radio communications devices

[2] See TAC Charter (December 11, 1998).
[3] Official Requests from the Commission to the Technological Advisory Council, Memorandum of Requests No.1 (May 26, 1999).
[4] *Id.* at 2.

> emerge it is becoming increasingly important that the Commission base its decisions on a reliable assessment of the noise floor within the United States and its territories. In examining technical limitations, the Commission must determine whether certain restrictive limitations should be relaxed because the incremental noise contribution is insufficient to justify the economic and innovation burdens associated with the restrictions or whether certain limitations should be continued or even increased because the incremental noise increase could impair the efficacy of existing systems. As we head into the next millennium and the Commission grapples with new and innovative communications technologies, it is essential that the Commission better understand the state of the current noise floor, and the impact of radio emissions on the efficacy of telecommunications systems. [5]

In response to the Commission's directive, the TAC concluded that it would be impossible for the Commission to engage in effective spectrum management until it "develop[s] a more complete understanding of the current state of the radio noise environment…[6] Thus, the TAC urged the Commission to immediately undertake a multi-part study of the noise floor that would include a detailed analysis of available noise floor literature, the creation of detailed noise floor models, performance simulations, and verification of the simulations.[7]

3. The TAC cautioned against implementing new spectrum management techniques or services *without first concluding extensive studies of the noise floor*. It stated that there could be:

> …a very serious emerging problem caused by the explosive growth of both intentional and unintentional radio sources. The future could be very different from what we might expect from past experience. The key to getting our hands around this issue will be a good set of models for both intentional and unintentional radiators which can then be used to predict the evolution of the noise background…[8]

Further:

> [W]e could potentially be entering a period of rapid degradation of the noise environment. Such degradation would reduce our ability to meet the communications needs of the country. The principal negative impacts are likely to be reductions in the performance or reliability of wireless systems or increases in their costs.[9]

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[5] *Id*, at 3.
[6] FCC Technological Advisory Council, Second Meeting Report at 1, 9 (Oct. 28, 1999).
[7] FCC Technological Advisory Council II, Second Meeting Report, at 8-9 (Nov. 23, 2001)
[8] FCC Technological Advisory Council, Third Meeting Report, at 1 (Jan. 3, 2000).
[9] FCC Technological Advisory Council, Fourth Meeting Report, at 23 (Annex 4) (Mar. 24,2000).

The TAC later noted that, until noise floor information is organized and analyzed, the Commission will not have a firm basis for deciding whether current noise standards are too tight, too loose, or appropriate.[10] *Yet, sixteen years later, no such study has been conducted*. Now, and for the past several decades, new noise sources are being developed and have been developed and the proliferation of electronic devices continues as fast as the technology and the regulatory processes will allow. Many of these individual sources of RF noise may be consistent with current Commission rules,[11] but in some cases, individually and in the aggregate, they may (and ARRL believes that they do) negatively impact the overall electromagnetic noise environment.[12] Because the Commission's resources are woefully inadequate to address RF noise through widespread enforcement of Part 15 and Part 18 rules governing RF emitters after the devices are deployed, the only reasonable means of dealing with them is to enact and enforce, *ex ante*, appropriate rules for RF emitters that are based on actual knowledge of the noise floor and trends over time. The growing number of interference complaints indicates that any increase in noise levels will result in harmful interference, so these rules may need to require a decrease in the permitted limits for emission to balance the aggregate noise potential of a growing number of noise emitting devices.

4. Subsequent to the TAC's meeting reports and initial advice with respect to noise floor evaluation, a Spectrum Policy Task Force (SPTF) composed of Commission staff members was formed by the Commission "to assist the Commission in identifying and evaluating changes in

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[10] FCC Technological Advisory Council, Sixth Meeting Report, at 9 (Sept. 27, 2000) (discussing Abstract presented by George H. Hagn).

[11] This is not generally true with respect to wide-area noise sources such as overhead power lines, RF lighting devices and other Part 15 or 18 devices. ARRL has repeatedly filed complaints about both the substance of these rule-violative devices and the marketing and sale practices of those who market and sell those devices, where overall compliance is rather low indeed. To date, the Commission has made no mention of nor responded at all to any of these complaints.

[12] FCC Technological Advisory Council, Sixth Meeting Report, at 25 (Sept. 27, 2000) (Annex 4: Abstract of Hagn talk).

spectrum policy that will increase the public benefits derived from the use of radio spectrum." [13] On November 7, 2002, the SPTF issued a Report recommending sweeping changes in the Commission's approach to spectrum management.[14] In particular, the SPTF Report suggested that the Commission adopt a new and untested approach to spectrum management that incorporated an "interference temperature" concept. Basically, the staff proposed to divide each spectrum block horizontally into a licensed portion above a specified signal level and an unlicensed portion below that level. Given the newness of the concept and the dangers of implementing a new scheme of spectrum management, the SPTF identified two prerequisites to the implementation of the interference temperature concept: (1) the compilation of current, comprehensive data regarding the noise floor (including a standard method for measuring the noise floor) and existing spectrum usage; and (2) an evaluation of current and future receiver environments. The SPTF Report, at p.28 stated:

> The Commission could use the interference temperature metric to establish maximum permissible levels of interference, thus characterizing the "worst case" environment in which a receiver would be expected to operate. Different threshold levels could be set for each band, geographic region or service, and these thresholds should be set after the Commission has reviewed the condition of the RF environment in each band. This review should include actual spectrum measurements of the RF noise/interference floor. In addition to obtaining better data regarding the noise floor, the Commission should adopt a standard methodology for measuring the noise floor. Further, the Task Force recommends that the Commission create a public/private partnership for a long-term noise (interference temperature) monitoring network and for the archiving of data, for use by the FCC and the public.

5. On July 7, 2003, the TAC convened a public meeting regarding the measurement and management of spectrum interference.[15] The TAC presentations at that meeting again noted that

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[13] Spectrum Policy Task Force Report, ET Docket No. 02-135 (Nov. 7, 2002) ("SPTF Report").
[14] *Id.*
[15] See, *Technological Advisory Council ("TAC") to Hold Meeting*, Public Notice, DA 03- 1991 (June 17,2003).

there was no then-current data regarding either the noise floor or current spectrum usage.[16] From the foregoing, it is clear that, starting well more than a decade ago, the need for a thorough investigation of the RF noise floor in various environments has been repeatedly acknowledged to be a prerequisite to and a necessary first component of any improved spectrum management plan in a given frequency band. Surprisingly, however, and despite the clear acknowledgement that these studies were necessary, no progress in performing such seems to have been made between May of 1999 and the present time.[17] Yet, the need for a comprehensive evaluation of the ambient noise environment, especially in the medium-frequency (MF), high-frequency (HF), VHF, UHF and low microwave ranges is more compelling all the time.

6. During the Commission's consideration of the concept of "interference temperature" following the 2002 release of the Spectrum Policy Task Force Report, the Commission heard from several commenting parties who noted that the interference environment in which a receiver operates can be highly variable and its characteristics may often be strongly service-related. That environment should first be identified and characterized to allow, at least in principle, the development of emission criteria that provide for quantitative comparisons of receiver performance. The argument was that the Commission cannot begin a realistic evaluation of the benefits of receiver standards until noise floor studies are completed, and any such evaluation should include an analysis of the noise floor in various environments (i.e., discrete bands of spectrum in varied geographical areas, including urban, suburban, exurban and rural areas) with respect to different services and different technologies.

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[16] TAC, Measurement Technology and Issues, presentation by Robert J. Matheson, NTIA/ITS (July 7, 2003).

[17] Such was not the case earlier. CCIR conducted a major survey of business, residential and rural man-made noise levels in the Continental United States between 1966 and 1971. This study formed the basis of the CCIR model for man-made noise (CCIR Report 258-5). In 1993, measurements of man-made noise levels were made in business areas of Montreal and Ottawa and in residential Ottawa. The results of those measurements tended to show a decrease in noise levels, caused in part by the localized practice of using buried powerlines rather than overhead powerlines.

7. In summary, it is surprising that, despite repeated expressions of strong agreement among spectrum management professionals and eminent technicians that RF noise studies are critical to any progressive spectrum management program, no such noise studies have been commenced. Instead, the Commission has since 1999 skipped the urgent step of evaluating the RF environment before repeatedly and constantly making allocation decisions. This, to ARRL, puts the cart squarely before the horse. In ARRL's view, an RF noise study is a necessary prerequisite to any spectrum allocation decisionmaking going forward (especially in making any provision for unlicensed broadband services); and the study should include actual spectrum measurements of the RF noise/interference floor. In order to obtain quantitative data regarding the noise floor in various environments and trends over time, the TAC should adopt a standard methodology for measuring the noise floor. Further, as was urged more than a decade ago, there should be created a public/private partnership for a long-term noise monitoring network and for the archiving of data, for use by the Commission, NTIA and the public, to facilitate next-generation spectrum management. The Amateur Radio Service provides a fertile ground for high-quality data gathering and measurements in all types of environments.

## II. Methodology of the TAC Noise Study and Determination of Trends in the Radio Spectrum Noise Floor

8. The Notice, at page 2, asks a series of specific questions related to the conceptualization and methodology of the TAC noise study. ARRL's input with respect to these questions follows. First of all, it is beyond question that there is a generalized noise problem (considered from the perspective of the Amateur Radio Service, which has relatively small allocations throughout the radio spectrum). There is ample evidence of this as is discussed

below.[18] However, the Amateur Service is, due to the regulatory structure of the Service, more flexible, adaptable and able to be more innovative in many respects in dealing with the increasing ambient noise issues than are most other radio services. This is due to the general absence in the Amateur Service of specific frequency or channel assignments; the ability of Amateurs to utilize a plethora of different frequency bands and emission types; and the technical ability of radio Amateurs to use filters, directional antennas and other noise mitigation techniques in order to minimize the effects of radio noise to a greater extent than can other radio services. Although these mitigation techniques have their limitations, they do allow Amateur Service licensees to make more productive use of spectrum that is subject to noise issues than can some other radio services. At the same time however, Amateur Service receivers in the MF, HF and VHF bands and especially in the microwave region are extremely sensitive and are in some respects far more susceptible to ambient noise than are receivers in other services. Worse, they are geographically proximate to noise from power lines and from large numbers of residential and commercial consumer devices. These factors, in a residential RF environment, make the effects of aggregate RF noise extremely disruptive to normal Amateur Radio experimentation, emergency preparedness exercises and public service communications.

9. The Commission has stated very recently its assumption (which in ARRL's extensive anecdotal experience with communications in the MF range has proven correct) that there exists an increasing noise floor in the AM broadcast band between 530 kHz and 1705 kHz.[19] Docket 13-249 is an ongoing proceeding intended to help revitalize the AM Broadcast Service through

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[18] ARRL and the Commission receive radio-interference reports on a daily basis. The vast majority of these involve some form of man-made noise. Although there are natural sources of radio noise, these sources tend to be more sporadic in nature, and radio communications is almost always possible even in conditions in which significant natural noise is present.

[19] The Amateur MF allocation at 1800-2000 kHz exhibits the same characteristics as does the AM broadcast band.

various regulatory reforms.[20] The Commission acknowledged in the 2013 *Notice of Proposed Rule Making*[21] in that proceeding that the high noise levels in the AM band are expected to increase further with the increases in the number of electronic products (and given the aging infrastructure in incidental radiators such as power lines). However, in the AM improvement proceeding, the Commission seemed to accept as a "given" that the unquantified ambient noise levels in the AM broadcast band (and therefore in the remainder of the MF and HF spectrum as well) would continue to increase; and that the effects of a deteriorating RF environment in the MF and HF range is something to be responded to on a regulatory basis *without addressing the noise environment itself*. In its October 21, 2015 *Report and Order* in the proceeding, there was a reference to the Commission's proposal to change nighttime and critical hours protection for Class A AM stations. The argument from commenters was that they could provide better service, with more power to "*overcome the local noise floor*," if the protection requirements for Class A stations were relaxed. There was no discussion in that docket, either in filed comments or by the Commission, of the possibility of reducing the noise floor. Relative to this, the Commission stated that: "[i]n this proceeding, spectrum scarcity is not the problem as much as is the need for existing AM stations to overcome *an increasing noise floor* that inhibits local service, both day and night." The discussion was limited to power increases and reduction of protection criteria, rather than the commencement of a discussion about quantifiable reduction of the noise floor. With respect to nighttime root-sum-square (RSS) methodology for AM interference calculations, the Commission said that some commenters urged a return to the 50 percent exclusion method used prior to 1991, which considered only the skywave contributions to RSS calculations of co-

[20] See the *First Report and Order, Further Notice of Proposed Rule Making, and Notice of Inquiry* FCC 15-142, 30 FCC Rcd 12145, released October 23, 2015; 81 Fed. Reg. 2818 *et seq*. The proceeding is still open.

[21] *Revitalization of the AM Radio Service*, Notice of Proposed Rule Making, 28 FCC Rcd 15221 (2013).

channel stations, on the theory that it would enable AM broadcasters to improve their facilities and signals and thus *overcome the "increasing noise floor."*

10. So, there is most certainly a noise floor problem. The magnitude of this problem and the extent of it in the 21st Century is virtually unknown, however, and clearly it will vary according to geographic area, frequency range, and radio service affected. So, the need for this study is most urgent at the present time.[22] The expected major sources of noise that are of concern to radio Amateurs are principally overhead power lines; incidental emitters generally, and especially the growing number of switching-mode power supplies, pulsed DC motors, RF lighting devices, battery chargers, solar power systems, and plasma television receivers. Many devices generate noise that is ultimately radiated, although Commission regulations also address the amount of noise that is conducted onto the AC mains. Although radiation from the AC mains wiring is the mechanism by which most interference is propagated, it is possible for conducted signals to directly impact other equipment also plugged into the AC mains.

11. The Commission's rules classify emitters of noise under several broad categories: intentional emitters, unintentional emitters (including carrier-current devices) and incidental emitters. The majority of noise sources involved in interference problems and complaints are either incidental emitters or unintentional emitters. Traditionally, incidental emitters have included power-line wiring and motors, for example. Although defects in the power-distribution system (and to some extent the power-transmission system) continue to be a major source of

[22] The Commission cannot rely on the presence or absence interference complaints as a metric for determining or evaluating the extent of the problem of an increasing noise floor. Non-technical members of the public, such as AM Broadcast listeners, do not complain about interference due to high noise levels. Instead, they simply abandon the medium. Mobile broadband consumers will change geographical location if communications fail in a given area due to RF noise levels. They don't translate to complaints generally. Technically inclined persons such as radio Amateurs and broadcast engineers are more likely to submit interference complaints to the Commission, but the Commission's online complaint filing system candidly informs complainants in most cases that the Commission will not address individual complaints due to resource limitations. Because there is in effect no post-hoc remedy for noise based interference, the complaints, whether or not based on noise floor, diminish over time and are anecdotal in any case.

noise and interference, changes in technology have resulted in many devices that used to be low-noise incidental emitters, such as motors and incandescent lighting devices now being considered unintentional emitters, such as pulse-width-controlled motors and LED light bulbs. Unintentional emitters are also a major source of man-made noise. The inefficient analog power supplies of days past have been almost universally replaced with more energy-efficient switch-mode power supplies, creating a noise potential that did not exist heretofore. These devices are regulated by Commission rules which set limits on conducted and radiated emissions.[23]

12. The Notice was seemingly nonspecific relative to intentional emitters, although these have also been a source of noise for licensed radio services. Higher-powered intentional emitters are permitted in many of the Part 18 Industrial, Scientific and Medical (ISM) bands, along with licensed radio services. Although licensed services are not protected from interference from ISM devices using these ISM bands, Part 15 intentional emitters can be and frequently are a source of interference to licensed users. Even among unlicensed users, the presence of other unlicensed users is very much a factor in the design of reliable systems. Thus, the presence of all types of signals in any particular band or band segment should be included in the evaluation of the presence of intentional emitters and in the calculation of the noise floor.

13. As to the question which services and products are most significantly affected by ambient RF noise at the present time, ARRL can speak with authority only to the Amateur Radio Service. Over decades of time, ARRL has received a large number of reports of interference to Amateur Radio from a variety of noise sources. ARRL also has received reports of strong interference to the AM broadcast band, and some interference reports involving non-Amateur VHF and UHF spectrum. So in ARRL's experience, the services most significantly affected by

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[23] In ARRL's experience, a number of switching-type devices which do not meet those limits are currently being marketed with little or no regulatory oversight.

ambient RF noise are the Amateur Radio Service; the AM Broadcast Service (and to perhaps a lesser extent the FM and Television Broadcast services); reception in the United States of international broadcast stations; cellular telephones; and individual RF devices such as electronic key fobs, the operation of which can be compromised or prevented by high levels of unwanted noise. There is conducted powerline noise that affects wireline telephone and cable service as well.

14. The Notice asks, if there is determined to be a noise problem created by incidental radiators, what sorts of government, industry and civil society efforts might be brought to bear to ameliorate the noise they produce. Answers to this open-ended question are likely to be somewhat radio service-specific. However, in every case, some level of enforcement is necessary prior to the point of sale of consumer or industrial devices, and at the utility level in power line cases, in order to create a deterrence effect. The Commission has failed to assess visible, timely and meaningful sanctions in cases that can't be resolved cooperatively. These include, for example, dozens of cases involving non-compliant and uncooperative power line noise contributors. ARRL's laboratory staff have worked with Commission staff for many years in an informal relationship of referrals for the purpose of cooperatively and informally resolving power line and other interference cases involving Amateur Radio operators. ARRL, upon referral by Commission staff, does field investigations and uses technically competent professionals to address some cases of severe power line interference to radio Amateurs, and in other cases consults with more technically advanced Amateur licensees to help them identify and resolve power line noise quickly and amicably. Ideally, this is done cooperatively with the power utility. If, however, the power utility is unresponsive, or if (as is often the case) the utility lacks technical staff or consultants capable of remedying the ascertained interference caused by the

subject power line(s) and is unwilling to retain such, then ARRL staff provides a briefing with its findings to the Commission Enforcement Bureau staff. It is at this point that the process has in the past broken down. There have never, in ARRL's experience, been any meaningful sanctions brought by the Commission against even the most recalcitrant power utility, regardless of the severity of the interference problem.[24] As such, open cases have existed in ARRL's and the Commission's Spectrum Enforcement Division files for up to a dozen years in some cases without any remedial action. These kinds of festering, unresolved interference problems and the virtual absence of the allocation of any Commission enforcement resources to egregious power line and other major Part 15 interference cases bode ill for control of ambient noise levels in urban and suburban areas. The deterioration of overhead power lines, and the current proliferation of municipal installations of LED lighting systems with streetlights and traffic lights along and on public rights-of-way stand to substantially increase the levels of RF noise in these environments in the near term. No enforcement coupled with no educational outreach to users and consumers, be they municipal governments, utilities, individuals or other entities is an abandonment of the Commission's mandate.

15. Notwithstanding the foregoing, there is some visible progress that has resulted from the informal ARRL/FCC staff understanding (discussed above) with respect to noise-related interference cases. ARRL has willingly participated in this cooperative effort whereby ARRL laboratory staff does "triage" in interference cases. The important factor in the success of this effort is the accurate identification of the correct interference source and the effort to cooperatively and quickly resolve the interference problem directly with the involved operator of

[24] This is not to say that there is nothing being done at all. ARRL is quite pleased with the fact that Commission Enforcement Bureau staff issues Letters of Inquiry to power companies. However, followups to those letters with field investigations and sanctions where called for are effectively non-existent.

the noise source without involving the Commission.[25] This program could be improved and expanded to other industry groups representing noise interference victim radio services and a willingness on the part of the Commission to take action where the cooperative effort fails. Key to any such program is effective, timely and visible enforcement of rules when unresolved interference is not addressed by the responsible operator of the offending device, system or noise contributor. After efforts that may involve hundreds of hours of ARRL and Commission staff time, it is critical that visible, timely and appropriate enforcement measures be taken in at least a few cases, not only to resolve the most difficult compliance cases but to provide a deterrence effect that will encourage voluntary compliance by other Part 15 users. The Commission and the TAC should engage industry groups to join and duplicate these types of cooperative programs, and ask the manufacturers of Part 15 devices and systems to proactively work with users of radio spectrum to cooperatively identify noise sources and to take appropriate remedial actions where needed.

16. As to the government actions that might be appropriate with respect to incidental radiators, the rules, generally speaking, are adequate as they are currently stated. This is primarily because in addition to emissions limits, the rules require that any harmful interference

[25] As but one example of the value of this program, in May of this year, the ARRL Laboratory received a phone call from an Evanston, IL police officer. Though not Amateur Radio related, the police officer had contacted the Commission asking for help with a public safety issue, but the Chicago FCC Field Office did not resolve the problem. The officer reported that a particular neighborhood in Evanston experienced non-functioning key fobs, cell phones, and similar devices. People had been unable to open doors, start their cars or use their cell phones in this area. An ARRL representative in Chicago investigated on site. This confirmed that wireless automobile key fobs would not allow owners to open their vehicles, or in the case of some expensive cars, owners could not start their cars until they were towed to a point a block away. Also it was reported that the vehicle owners were not able to use their cellphones to summon help when this occurred. The Evanston PD's request for help from FCC triggered the response that this was a car maker's problem and not something that the Commission would investigate. Using a Radar Engineers-240A Noise Signature Receiver and UHF Yagi antenna to survey the affected city block in frequency ranges used by key fobs, a survey was taken along the sidewalks of the block. The interference source at the center of the block was identified as a neon sign transformer replacement power supply. It created a very significant radiated signal throughout a city block. This situation demonstrates the electromagnetic compatibility problems that are evolving due to a plethora of non-compliant imported unintentional RF emitting devices.

that occurs be addressed by the operator of the device causing interference. However, municipalities are now purchasing RF lighting devices as mentioned above, most undoubtedly completely unaware of the interference potential of LED lighting devices that might be deployed ubiquitously throughout municipalities and creating grids of high noise levels, completely unaware of the Section 15.5 rule calling for the operator of an interference-causing RF device to cease operating the device if interference to authorized services develops. Additional public notices and a few well-placed, well-publicized and timely enforcement actions in egregious cases[26] will create some needed deterrence to the marketing and sale of non-compliant, unlicensed RF devices. Industry contributions to the management of RF noise are ongoing. For example, IEEE has under development a recommended practices and procedures standard for power line interference resolution. The Commission should encourage power companies to use that standard in maintaining their overhead power lines and the standard could be incorporated by reference in the Commission's Part 15 rules when available.

17. Question 2 of the Notice asks where, spectrally, spatially and temporally the noise problem exists. For incidental and unintentional emitters, noise is typically stronger at lower frequencies. At HF, for example, noise from motors, power lines, switching power supplies and video terminals is generally much stronger on the lower part of the spectrum. This significantly impacts the AM broadcast band, as well as MF and HF Amateur allocations. ARRL has also received reports of interference to VHF and UHF spectrum from incidental emitters such as power lines and unintentional emitters such as LED bulbs and LED billboards. There are strong enough radiated RF emissions from incidental radiators to cause interference in the VHF, UHF

[26] It is notable that there has not been even one Notice of Apparent Liability issued with respect to interference from incidental or unintentional radiators, notwithstanding the presence of long-pending (i.e. more than a decade in some cases) complaints and well-documented cases. On information and belief, the former Washington state field office had prepared a Notice of Apparent Liability recently in a fully investigated case involving deployment of an RF lighting device, but the Enforcement Bureau in Washington inexplicably refused to issue it.

and microwave bands to Amateur Service stations and other licensed radio services in most environments, where weak-signal detection can be negatively impacted to the point of preclusion.

18. Spatially, noise is present in indoor and outdoor environments. Each environment has its own set of sources and problems. Indoors, the biggest factor in the impact of man-made noise is the physical proximity of noise sources and affected victim devices.[27] This is true in the Amateur Radio Service where, for a number of reasons (including but not limited to overly restrictive land use regulations), licensees must attempt to use indoor antennas, primarily for communications in HF and VHF allocations. But the proximity of indoor noise sources can and does impact broadcast radio reception, over-the-air television, and the use of other wireless devices such as mobile broadband, WiFi and even wireless door locks and vehicle starters. The case referenced hereinabove at footnote 25 in which noise from a neon sign was causing interference to vehicle door locks and the ability to start vehicles that were parked in the parking lot of the business running the sign is instructive. Similar interference instances to Amateur stations from consumer electronics in homes, from both indoor and outdoor sources, occur all the time. Outdoors, AM broadcast reception and Amateur Radio mobile operation is hampered, if not precluded in many cases by overhead power lines which radiate along miles of roadways parallel to vehicular travel and by RF lighting devices including the now-proliferating "grow lights" which cause high levels of RF noise at MF and HF throughout entire residential communities.[28]

[27] A single RF lighting device in a residential area can cause interference at distances from the emitter up to 500 feet or more, based on investigations by ARRL Laboratory staff.

[28] ARRL has measured the interference contours of "grow lights", commonly imported from China and other offshore manufacturing sites, at up to a mile radius from a single emitter in a single residence. ARRL has, as noted above, filed a series of complaints concerning these devices which the Commission has thus far, in over a year, failed to adjudicate.

19. Urban environments, where there are large numbers of devices with radiated or conducted emissions and lower desired-to-undesired signal ratios pose a compellingly adverse problem with RF noise. Amateur Radio stations are most often located in suburban areas where this problem is similar.[29] It is noted that in past evaluations of man-made noise, different types of environments were considered. For example, in Recommendation ITU-R P.372-8 (most recent version 2015), radio noise was evaluated and quantified in business, residential, rural, quiet rural and Galactic noise only environments. It is important to have meaningful correlations between quantitative measurements of ambient noise and the geographic environment where those measurements are taken.[30]

20. With the proliferation of new types of noisy electronic devices, radio operation in cities has become almost impossible, although cities have never been a pristine radio environment. Rural settings are quieter, of course, simply due to the smaller number and wider physical separation of noise sources. Even in rural settings, though, noise can be significant from power-line sources, from farming equipment and, in areas where greenhouse farming may be ongoing, new types of high-powered lighting controllers are being used. A number of interference reports have been reported to the Commission, and at least one citation has been issued.

[29] The problem of consumer devices interfering with each other is one that is not fully addressed through the rules on limits and device-operator responsibilities. The limits are set rather high by radio protection standards, and although the current limits do a reasonable job of protecting from interference from "the house next door" in a residential area, they do a poor job of protecting against interference within a single residence by devices owned and operated by residents of that home. They are no more effective at protecting against interference in indoor settings like apartment buildings, where all electrical wiring is common, separated electrically only by breaker panels and metering that are not intended to filter noise conducted onto one apartment's wiring from another apartment unit. The wiring and the devices themselves radiate at HF, VHF and above.

[30] In this connection it is noteworthy that routinely, in "big box" stores and chain hardware stores such as WalMart, Home Depot, Lowes and other similar retail outlets, RF lighting devices and other types of RF-generating equipment intended exclusively for deployment in industrial environments is regularly and without any distinction made sold to consumers for use in residential environments. ARRL has filed complaints with the Commission and with the Office of Engineering and Technology about this practice which have gone unadjudicated for well more than a year.

21. The Notice asks where temporally the noise problem exists. At MF and HF, man-made RF noise is known to propagate via skywave. Like desired-signal skywave propagation, the propagation varies between night and day, season of the year, and which part of the current sunspot cycle we are in at a given time. The levels therefore vary greatly. ARRL has received a report of an incident that involved an Amateur who lived in a remote area of New Mexico. This Amateur observed a 10- to 15-dB drop in noise levels on the 7 MHz Amateur band at the exact time a major power blackout occurred in southern California. Clearly, man-made noise is being propagated by skywave, in addition to the presence of a growing number of local sources.

22. The third series of questions in the Notice ask generally about quantitative evidence of the overall increase in the total integrated noise floor across various segments of the radio frequency spectrum. This is the definitive question with respect to man-made noise, and perhaps the most difficult to answer succinctly.[31] Much of the current knowledge of the levels of man-made noise is derived from studies done in the 1970s, and the raw data, test conditions and test methodology from those studies may not be documented anywhere. From all indications, the measurements were made using calibrated receivers and a vertical antenna, in a number of indoor and outdoor environments, in the industrial, urban, rural and remote areas outlined in the published ITU-R Recommendation P.372.[32] There are numerous anecdotal claims that noise levels are rising. It is logical to presume as much, because there are clearly far more numerous potential noise sources now than there were in the 1970s, when the most of the definitive measurements of man-made noise were initially done. The results of these studies, and some subsequent work, was compiled by the ITU-R and published in the P.372 Recommendation.

[31] ARRL receives a steady stream of interference complaints from Amateur Radio operators relating actual incidents of interference from man-made noise emitters, such as RF lighting devices sold at "big box" hardware and home improvement stores. Field investigations of some of these has verified that they are related often to unintentional or incidental emitters.

[32] The most recent version of this document is P.372-12, 07/2015.

P.372 has been revised over the years, as the result of the evaluation of new studies that were not as thorough as some of the work done to support earlier versions. In general terms, these newer studies did not contain sufficient evidence to warrant a significant change in the levels of man-made noise described in the Recommendation, although the frequency range was extended and additional information about atmospheric noise was included.

23. A number of factors could account for this finding. Some types of emitters, such as electric motors, are likely more quiet now than they were in earlier years. More stringent regulations on emissions from various unlicensed devices may have resulted in a quieting of the stronger of the noise generators, and modern motor vehicles do not generally have as much ignition noise or alternator whine as did older cars. The possible decrease in extremely noisy devices may offset a more general increase in the lower levels of noise from a larger number of devices, so the median levels may not have changed significantly. However, until all of the studies are analyzed, no one can say with certainty. With a large number of near-term studies to be conducted and evaluated, this will take time.

24. The change from an old paradigm with a number of strong emitters and a lower general noise floor to a noise environment in which there is more intermediate-level noise, more uniformly spread across spectrum is significant in terms of the impact on radiocommunications. A few strong emitters on a few frequencies may not cause harmful interference at all to some victim receivers, whereas a more broadband noise emitter, even at a lower level, could impact radio significantly. Current regulations and industry standards do not take this into effect, although this is something that needs to be more carefully considered.

25. The Notice asks how the integrated levels of man-made noise may have changed. Older studies looked at median values of man-made noise, but did not analyze the ways in which

it varied by frequency. In many of the older studies, there were few criteria given for the selection of locations to make measurements, and a relatively small number of sample locations for each type of environment were chosen. It is hard to determine after the fact how representational they were of the environments of the time, or to correlate those selections with different permutations that could have been chosen. This makes it difficult to correlate one study to another.

26. To obtain sufficient sensitivity to enable measurements to be made of lower-levels of noise, small calibrated test antennas cannot be used. The measurements that were made were typically done on HF with vertical antennas, and on VHF and above with small Yagi antennas. Although this does allow sensitivity, the actual antenna gain and antenna factor of a vertical antenna will vary with the characteristics of the ground over which it is used, and there is little evidence about how these variations were accounted for in the initial testing. Also, a vertical antenna will have a full response to only vertically polarized signals, further complicating the analysis of actual results.

27. In various studies, different detectors may have been used, and certainly different bandwidths, often requiring corrections for bandwidth, to standardize the measurements against the bandwidths used in various standards. This correction, however, would be different for different types of noise and signals, and there is no easy way to determine just what types of signals were being measured, and thus what correction factors would be appropriate. Other factors can very much impact the levels of man-made noise. These include time-of-day variations; skywave propagation; lighting noise; and variations over the 11-year sunspot cycles. All of the above factors make the correlation between various prior studies rather difficult. ARRL is gathering a bibliography of these studies, [33] from a number of sources, and will begin

[33] A bibliography of studies and papers found to date is attached hereto as ***Exhibit A***.

the process of analyzing results, but that analysis will take some time. ARRL will provide its data and analysis to the TAC, and ARRL will continue to pursue these questions through standards development organizations such as ANSI ASC C63® and the IEEE EMC Society. It is recommended that the TAC utilize the work of these organizations as well.

28. At its EMC Symposium held in August of this year in Ottawa, ON, Canada, at a number of committee meetings, the IEEE EMC Society expressed interest in the Notice and the subject of man-made noise in general. This was discussed in at least three of the EMC Society Technical Committees, and the IEEE recently approved a project to revise IEEE Std. 473, a standard on site surveys which does include test methodology for the measurements of signals and noise at test sites and at locations of equipment. The development of consensus standards may be the most effective and accurate way to resolve questions about what constitutes noise, how it should be measured and how the different test methodologies used over years' time can be correlated to each other. ARRL is a voting member of ANSI ASC C63®. A member of ARRL's staff is also a voting member of the IEEE sponsoring committee on EMC standards as well as a member and the Secretary of the P473 Working Group that is beginning its revisions of Std. 473, so all of these questions are being considered by various groups within the EMC Society. ARRL's delegate is currently discussing these issues with the Chairs of three of the Technical Committees and a number of interested parties. If there is sufficient interest, ARRL expects to propose a new standard on the methods used to measure man-made noise.

29. The Notice asks at what levels the noise floor causes harmful interference to particular radio services. The Amateur Radio Service is expected to operate in a wide range of environments, using a wide range of frequencies, operating modes, and a combination of digitally decoded and human decoded radio techniques. Amateur Radio receivers vary in

sensitivity with different operating modes and emissions. As such, any increase in noise will have a significant impact on radiocommunications. In many cases, radio Amateurs and other HF users are literally listening to signals at the present noise levels, and even a modest increase can eliminate the ability of two stations to communicate on a given circuit. Although Amateur Radio and other spectrum users, generally speaking, have managed to function in the present noise environment, the convention of having spectrum changes result in more than a 1 dB increase in interference is a reasonable standard to continue to apply. (If this convention is applied for a large number of changes, however, each dB decreases communications effectiveness, so this can and will reach a point of completely diminished returns.)

30. Question 4 of the Notice asks how a noise floor study should be performed. There are several major factors that should be studied. The first is how noise varies with time. The prerequisite for this question is to determine whether *man-made* noise levels are changing on a long-term basis. To answer this question in the near term, older noise studies will need to be analyzed as best as can be done, and new studies will need to be performed over a period of years, including over an entire 11-year sunspot cycle.

31. The focus of the noise study should be an accurate determination of what noise levels exist in as wide a range of indoor and outdoor environments as possible. It should, to the extent possible, determine what types of noise are being found: broadband, non-specific noise; broad noise spectral peaks; broadband digital noise; and noise occurring on discrete frequencies.

32. The methods to be used and the measurement of noise is another key question. Historically, quasi-peak measurements of noise have been done. A quasi-peak detector was originally chosen, with time constants selected to be a reasonable match to a human ear's perception of pulse noise to an amplitude-modulated signal. Although this test method should be

retained in order to maintain correlation with historical data, the Commission and the telecommunications industry should reevaluate the usefulness of a quasi-peak measurement. Most radio communication today is not full-carrier, double-sideband amplitude modulation, so the initial reasons for the limiting the choice of detector no longer exist. FM signals are more immune to impulse noise. For digital signals, with respect to the vast majority of modern communications methods, if a digital signal is not error corrected, a single impulse can wipe out bits that will not be recovered. This would indicate that a peak detection method would be more useful. For error-corrected signals, a single impulse would be ignored, so an average power or RMS detection would be more useful. This really needs to be decided by industry consensus, through standardization of methodologies.

33. The question of measurement bandwidth is also key. The CISPR bandwidths used for most EMC measurements are typically wider than the communications channels used by radio services. This usually means that any measurement of "noise" will encompass a number of communications channels that are in use by that service, and so this measurement will often include one or more signals that are not noise at all, but are signals of the desired, licensed radio service. Some noise studies have used narrower measurement bandwidths, but this can only be extrapolated accurately to a wider bandwidth if the nature of the noise signal is known, and steps are taken to exclude intentional, licensed signals from a measurement of noise. Many radios and test instruments today are capable of capturing a large amount of digital data in a real stream of actual signals, so software digital processing techniques may be able to sort out some of these issues. But again, to do so will require consensus on just what needs to be measured and recorded, necessitating consensus standardization.

34. The Notice asks for the spatial and temporal scales at which noise should be

measured. To the extent that data can be evaluated, the more spatial locations, the better. Although a reasonable sample can be developed to measure noise in various environments (such as industrial, residential, etc.) there may be reasons to have a less coarse determination of noise sources. It may be useful to see how noise varies within a neighborhood, for example, or to see how noise varies along power lines.[34] Measuring to a fine spatial scale may allow the average power of noise radiated in a given unit area to be used to perform skywave predictions of noise at HF, to cite another example. So, a combination of sampling of environments, and more rigorous spatial testing to develop data for further analysis could work together to form a complete noise-study program.

35. The Notice asks whether monitoring instrumentation should be capable of determining the directions of the noise sources, and if so, how those data would be used. Although this could be considered to be an ideal capability, the complexities of making such determinations may preclude its use in most noise studies. In general, if a receiver is receiving noise, there is little reason to think that noise from different directions would affect how that receiver performs, unless the orientation of a directional antenna with respect to specific noise sources is known. There could be some value to making some measurements with respect to direction, but mostly to investigate better methods to do this. Direction finding can be a valuable troubleshooting tool to identify a noise source, but that may be a different kind of study.

36. As to an optimal height above ground for measurements, modeling studies performed by ARRL and submitted in various docket proceedings heretofore have shown that noise levels vary significantly with height above ground. This can be important to know because in many radio services, receive antennas are located significantly above ground level, and knowing the

[34] This is a subject about which the Commission has no useful information and, while debating the appropriate rules for broadband over power line systems, nothing more sophisticated than dead reckoning was used to gauge the level of attenuation of power line radiation of PLC signals down the lines.

noise levels at different heights could be important. However, this is simply not practical on a regular basis. Industry standards typically set measurements of emissions at a height of 1 or 2 meters for measurements of signals below 30 MHz and 1 to 4 meters, in one meter steps, for frequencies above that. For a measurement of noise in the field, measurements at practical heights above ground may be the only way that a study can reasonably be conducted. Making measurements by means of existing standards is important, because it is the only accurate way to compare different studies. It should be possible to establish some correlation between low-height measurements and noise levels at greater heights through modeling and/or some spot studies, and that correlation could be used by regulators to set appropriate emissions limits.

37. Measurement uncertainty is an area that has been addressed repeatedly in various industry standards. Although those performing measurements are of course striving for accuracy, there are a number of factors that make it impossible to be perfect in measurements. Typically, in EMC measurements, measurement uncertainties of several dB are typical. It would not be practical to try to calculate or measure measurement uncertainties in all of the measurements to be made of noise. The in-situ environments are not calibrated open-area test sites, so no measurement that will be made is going to predict accurately what the field strength of the signal being measured will be at any other location. Measurements can be made only of the exact location where the test antenna is located. The accuracy will be as good as the measurement uncertainty of the spectrum analyzer or test receiver used, the antenna, and the uncertainties of cabling, connectors, attenuators and other equipment. This is the accuracy that is used for EMC measurements worldwide, and it has been sufficient to create standards, regulations and conforming products. It should be sufficient for the TAC noise study.

38. There are wide differences in the amount of man-made noise in different time,

location and frequency domains, and in order to have firm knowledge of the number of measurements that would be statistically sufficient, one would need to conduct a very large number of measurements in order to ascertain the range of expected data, of possible data and of the number of outlier measurements showing results significantly better or worse than the mean or median values. Other questions that will need to be answered include the problem of non-compliant devices, and how levels of noise that clearly represent a non-compliant device should be considered in evaluating man-made noise. ARRL has found, for example, that many of the high-powered lighting devices being used for indoor horticulture and farming are have conducted emissions that are very far above the permitted levels. Two models measured 58 dB over the Part 18 consumer limits, meaning that one device was making as much noise as 650,000 legal devices[35]. Non-compliant devices will significantly skew any averaged or integrated calculations of man-made noise. They should ideally be excluded, although it is not usually possible or practical to identify a non-compliant device when making field measurements of noise.

39. The Notice asks whether measurements from uncalibrated, or minimally calibrated, devices can be combined. Measurements with calibrated test equipment represent an ideal, although test equipment is usually not as sensitive as real receivers and antennas, so even this has limitations. The 1970s studies, for example, used a vertical antenna for some of the measurements below 30 MHz, with the gain and antenna factors calculated from the theoretical gain of the antenna and typical ground losses. Relatively few organizations, companies or people have the necessary equipment to make calibrated measurements of field strength across a wide frequency range. ARRL has such equipment and is preparing to help with these studies over extended frequency ranges, using calibrated antennas and spectrum analyzers and receivers with

[35] These devices are being marketed for use in residential environments. They are available in various retail outlets that sell products intended for use by the commercial and residential hydroponic or conventional gardener or farmer.

peak, average and quasi-peak detectors. If the bar is set so high that only fully calibrated equipment can be used, there will be in all likelihood a dearth of additional studies done. Although the accuracy is somewhat lower with tests not necessitating calibrated equipment (especially antennas), there is a lot of data that can be gathered if the ability to use peak- or average-detecting spectrum analyzers and actual antennas instead of calibrated one is used in field-strength studies. If one has an analyzer or receiver that can read actual values, rather than just the relative values provided by a receiver S meter, it is possible to make measurements of at least average and/or peak values of noise, if the gain of the receive antenna is used to calculate an antenna factor and the losses of cabling and other accessories that may be in the receive chain can be estimated. At some loss in accuracy, one can make assumptions about bandwidth extrapolation of the measurement receiver to the bandwidths used in CISPR or ANSI C63.4 standard measurements. There are still some caveats with respect to the antenna factor, because the gain of a directive receive antenna may be known, but that gain is correct only for specific azimuth and elevation angles, but the gain of the antenna and resultant antenna factor is a good first-order approximation, and although the actual level of noise may be greater than that measured, it cannot be lower. It is apparent, however, that more data is always useful, and if carefully constructed, "uncalibrated" measurements can be made in a way that can be extrapolated reasonably well to calibrated measurements. It may also be useful to do some spot checking of the accuracy of some of these uncalibrated methods, using calibrated equipment.

40. As to the possibility of "crowd sourcing" a noise study, this is proving to be a valuable and valid engineering technique, if the caveats are identified and there is some oversight over the techniques, the actual measurements and the determination of results. This can be made somewhat more accurate if there is a single procedure published describing what minimum

system and equipment requirements must be met, information about what locations should be used and clear instructions on how to determine antenna gain, losses and how to differentiate between signal and noise. This may be another opportunity for an industry “Recommended Practice” standard. The following is a partial list of factors that may need to be considered: (1) A spectrum analyzer or receiver that provides accurate readings of received signal levels (RSL) must be used. It is not sufficient to use a receiver that provides output only in relative signal strength readings. (2) The bandwidth of the analyzer or receiver must be reasonably known. The manufacturer published data on filter bandwidth would generally be sufficient. Measurements of filter bandwidth could also be made. (3) The ability to make quasi-peak measurements would be best, but average or peak measurements could be useful and subject to at least approximate correlation with quasi-peak values. (4) Antenna gain must be known, as well as other antenna-system losses. (5) The test engineer or technician should be familiar with various noise signals and various desired signals, to be able to differentiate between signals and noise. (6) Standardized reporting should be required.

41. The increasing use of software-defined radios (SDR) could also add significantly to a crowdsourcing effort. Many SDRs report received signal levels quite accurately, and they are now digitizing large swaths of spectrum. There is a large and growing number of SDRs in the hands of experienced Amateur Radio operators, and if a suitable application were written, operators could volunteer their station when it is not being used for other purposes, to allow the collection of a large number of measurements across frequency and time. ARRL is in the process of contacting a few SDR manufacturers, to ask what the feasibility of such a program could be, and to ask what kind of effort and time frame could be used. ARRL may volunteer to be a collection point and analyzer of the resultant data if the TAC finds this option useful. Receiver

noise measurements commonly logged by certain users including Amateur Radio licensees could be made available and would be useful for noise floor studies if the actual RSL is known, as well as the antenna gains and losses.

42. The amount of data that must be collected in order to reach a conclusion will depend on the nature of the data. Noise levels are expected to vary significantly with location, frequency and time, and until the range of possible results is known, and statistical analysis done on actual data, the number of measurements needed to have a desired level of certainty is not known. A better approach could be to keep a running tab on the statistical factors, so that the reliability of measurements can be tracked as they occur. Because measurements must be made in a wide variety of environments, and across an 11-year sunspot cycle to completely assess the impact of propagation on noise levels, the amount of data collected will be huge over time. Clearly, conclusions can be reached at a number of steps in these processes, if the statistical analysis of accuracy is included in the results.

43. Distinguishing noise from signals is complicated. One operator's signal is another operator's noise. A first approximation of this can be made by ear, if the operator is familiar with the sound of various desired signals, most of which is digital in nature. However, there are modulation techniques that result in a desired signal that is very noise like in nature (e.g. spread-spectrum signals) and it may be difficult to always differentiate desired signals from noise. If the purpose of these studies is to determine the levels of man-made noise and how they vary with time, it is important that desired and licensed signals be not mis-measured as noise. This is another area where industry standards could be developed to outline how to make noise studies using calibrated equipment, uncalibrated but accurate receivers and how to analyze data, report data and differentiate noise from desired signals.

44. Noise can be characterized and its source identified, using operators trained in doing so. However, this can often be very time consuming, with a single noise source sometimes taking hours, or even days, to identify. The IEEE EMC Society Standards Development and Education Committee is sponsoring the development of an IEEE Recommended Practice on the resolution of power-line noise complaints (P1897). This standard includes considerable detail on how to identify and locate a noise source. It is expected to be in ballot by the end of 2016 and published sometime in early 2017. For the time being, the TAC should concentrate on actual noise-level studies, relying for the time being on the standardization work that is underway.

45. There is no threshold level, below which measurements should be ignored, although any measurement campaign will have a threshold below which measurements cannot be made. Some of the measurements made will show a very low value of noise, and those should not be ignored, but included in the tabulations so that median and mean values can be determined. It is quite sufficient to report that a particular level was below that noise floor, ie. "Less than -10 dBuV/m", but the results should be included in any noise studies.

## III. Conclusions

46. The TAC and the leadership in this study initiative are to be congratulated for finally undertaking what has been universally determined to be necessary for well more than two decades. The Commission should not have made spectrum management decisions without this noise information and it is unfortunate that the initiative has been delayed this long. ARRL and its members in the Amateur Service are able to be of use in gathering data for the noise study and the urgency of initiating it should be tempered by the prerequisite need to develop a standardized and valid methodology for conducting the study. It is hoped that these comments will provide substantial input into the formulation of the methodology. ARRL should be considered a willing

resource in the TAC effort and we hope to contribute substantially to the effort. We also hope that these comments will serve as a stimulus for the Commission to re-evaluate its "hands-off" policy with respect to the most recalcitrant and unhelpful operators of incidental and unintentional radiators which are causing long-term interference problems, such as electric utilities. The unwillingness of the Commission to issue meaningful sanctions has led to the virtual absence of any incentive to comply with the Commission's Part 15 non-interference obligations.

Therefore, the foregoing considered, ARRL encourages the TAC in its effort and is hopeful that the noise study will provide for the first time a useful, objective basis for spectrum overlays and other allocation decisions in the future.

Respectfully submitted,

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# EXHIBIT A

## Bibliography of Articles Relating to the Description, Impact and Study of Man-Made Noise


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Note: This document is stored at:
https://www.dropbox.com/s/ntm9gro72yycp5a/NoiseStudiesBibliography.html

Table 1: Articles about noise studies and noise data

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