Setting Standards for Excellence

KYLE PITSOR
Vice President, Government Relations

August 11, 2016

Submitted online: http://apps.fcc.gov/ecfs//

Mr. Greg Lapin
Mr. Lynn Claudy
Federal Communications Commission
Technological Advisory Council
445 12th Street, SW
Washington DC 20554

Re: NEMA Comments on FCC Noise Floor Technical Inquiry 16-191

Dear Messrs. Lapin and Claudy,

As the leading trade association representing the manufacturers of electrical and medical imaging equipment, the National Electrical Manufacturers Association (NEMA) provides the attached comments on the FCC Technical Inquiry for Trends in the Radio Spectrum Noise Floor. These comments are submitted on behalf of NEMA Lighting Systems Division member companies.

NEMA founded in 1926 and headquartered in Arlington, Virginia, represents nearly 400 electrical and medical imaging manufacturers. Our combined industries account for more than 350,000 American jobs and more than 6,500 facilities across the U.S. Domestic production exceeds $117 billion per year.

Please find our detailed comments attached. Our Member companies count on your careful consideration and we look forward to an outcome that meets their expectations. If you have any questions on these comments, please contact Alex Boesenberg of NEMA at 703-841-3268 or alex.boesenberg@nema.org.

Sincerely,

Kyle Pitsor

Kyle Pitsor
Vice President, Government Relations

NEMA Comments on FCC Noise Floor Technical Inquiry DA 16-676

1. Is there a noise problem?

This is a controversial question. It seems rational to say that society has never before experienced this level of man-made noise from incidental, intentional, and unintentional radiators. This is derived mostly from the rapid development of the consumer electronics industry (Chandler, Hikino, & Von Nordenflycht, 2009). However, electromagnetic interference design concerns have become a regular quality item for consumer electronic industries. Modern consumer digital electronic devices use less energy to perform similar functions than their analog predecessors, and they tend to be fully covered under federal EMI regulation as digital devices (FCC-47-Part-15, 2009).

Some researchers report concerns of increased noise floor level (Wagstaff & Merricks, 2003); whereas, other research (Achatz & Dalke, 2001), published by the United States Department of Commence (DOC) Assistant Secretary for Communications and Information, reported a decreased noise floor level in residential environments, as well as no noise floor level change for the commercial environment in 25 years (Achatz & Dalke, 2001) (see Figure 1). A research study to identify if a noise problem exists seems to be a reasonable approach. Given this contradiction, it is important that a research study be implemented to identify if a noise floor increase has occurred and, if so, what the magnitude is for different environments and frequency ranges.

5. CONCLUSIONS

Man-made, non-Gaussian noise was observable in all 137.5 MHz and 402.5 MHz business and residential measurements. It was also found at 761.0 MHz in business measurements but absent, for all practical purposes, at 761.0 MHz in residential measurements. VHF measurements were found to be consistent with previous measurements [4]. As in the previous study, 137.5 MHz residential F_{am} seems to have decreased from levels measured 25-30 years ago, while 137.5 MHz business F_{am} has remained constant.

Figure 1. Screenshot showing DOC research first conclusion.

Note: Achatz, R., & Dalke, R. (2001). Man-made noise power measurements at VHF and UHF frequencies. NTIA Report 02-390. In N. Assistant Secretary for Communications and Information. Victory (Ed.): United States of America Department of Commerce. Achatz & Dalke

DOC research findings (Achatz & Dalke, 2001) were consistent with Hagn, Lauber & Bertrand's measurements and models for the United States commercial and residential environments (Hagn, 1987; Lauber & Bertrand, 1984). Concurrently with the DOC research findings from 2001, a United States noise floor model can be drafted using the traditional noise floor modeling for the 100 KHz to the 200 MHz range(ITU_R_P372_12, 2015), and the Hagn model from 200 MHz to 1 GHz (Hagn, 1987).

1.a. What are the expected major sources of noise that are a concern?

According to Wagstaff & Merricks, man-made noise in the 40 MHz to 3 GHz region may be produced by a wide variety of equipment (Wagstaff & Merricks, 2003). These encompass: electric motors, car ignition systems, neon lights and others. Achatz & Dalke added power distribution and transmission, industrial equipment, consumer products, and lighting systems (Achatz & Dalke, 2001). The ITU report concurs with both of them (ITU_R_P372_12, 2015).

1.b. What services are being most impacted by rising spectrum noise floor?

According to Wagstaff and Merricks, sservices that may be impacted by an increased noise floor are primarily AM/FM radio, and analog TV (Wagstaff & Merricks, 2003). We note that since this study was completed, analog TV services have ceased.

1.c. If incidental radiators are a concern, what sort of government, industry and civil society efforts might be appropriate to ameliorate the noise they produce?

The government could contribute with basic research to understand the phenomena better and with focused research to address specific industry sector concerns. Industry and civil society could engage in training and education for consumers to better understand what man-made noise is, how specific consumer devices mitigate noise, and to further spread best installation practices concurrent with the National Electrical Code.

2. Where does the problem exist?

2.a. Spectrally

Most researches characterize noise floor levels derived from man-made devices in terms of White Gaussian Noise (WGN) and Impulsive Noise (IN), in a range from 100 KHz to 1 GHz (Achatz & Dalke, 2001; Hagn, 1987; Lauber & Bertrand, 1984; Wagstaff & Merricks, 2003).

2.a.i Spectrally, What frequency bands are of the most interest?

Traditional floor noise models used by organizations like ITU from the 1970's characterize noise floor levels in a frequency range from 100 KHz to 1 GHz (ITU_R_P372_12, 2015) (see Figure 2).

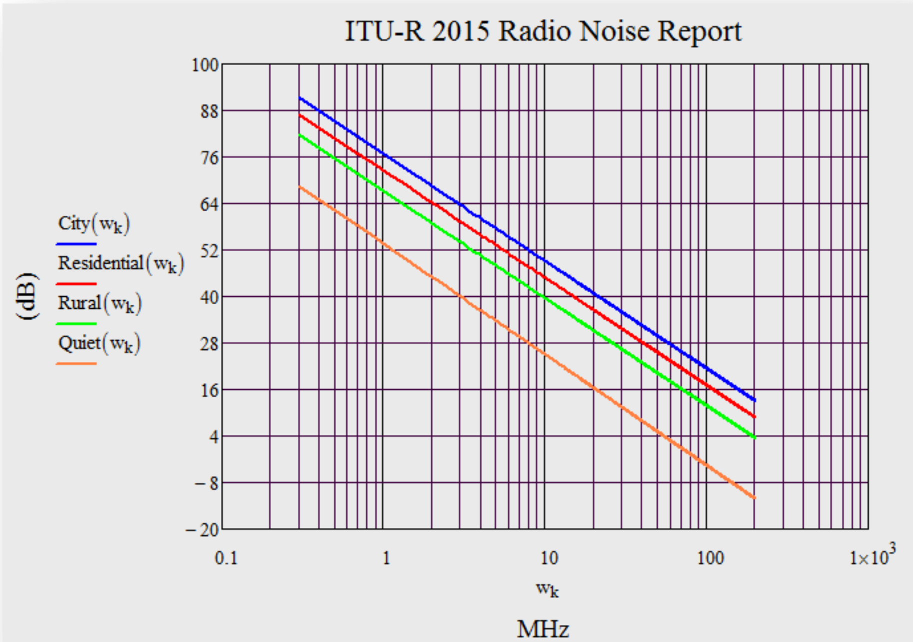

Figure 2. Diagram illustrating noise floor traditional characterization.

Note: adapted from: ITU_R_P372_12. (2015a). Recommendation ITU-R P.372-12 Radio Noise. Geneva: International Telecommunication Union, Radio Communication Sector.

As noted in response to Question 1, the United States Department of Commerce proposed research that would update a noise model to include frequencies up to 1 GHz, characterizing and extended the noise floor level after 200 MHz originally developed by the Hagn model (Hagn, 1987) (see Figure 3).

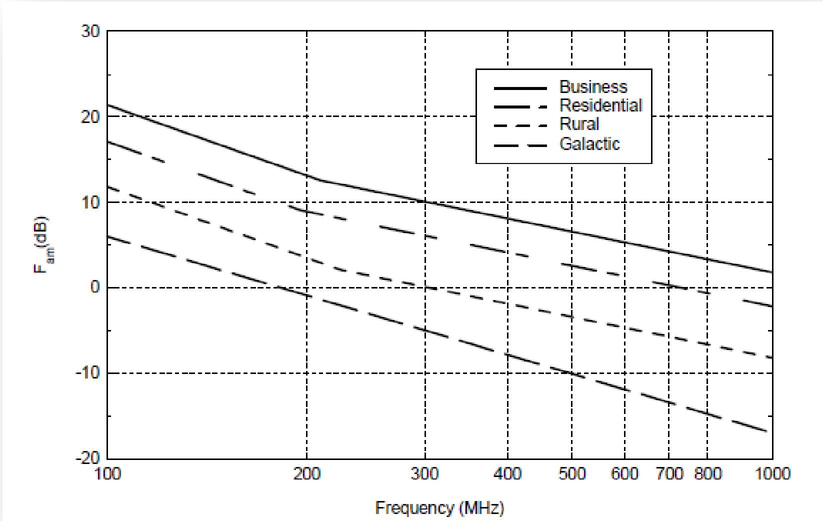

Figure 3.Picture showing DOC extended model.

Note: adapted from: Achatz, R., & Dalke, R. (2001). Man-made noise power measurements at VHF and UHF frequencies. NTIA Report 02-390. In N. Assistant Secretary for Communications and Information. Victory (Ed.): United States of America Department of Commerce.

It is unclear what reporting might be above 1 GHz. The man-made noise level reported in the DOC model for commercial environment is about 2 dB at 1 GHz; whereas, the noise level from the sun is about 25 dB (Wagstaff & Merricks, 2003). Furthermore, the noise level from the sun at 5 GHz is about 19 dB; whereas, man-made noise level models' prediction estimate is less than 1 dB. Thus it seems reasonable to consider a frequency range of interest for a noise floor study between frequencies from 450 KHz to 1 GHz (or higher) as a first approach.

We note that 450 KHz is the AM radio service lowest frequency limit, and man-made noise levels above 1 GHz are lower than those from the sun by a factor of 10 or more.

2.b Spatially

2.b.i Spatially, Indoors vs Outdoors

Most standards and research papers discuss radio emission environments in terms of commercial and residential settings, or consumer and non-consumer environments. The terms 'indoors' or 'outdoors' may be in reference to a commercial space or a residential space. Figure 4 shows the man-made noise expected from the DOC model. The non-consumer data has been labeled "City".

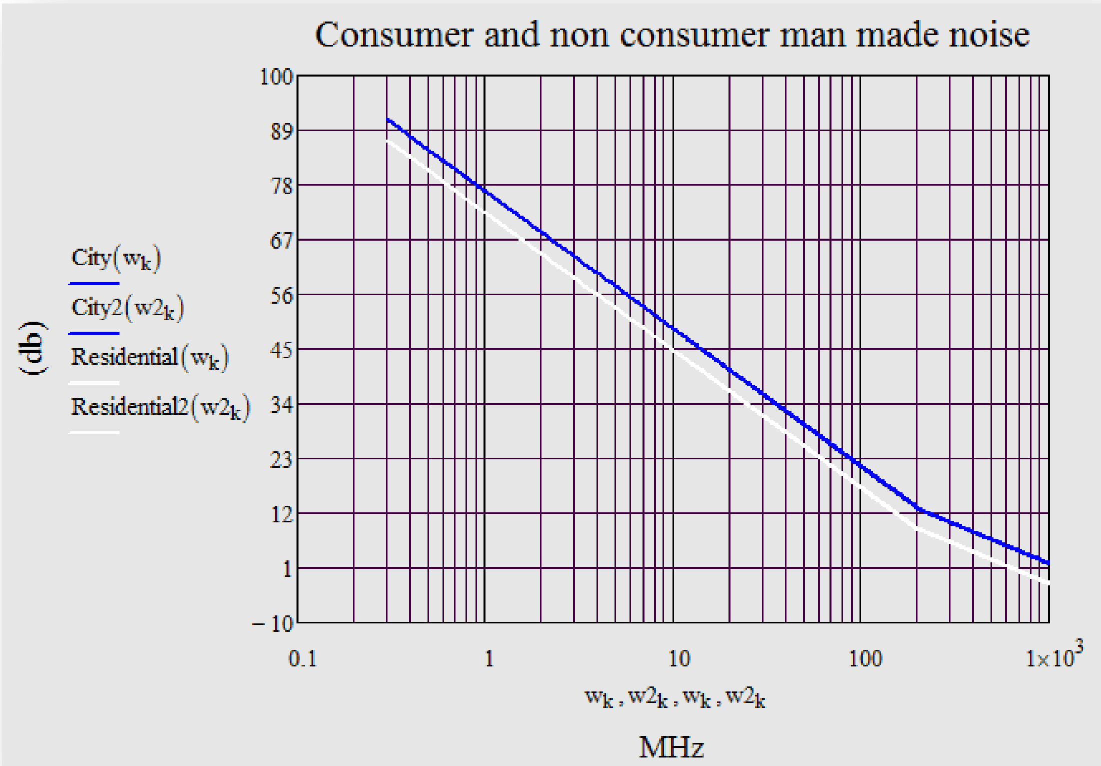

Figure 4. Illustration detailing consumer and non-consumer man-made noise.

Note adapted from: Achatz, R., & Dalke, R. (2001). Man-made noise power measurements at VHF and UHF frequencies. NTIA Report 02-390. In N. Assistant Secretary for Communications and Information. Victory (Ed.): United States of America Department of Commerce.

From figure 4 one can conclude that, according to the United States Department of Commerce proposed model, a man- made noise difference of about 4.3 dB among consumer and non-consumer environments is a rational expectation. This finding does not means that a noise problem exists; rather, it describes a fact that consumer environments are quieter than non-consumer environments.

2.b.ii Spatially, Cities vs rural settings

The ITU report discusses man-made noise level differences among cities and rural settings (ITU_R_P372_12, 2015) (see Figure 2).

2.b.iii Spatially, How close in proximity to incidental radiators or other noise sources?

If one assumes that the potential services that may be affected by an increased noise floor would be radios and TV services, then question 2.b.iii can be rephrased as, “does an interference issue from an increased floor noise exists, given the expected distances between radios and TV receivers to other (digital) consumer electronics? This is a difficult question to answer because all sorts of potential scenarios are possible. One could imagine a consumer placing a small TV set on the top of his microwave oven. Such practice may result in a harmful interference. The problem may be quickly solved by placing the TV set a few feet away from the microwave oven, rather than through more stringent emissions standards. Similarly, AM radio reception will always have additional noise for a consumer living close to a power distribution line.

2.b.iv Spatially, How can natural propagation effects be accounted for in a noise study?

Natural propagation effects may account for multiple phenomena. The ITU report describes considerations to various natural propagation effects (ITU_R_P372_12, 2015).

2.c. Temporally

2.c.i Temporally, Night versus day?

A natural difference between night and day exists. The sun is the major noise contributor for frequencies above 100 MHz (Wagstaff & Merricks, 2003) (see Figure 5).

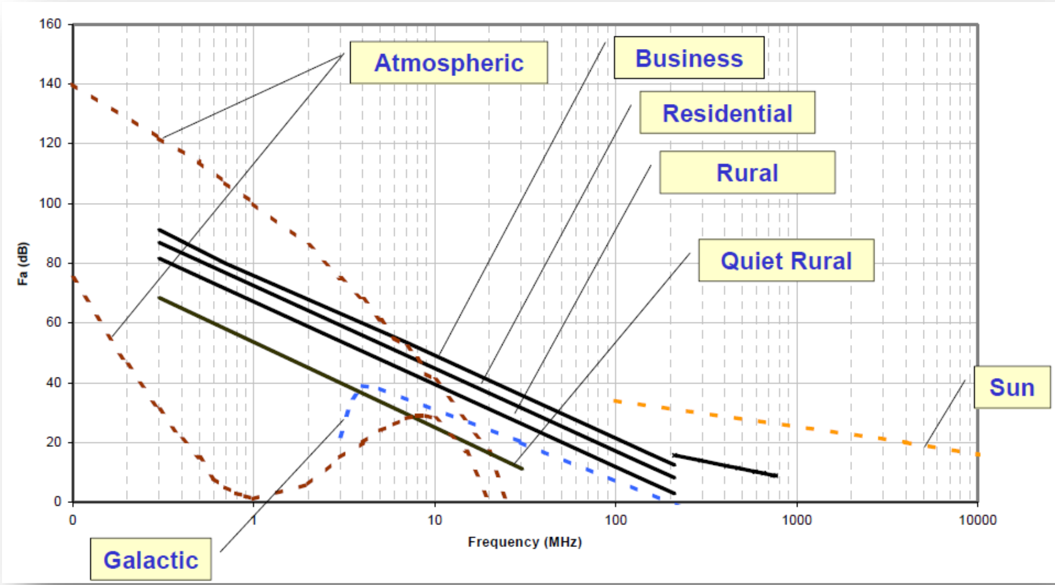

Figure 5. Diagram displaying natural and man-made noise.

Note: adapted from: Wagstaff, A., & Merricks, N. (2003). Man-Made Noise Measurement Programme. Little Paxton, St Neots, Cambs PE19 6EL: Mass Consultants Limited.

Electronic street lighting has begun a significant expansion in recent years; however, these products would need to almost double their man-made noise to raise the noise floor to the same level as the sun's contribution for the same frequency range. It seems rational to expect that radio services operating in these frequencies may experience more difficulty during the daylight hours because of the floor noise contribution from the sun.

2.c.ii Temporally, Seasonally?

We did not find sufficient previous empirical research to discuss this question in detail. It is reasonable to expect that weather change impacts the use of major appliances like heaters, air conditioning, artificial lighting, as well as indoors vs outdoors activities. Further empirical field research would seem necessary.

3. Is there quantitative evidence of the overall increase in the total integrated noise floor across various segments of the radio frequency spectrum?

This is yet another controversial item of discussion. Some researchers found no evidence of a noise floor increase (Achatz & Dalke, 2001); others reported an increased noise floor (Wagstaff & Merricks, 2003). Figure 6 shows the later research findings for non-consumer environments.

The blue line in Figures 6,7,8, and 9 describes the traditional limits from 1970s surveys as reported by the ITU (ITU_R_P372_12, 2015); whereas, the green line describes the Wagstaff & Merricks' surveys in the early 2000s (Wagstaff & Merricks, 2003). The two surveys frequency overlap is limited to a space from 80 MHz to 200 MHz. In this comparison, the noise floor seems to have increased about 15 dB. Clearly though, additional research is required to expand results beyond the narrow overlap region shown.

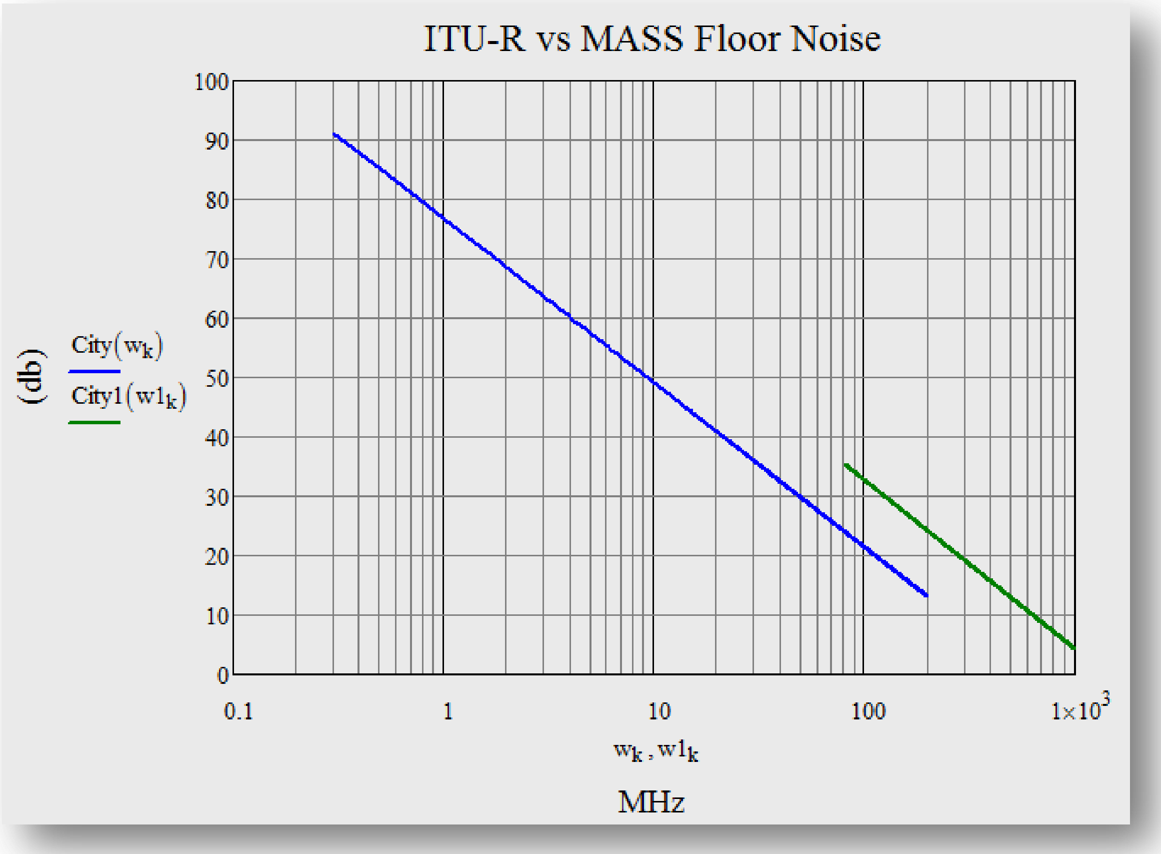

Figure 6. Picture showing non-consumer floor noise. Note: adapted from: Wagstaff, A., & Merricks, N. (2003). Man-Made Noise Measurement Programme. Little Paxton, St Neots, Cambs PE19 6EL: Mass Consultants Limited.

Figure 7 shows the consumer environment survey findings from the same study. Congruently with Achatz & Dalke (Achatz & Dalke, 2001), this research does not lead to a conclusion that a noticeable increase on the consumer noise floor has occurred.

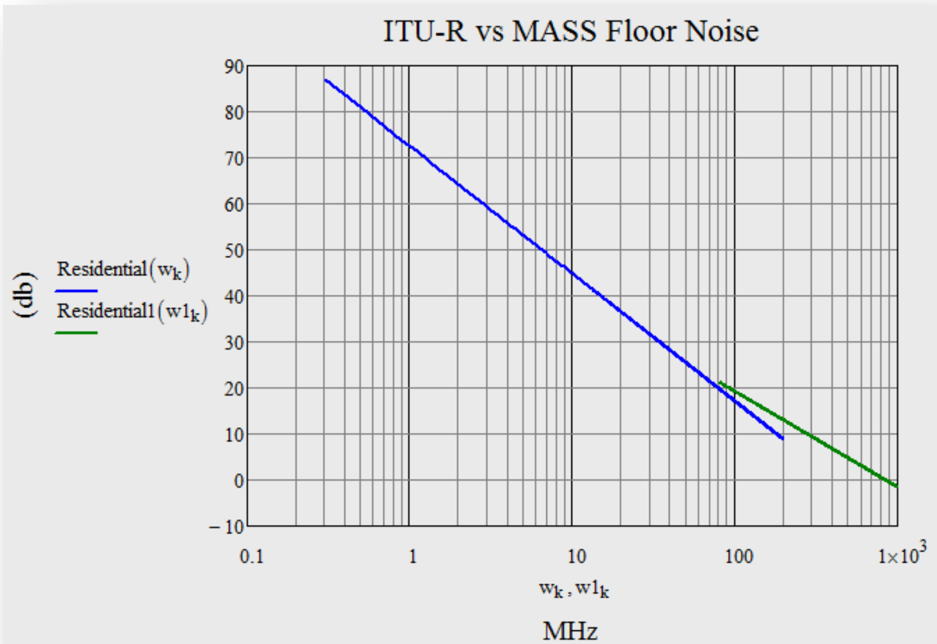

Figure 7. Graphic illustrating consumer floor noise.

Note: adapted from: Wagstaff, A., & Merricks, N. (2003). Man-Made Noise Measurement Programme. Little Paxton, St Neots, Cambs PE19 6EL: Mass Consultants Limited.

The Wagstaff & Merricks' surveys were conducted in the European Union, specifically in the United Kingdom (Wagstaff & Merricks, 2003). *We do not know how this survey may relate to the United States electromagnetic environment because the electrical code and construction practices differ*. However, following is some comparison with the United States Department of Commerce research model (Achatz & Dalke, 2001) with the Wagstaff & Merricks research (see Figure 8).

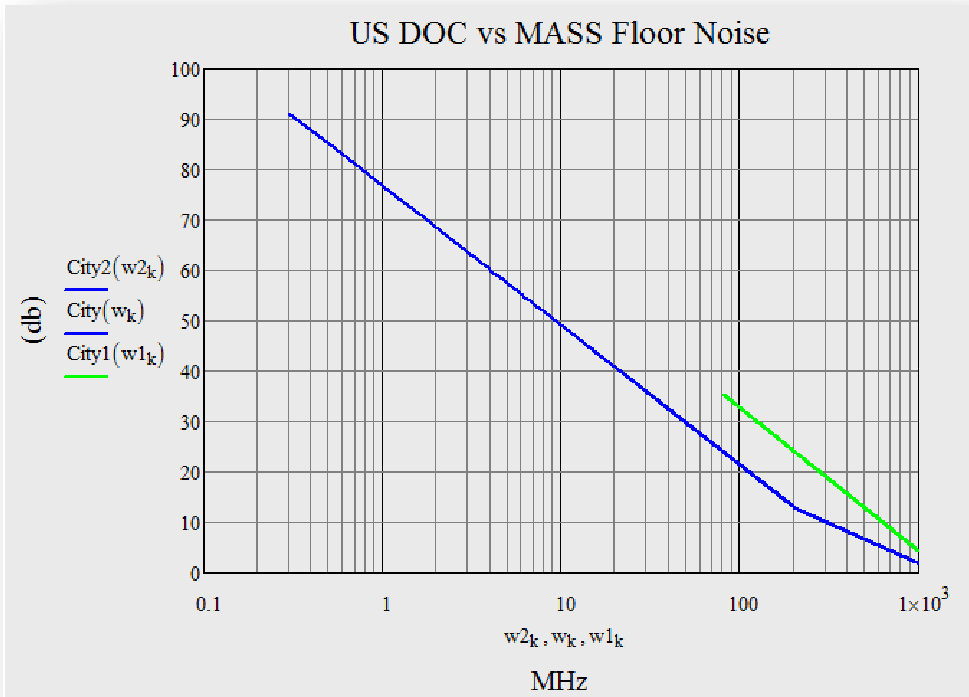

Figure 8. Illustration describing DOC and European non-consumer noise floor models.

Note: this figure was developed by a NEMA member based on original research from Achatz & Dalke (Achatz & Dalke, 2001) and Wagstaff & Merricks (Wagstaff & Merricks, 2003).

The gap between the two models decreases after 200 MHz. This difference becomes almost negligible around 1 GHz. It would be incorrect to directly compare the results of these studies since they are from two unlike geographical areas; the test equipment used was different, the test protocols were dissimilar, and the surveys were created in different years. However, the area that shows the largest gap coincides with the FM radio and old analog TV channels. We could not locate an empirical study that compares the FM radio signal reflection properties among construction materials used in the U.K. and the U.S.

One may conclude that a consistent study with unified variables is necessary to determine the current situation in the U.S.

The consumer environment floor noise reported by the United States Department of Commerce research and the aforementioned European report are quite similar, except for a small gap around 200 MHz (see Figure 9).

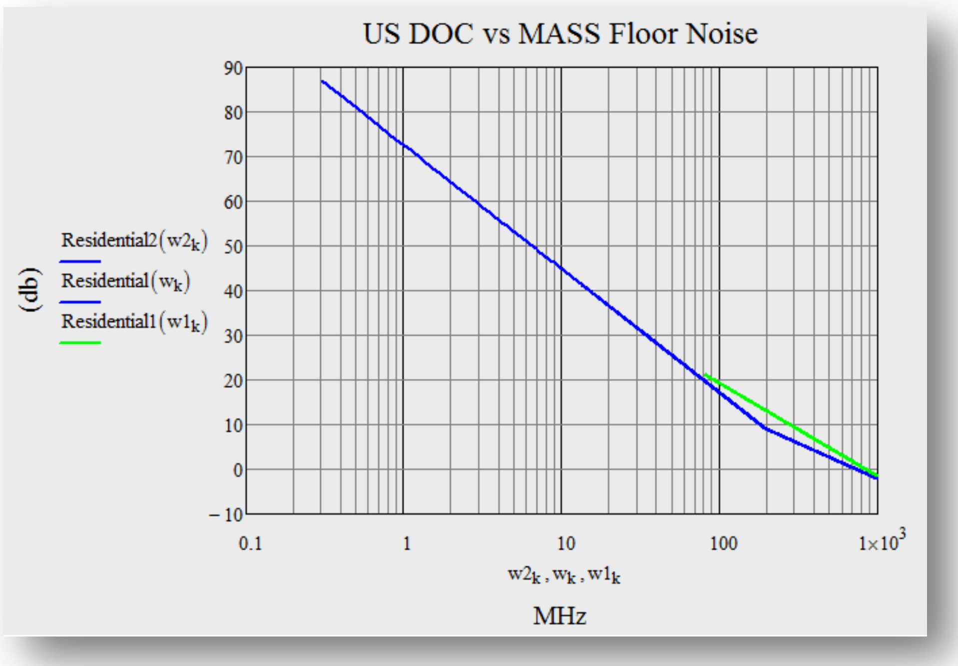

Figure 9. Drawing describing DOC and European consumer noise floor models.

Note: this figure was developed by a NEMA member based on original research from Achatz & Dalke (Achatz & Dalke, 2001) and Wagstaff & Merricks (Wagstaff & Merricks, 2003).

Now that the transition from analog to digital TV services in complete, a new survey of this sector is needed. It may be that the above gap evidenced between the two studies above will become smaller.

3.a. At what levels does the noise floor cause harmful interference to particular radio services?

This is a complicated question which is contingent on specific cases defined by the characteristics and environments of particular radio services. The immunity characteristics of the various radios themselves are also a likely impact factor. A limited man- made noise source may result in harmful interference if it is in direct contact with a radio receiver. However, in general, it seems rational to keep the man-made noise below the sun's noise contribution for frequencies above 100 MHz (see Figure 5).

3.b What RF environment data from the past 20 years is available, showing the contribution of the major sources of noise?

The following list names a few man-made noise reports; some suggest that the floor noise has increased (Wagstaff & Merricks, 2003), while others suggest that the non-consumer floor noise has been kept the same and that the consumer floor noise has decreased (Achatz & Dalke, 2001; Spaulding, 1997).

Other researchers are challenging the traditional average White Gaussian Noise (Fam) metric while supporting the conclusion that the consumer environment noise floor has decreased (Wilbur, 2005). This literature review did not show any empirical test reports, from any United States cities, demonstrating a noise-floor increase.

Table 1

RF Environment Data

Author	Publication
Achatz, R., & Dalke, R. (2001)	Man-made noise power measurements at VHF and UHF frequencies
Hagn, G. (1987)	Man-made radio noise and interference. Paper presented at the AGARD Conference. No 420, Lisbon, Portugal.
ITU_R_P372_12. (2015)	Recommendation ITU-R P.372-12 Radio Noise
Lauber, W., & Bertrand, J. (1984)	Man-made noise level measurements of the UHF radio environment.
Spaulding, A. D. (1997)	The natural and man-made noise environment in personal communications services bands
Wagstaff, A., & Merricks, N. (2003)	Man-Made Noise Measurement Programme
Wilbur, V. (2005)	An examination of man-made radio noise at 37HF receiving sties

Note: complete bibliographical details are provided in the References section.

3.c Please provide reference to scholarly articles and other sources of spectrum noise measurements.

In addition to the research journal papers and research reports described in the previous question response, it seems prudent to consider material from some of the Unites States National Academies committees' reports published by the United States Research council (see Table 2).

Table 2

U.S. National Academies References

Author	Title
Cohen et al. (2010)	Spectrum Management for Science in the 21st Century
Liddle et al. (2011)	Wireless Technology Prospects and Policy Options
DeBoer et al. (2013)	Views of the U.S. NAS and NAE on Agenda Items at the World Radio Communications Conference 2015
Sicker et al. (2015a, 2015b)	Telecommunications Research and Engineering at the Communications Technology Laboratory of the Department of Commerce: Meeting the Nation's Telecommunications Needs

Note:: complete bibliographical details are provided in the references section.

4.- How Should a noise study be performed?

Note:: Items 4.a to 4.h are addressed together in a combined response.

Given the contradictory findings among researchers, and the lack of additional studies in more recent years when connected device use has skyrocketed, we strongly support a new noise floor study. Whereas no U.S. based research shows an increased noise floor, critical changes that may potentially affect the noise floor have occurred; 1) TV broadcasting transformation from analog to digital; 2) Cell phone networks have moved into higher frequencies than those used in the early 2000s; 3) Consumer electronic devices have been digitalized and came under federal regulations (FCC-47-Part-15, 2009); 4) Energy efficiency regulations pushed towards a fraction of the energy usage for the same performance or service; and 5) There was a large scale introduction and adoption of wireless devices. It is possible to argue that all of these changes resulted in an actual reduction of unintentional emissions.

Previous research has expressed man-made noise through two components: White Gaussian Noise (WGN) and Impulsive Noise (IN). A new noise floor study should first focus on considering the advantages and concerns of using traditional metrics such as noise factor.

f_a: the external noise factor defined as:

$$f_a = \frac{p_n}{k\, T_0\, b}$$

NOTE 1 – F_a is the external noise figure defined as:

$$F_a = 10 \log f_a \quad \text{dB}$$

p_n: available noise power from an equivalent lossless antenna

k: Boltzmann's constant = 1.38×10^{-23} J/K

T_0: reference temperature (K) taken as 290 K

b: noise power bandwidth of the receiving system (Hz)

l_c: antenna circuit loss (available input power/available output power)

l_t: transmission line loss (available input power/available output power)

f_r: noise factor of the receiver.

Figure 10. Illustration depicting the noise factor metric.

Note:: adapted from: ITU_R_P372_12. (2015). Recommendation ITU-R P.372-12 Radio Noise. Geneva: International Telecommunication Union, Radio Communication Sector

Congruently, median values of man-made noise are shown below (Achatz & Dalke, 2001; ITU_R_P372_12, 2015).

$$Fam = c - d\log f$$

Note that for man-made noise, the external noise figure is given by various research authors. In this case, external noise figure means the component of the noise which has a

Gaussian distribution. Man-made noise often has an impulsive component and this fact may be important in assessing the effects on performance of some types of radio systems and networks.

The consideration of this metric will benefit from addressing the concerns raised by Wilbur (Wilbur, 2005). It is interesting to notice that he concluded that overhead power lines and their associated hardware were the major noise contributors. Furthermore, Wilbur suggested that the ITU noise model (ITU_R_P372_12, 2015) is not useful in the modern era (Wilbur, 2005). He suggested a new noise model based on the number of overhead power line poles in the line of sight.

It may be that the traditional model based on WGN and IN is still valid; however, a critical review of this metric and its consequent validation is important to decide which noise floor model is the most valid test method to follow. Assuming that a critical review resulted in favor of keeping the traditional metrics, the equipment and test method describe by Achatz & Dalke's research seems to be a reasonable approach (Achatz & Dalke, 2001). The mobility arrangement presented in Wagstaff & Merricks' research is an additional consideration (Wagstaff & Merricks, 2003).

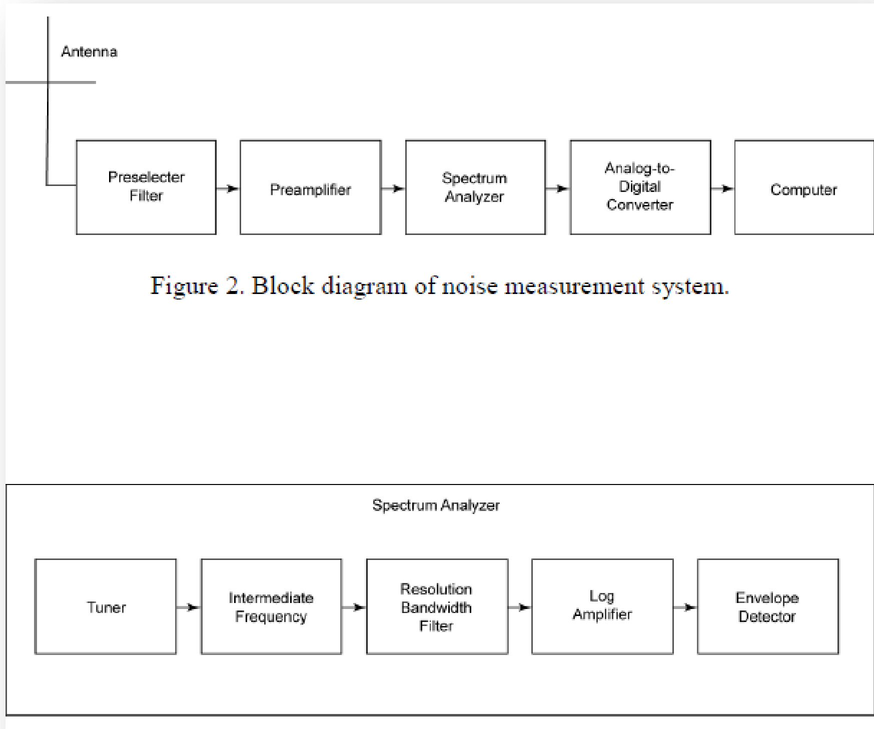

Figure 11. Diagram describing the noise factor equipment setup.

Note:: adapted from Achatz, R., & Dalke, R. (2001). Man-made noise power measurements at VHF and UHF frequencies. NTIA Report 02-390. In N. Assistant Secretary for Communications and Information. Victory (Ed.): United States of America Department of Commerce.

We recommend the FCC extend the survey of the noise floor up to 1 THz to include all modern communications.

Conclusions

The question of whether the noise floor has been rising is still controversial. It seems rational to expect that the man-made noise has been increasing just by the fact that the consumer electronics industry has developed quickly over the last 20 years (Chandler et al., 2009). However, the digitalization of consumer electronics, the transformation of the TV broadcasting from analog to digital, and United Sates Department of Energy minimum energy conservation standards imposing significantly lower power consumption limits on consumer electronic goods may have resulted in lower man-made noise levels for some products. This seems supported by the above noted findings from several researches indicating that consumer electrical environment noise has been reduced.

We cannot ignore concerns from other professional interest groups. Whereas average noise figures describes noise present at least half of the time in half of the examined locations, it is unclear if this figure addresses the concerns of a specific location and a specific time of day. Additionally, digital consumer electronic devices produce limited emissions; thus frequencies that were silent in the 1960s or 1970s may not be silent anymore.

Given all these possibilities, NEMA believes that a need exists to conduct a new study, in the terms we describe in our response to Question 4, because such a study is the best way to inform our combined understanding of the current noise floor levels and likely trends.

References

Achatz, R., & Dalke, R. (2001). Man-made noise power measurements at VHF and UHF frequencies. NTIA Report 02-390. In N. Assistant Secretary for Communications and Information. Victory (Ed.): United States of America Department of Commerce.

Chandler, A. D., Hikino, T., & Von Nordenflycht, A. (2009). *Inventing the Electronic Century. The Epic Story of the Consumer Electronics and Computer Industries, with a new preface*: Harvard University Press.

Cohen, M., Gasiewski, A., Backer, D., Balstad, R., Ellingson, S., Emerson, D., . . . Kolodzky, P. (2010). *Spectrum Management for Science in the 21st Century*. Washington, DC: The National Academies Press.

DeBoer, D., Judge, J., Blackwell, W., Cruz-Pol, S., Davis, M., Gaier, T., & Kellermann, K. (2013). *Views of the U.S. NAS and NAE on Agenda Items at the World Radiocommunications Conference 2015*. Washington, DC: The National Academies Press.

FCC. (2016). TECHNOLOGICAL ADVISORY COUNCIL (TAC) NOISE FLOOR TECHNICAL INQUIRY (Vol. ET Docket No 16-191). Washington D.C.: Federal Communications Commission.

FCC-47-Part-15. (2009). 47 CFR CH I Part 15 Radio Frequency Devices (pp. 751-870). Washington D.C.: United States Federal Communications Commission.

Hagn, G. (1987). *Man-made radio noise and interference*. Paper presented at the AGARD Conference. No 420, Lisbon, Portugal.

ITU_R_P372_12. (2015). RECOMMENDATION ITU-R P.372-12 Radio Noise. Geneva: International Telecommunication Union, Radio Communication Sector.

Lauber, W., & Bertrand, J. (1984). *Man-made noise level measurements of the UHF radio environment*. Paper presented at the IEEE National Symposium on EMC, San Antonio. Tx.

Liddle, D., Benkler, Y., Borth, D., Brodersen, R., Clarck, D., Darcie, T., . . . Katz, M. (2011). *Wireless Technology Prospects and Policy Options*. Washington, DC: The National Academies Press.

Sicker, D., Bernhard, J., Garmire, E., Goodman, D., Mcewen, H., & Mitchell, H. (2015a). *Telecommunications Research and Engineering at the Communications Technology Laboratory of the Department of Commerce: Meeting the Nation's Telecommunications Needs*. Washington, DC: The National Academies Press.

Sicker, D., Bernhard, J., Garmire, E., Goodman, D., Mcewen, H., & Mitchell, H. (2015b). *Telecommunications Research and Engineering at the Institute for Telecommunication Sciences of the Department of Commerce: Meeting the Nation's Telecommunications Needs*. Washington, DC: The National Academies Press.

Spaulding, A. D. (1997). *The natural and man-made noise environment in personal communications services bands* (Rev. ed.). U.S. Dept. of Commerce National Telecommunications and Information Administration: Washington, D.C.

Wagstaff, A., & Merricks, N. (2003). Man-Made Noise Measurement Programme. Little Paxton, St Neots, Cambs PE19 6EL: Mass Consultants Limited.

Wilbur, V. (2005). *An examination of man-made radio noise at 37HF receiving sties*. Naval Postgraduate School ;: Monterey, Calif.