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Education and Certification in Sound Pressure Level Measurement, Monitoring and Management at Entertainment Events

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ABSTRACT

A recent AES Technical Document on sound exposure and noise pollution due to outdoor music events proposes the creation of a live event sound level management initiative. In parallel, the World Health Organization, by way of the Make Listening Safe initiative, is preparing a regulatory framework for control of recreational sound exposure in entertainment venues. This paper considers how these developments could inform a certification scheme for live sound engineers and other key stakeholders. Such a scheme would detail current best practice and would allow venues, events, manufacturers and performers to voluntarily gain certification. This would help to boost public visibility of what an event or venue has done to promote the health and wellbeing of all key stakeholders.

1 Introduction

This paper discusses a project that looks at establishing a global certification scheme for Live Sound Engineers (referred to as *engineers* in this paper) focused on the ability to measure, monitor and manage sound pressure levels in and around music venues and entertainment events. Such a scheme could be extended to include other stakeholders, such as music venues and performers, with tailored trajectories to certification. This project is informed by the work undertaken by the AES Technical Committee on Acoustics and Sound Reinforcement and the Make Listening Safe initiative of the World Health Organization (WHO).[1] Make Listening Safe is developing a global standard for control of recreational sound exposure in entertainment venues, from a perspective of hearing health.

To inform discussions around the details of this Make Listening Safe standard, a survey was conducted amongst engineers across the world. One specific section of the survey was designed to ascertain the level of support for a certification scheme focusing on sound pressure level measurement, monitoring and management. The survey results indicate that there is strong support for such a scheme.

This paper is intended as a draft proposal to start a discussion about what such a scheme should look like, what a baseline curriculum should be, how it could be realized and if and how the AES should play a role in it. Crucially, as will be set out in this paper, tailored and specific education is the primary aspect of the certification scheme proposal. The scheme is not a body that sets or enforces sound levels or places engineers in a position of liability (e.g., with regard to patrons' hearing damage). It should provide a framework for engineers to develop their skillset and knowledge base to protect their own ears and manage the sound exposure of other stakeholders using current best practice.

Ultimately, a successful scheme to promote safe audience sound exposure at live events can never operate by itself. It must work hand in hand with best practices in venues (acoustics, system design, safe listening guidelines, practicality), local entertainment policy and occupational health & safety frameworks, and outreach to audiences, particularly about the use of hearing protection [1-3]. In many instances, sound pressure level maxima in music venues, specifically at festivals, are informed by environmental noise requirements, where provisions for healthy hearing and limited annoyance should work in tandem.

Initially the ideas focus on hearing health given that legislative frameworks for environmental noise are long established. However, as a point of departure, at the time of a performance when it matters most, the required skillsets to manage sound exposure and noise pollution overlap. Skillful use of an appropriate measurement setup at the mixing desk will enhance the position of the engineer in interactions with enforcement officers, enabling effective and efficient control of sound distribution.

2 Background

Despite there being a great many live sound engineers and educators amongst AES ranks, the live sound profession as a whole has an almost non-existent level of professional organization. There are hardly any peak bodies or guilds that unite touring or venue-based front of house, monitor or system engineers, with perhaps unions like IATSE[2] as an exception. Arguably this is something that suits the trade, matching the wide range of educational and other backgrounds of engineers the world over [4, 5]. A downside of this relative openness to the profession is that there is no minimal level of training, or expectation of training when it comes to both the risk and responsibility regarding exposure to dangerously high sound pressure levels.

2.1 Make Listening Safe

The point of departure for Make Listening Safe is the rapid increase in recreational sound exposure, particularly amongst young people. Entertainment

[1] https://www.who.int/news-room/events/detail/2020/02/17/default-calendar/consultation-on-make-listening-safe-2020

[2] International Alliance of Theatrical Stage Employees, Moving Picture Technicians, Artists and Allied Crafts of the United States

events contribute to this exposure, as do personal music players, gyms, motorsport, etc. Engineers have a role to play to help limit unsafe exposure and to reduce the number of young people at risk from unsafe listening practices, from the cited number of 1.1 billion.[3] At the same time, it is important to emphasize that sound exposure reduction is not an exclusive responsibility of engineers, but that other stakeholders such as musicians, venue management and promoters have supporting roles to play.

Similarly, outreach to patrons with regard to sound exposure awareness and the use of hearing protection will remain crucial. However, in many cases, particularly in larger venues, on-the-spot control of sound levels is in the hands of engineers, as is the negotiation with performers, with regard to on-stage levels, or with enforcement agencies with respect to sound emissions into neighborhoods.

3 Certification scheme

The idea of a certification scheme grew from discussions with stakeholders (peak bodies, sound engineers, venue managers) in several countries including Australia and the United Kingdom. It was first detailed in *Understanding and managing sound exposure and noise pollution at outdoor events*, a recent AES technical document, and dubbed the HELA (Healthy Ears, Limited Annoyance) initiative [6]. A primary driver is the need to work with current sound level regulations and to share best practice on how to work with such restrictions.

A certified engineer is a practitioner with relevant knowledge of hearing physiology and hearing health to limit unsafe sound exposure for all key stakeholders. As will be discussed in Section 4 of this paper, engineers come from a great range of educational backgrounds and have not necessarily studied sound engineering. Consequentially, an important challenge that faces a certification scheme is the balance between an inclusive curriculum and ensuring graduates are sufficiently equipped. A key consideration is that teaching and learning sound pressure level measurement, monitoring and management should be contextualized by best practices in sound system design and optimization.

By way of example, a good sound system design should provide even sound distribution across a venue to avoid discrepancies in sound exposure between patrons in front of the stage (close to the loudspeakers) and those further away. This is important given that sound levels are often measured, monitored and managed at front of house.

3.1 Tools

Current day specialist sound pressure level measurement and monitoring tools[4] are designed to help engineers realize best possible outcomes within the equivalent continuous sound pressure levels (Leq) that are increasingly used in local regulations or guidelines. Such regulations often utilize sliding averaging windows between 15 and 60 minutes (examples in table 1). However, in the complex ecosystem of venue acoustics and multiple sound sources (e.g. audience noise), these tools are only as good as the person using them.

By certifying themselves, engineers demonstrate that they can confidently work with key concepts that inform regulations and guidelines [1-3] as well as use the tools designed to support such responsibilities. These values, except for the Netherlands, were in some form or another derived from the current WHO guidelines for community noise ($L_{Aeq\ 240m}$=100 dB, < 5 days a year) from 1999 [7].

Country	L_{Aeq} (dB)	Time (min)	Additional
Belgium	100/102	60/15	
France	102	15	$L_{Ceq,15min}$= 118 dBC
Germany[5]	99	30	L_{Cpeak} <135 dBC
Netherlands	103	15	L_{Cpeak} <140 dBC
Switzerland	100	60	L_{AF} <125 dBA

Table 1. European examples of L_{Aeq} maxima from [2]. A and C indicate the weighting, F indicates a fast integration time (125ms).

[3] www.who.int/pbd/deafness/activities/MLS/en/

[4] Such as 10EaZy, METRAO, Smaart SPL, etc.

[5] The German value differs in that it is averaged in blocks of 30 minutes and not a running average.

3.2 Challenges

Several recent publications discuss challenges that occur when mixing to these Leq values [8-10]. By way of illustration, Figure 1 provides insight into how the different time frames typically develop over the course of an event.

The challenges that arise impact the engineer's ability to effectively deliver an exciting and engaging listening experience to all audience members. In smaller venues, acoustic conditions can strongly limit the amount of control engineers have over sound exposure, where additional solutions need to be sought, such as the reduction of on-stage sound level (most notably from the drums) alongside improvements to the sound system.

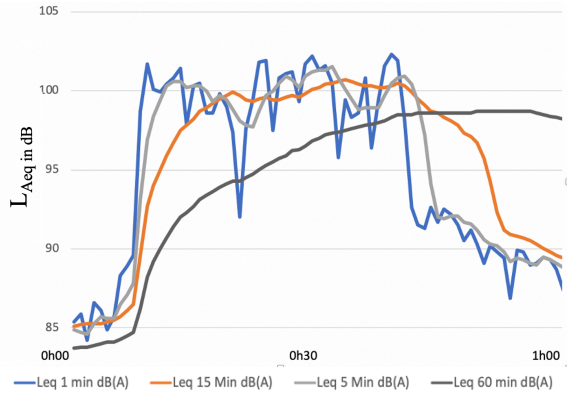

Figure 1. Different LAeq values from a live band performance plotted over the course of one hour.[6]

4 Survey response

A recent survey[7] amongst engineers found support and enthusiasm for a global learning and certification initiative that supports the implementation of local guidelines or regulations regarding maximum safe sound levels.

The survey ran from July to September 2020 using the Qualtrics online platform, with SPSS 27 used for statistical analyses, ethics approval was received from the National Acoustics Laboratories, the research division of Australian Hearing.[8] It attracted complete 1,735 responses from 62 countries (24 countries with n>10).

The tenor of the results is that apart from a significant gender imbalance (93.8% of respondents selected male, 4.2% female, 0.7% non-binary and 1.3% preferred not to say), engineers come from a great many backgrounds, especially when considering education. For the question *what is your highest level of general education?* respondents selected High School (23.2%), Tertiary (University, College, Vocational: 63.8%) and Postgraduate degree (13.0%).

When looking at levels of professional education, many different pathways appear (in a multiple-response question). One element that emerges is that even though respondents may report a tertiary or postgraduate degree as their highest level of general education, that degree is not necessarily related to live sound engineering.

Critically, what stands out in the results regarding professional education is the number of respondents selecting self-taught (54.3%) and the importance of manufacturer/industry training (selected by 42.8%).

4.1 Support for a certification scheme

In the survey, several questions were designed around this topic. Three 5-step Likert scales gauged respondents' general outlook on this idea:

1. The live sound industry should not be regulated (reverse coded for analysis so the statements are in agreement)
2. I would join such a scheme
3. I would be willing to attend training to gain certification for such a scheme

[6] Data recorded in 2020, at a pop and rock venue in Perth, Australia.

[7] A publication about the survey is in preparation, a public report is available at https://ql.tc/UC63dI

[8] We thank Dr. Elizabeth Beach for her help with the ethics approval process and the design of the survey.

Whereas the response (table 2) to the first question concerning regulation in general is mixed, responses to the second and third questions are more clearly supportive.

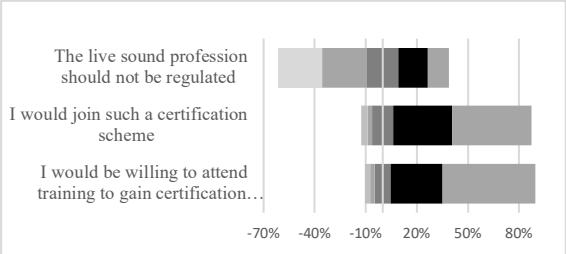

Table 2. Bar chart plotting support (count) for a certification scheme (n=1629). Left to right: Strongly disagree, disagree, neutral, somewhat agree ((black) and strongly agree.

4.2 Manufacturer / industry training

An increasing number of relevant industries (covering sound systems, audio infrastructure, hardware and software) are providing training for users at a variety of levels. Echoing comments in the survey, providing for integration of the learning outcomes for the certificate into existing and new industry training programs is highly desirable. Survey respondents who in their professional education indicated to have followed manufacturer/industry training (n=698) tend to be more in agreement with the statement *I would be willing to attend training* when compared to respondents who haven't (n=937).[9]

5 Survey: key terminology

An important initial question to consider is: what is the minimal required content to make the certificate both adequate and inclusive (when considering prior education, for instance)? Respondents' confidence was surveyed using 5-step Likert scales with a relevant, but not exhaustive, list of seven key terms:

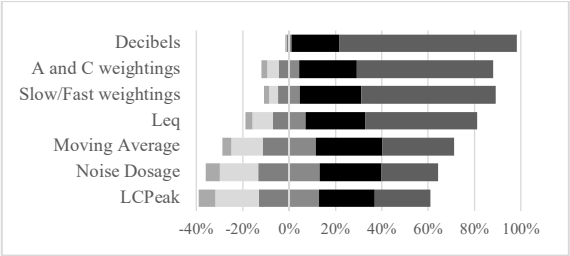

Table 3. Respondents' confidence using key terminology (n=1715). Left to right: not at all confident, not confident, neutral, confident (black), and very confident.

As can be seen from table 3, respondents self-report different levels of confidence when it comes to these terms (note, the survey did not randomize the order of the keywords, which means that the fixed sequence may have biased the responses).

5.1 Overall confidence and prior education

The responses to the seven key terms were averaged into a new 'average confidence' variable, ranging from 1 (not at all confident) to 5 (very confident).

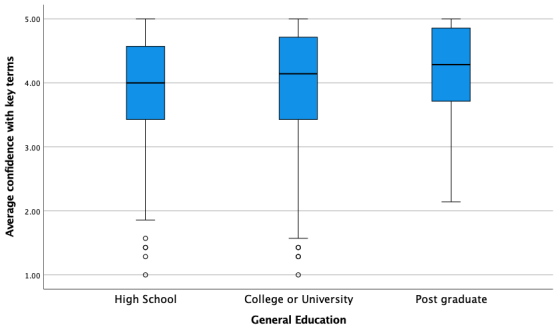

Figure 2. Average confidence with key terms vs general education

Considering the data in figure 2, the effect of general education on confidence with key terms is limited. Statistical analyses revealed small but significant differences between the *Postgraduate* versus *High School* groups and between the *Postgraduate versus College/University* groups but there was a nonsignificant difference between the latter two

[9] A t-test was significant, with a small effect size $t(1590) = 5.531$, $p < .001$, $d = 0.271$).

groups.[10] As pointed out previously, many respondents in those groups did not necessarily major in a degree relevant to live sound engineering.

Professional education is not considered in this analysis because of the many different possibilities that emerged from the multiple response question mentioned earlier. The survey did ask about specific content as part of any professional education. Surprisingly, respondents who selected 'Yes' to the question: *During your training, did you receive any education on how to manage sound levels, for instance by using sound level meters?* did not report a significantly different value on the average confidence scale compared to respondents who selected 'No'.[11]

A comparable outcome can be reported for the follow-up question: *During your training, did you receive any education on how to protect your ears as a Live Sound Engineer*?[12] This suggests that not all professional education providers cover the basic keywords investigated in the survey.

6 Learning outcomes

The insights from the survey, combined with the aims of Make Listening Safe and the Healthy Ears, Limited Annoyance initiatives, can be used to shortlist the following learning outcomes for the teaching and learning part of the scheme:

1. Certified engineers have the ability to work confidently with sound pressure levels, specifically with the application of:
    - Sound level measurements
    - Weighting (A and C)
    - Time-based averaging and L_{Cpeak}
    - Equivalent ontinuous levels
    - Moving averages
2. Certified engineers have a demonstrated knowledge of hearing physiology, specifically with regard to:
    - Loudness perception and equal loudness contours
    - Hearing damage (prevalence & protection)
3. Certified engineers can interpret, and operate informed by, local noise regulations:
    - Using data from multiple measurements, including from outside the venue
    - Liaising with enforcement agents or specialist sound guards
4. Certified engineers can assess a sound system with respect to:
    - Distribution of sound across a venue
    - Sound exposure of patrons nearest to stage and loudspeaker systems

7 Proposed governance structure

The AES is arguably the most prominent global organization to initiate and perhaps oversee this scheme, with a key role for the Technical Committee on Acoustics and Sound Reinforcement. Given the current Make Listening Safe initiative and the aim to reduce exposure to high sound levels around the world, the WHO could be a significant partner, specifically with respect to up-to-date and evidence-based audiological and epidemiological advice.

7.1 Survey: organization

A further set of questions in the survey asked who should organize a certification scheme (n = 1367):

- AES (54%)

[10] One-way ANOVA was significant ($F(2, 1680) = 7.471$, $p < .001$). Post-hoc Games-Howell analysis demonstrated that the difference between the means for the *Postgraduate* and *High School* groups was significant, but the effect size was very small ($p < .001$, $d = .09$) as was the difference between the means of the *Postgraduate* and *College/University* groups ($p = .001$, $d = .09$).

[11] There were no statistically significant differences between group means: $t(683) = -1.418$, $p = .029$.

[12] There were no statistically significant differences between group means: $t(686) = -0.576$, $p = .600$.

- WHO (16%)
- A national peak body (14%)
- Other (10%).

In the comments for *Other,* a number of different endorsements for the AES as a non-governmental origination were found as well as strong support for involvement of relevant industries.

Some well-rounded concerns were phrased as well. One such concern is that, in situations with questionable operators, a certified professional can end up being the scapegoat for issues with sound levels. Some respondents expressed the fear that a certification scheme would make participants liable to prosecution with respect to patrons' hearing damage.

In terms of governance, in the comments entered for *Other,* arguments for and against government involvement are made. Government agencies are, on the one hand seen as essential to enforce regulations, but on the other hand they are perceived as not understanding the intricacies of live sound engineering. Several respondents suggested that a certification scheme could be modelled after PLASA[13] in the United Kingdom, which operates a certification scheme for event rigging professionals.

A few strong objections were raised against regulation of sound levels per se with the argument that music is art and should not be regulated recuring. As indicated in the introduction, the scheme is not intended to regulate or enforce, but to provide engineers with the skillset to deal with specific sound levels, whether enforced or by choice.

7.2 Additional stakeholders

A secondary element is the possibility for venues (and perhaps performers and other stakeholders) to join the scheme. This could be a crucial element of the scheme's efficacy, as venues can choose to support existing staff in the certification process and where possible engage certified engineers as casual staff. Furthermore, this will give venues an opportunity to engage with existing or new local hearing health initiatives such as *I Love My Ears* in the Netherlands and *Hearsmart* in Australia.[14]

In a multiple-response question, respondents were asked which other stakeholders should be able to join (n = 1723):

Other than live sound engineers, who should be able to join such a scheme? (tick all that apply)

- Venues (88%)
- Festivals (83%)
- Bands, Musicians and DJs (67%)
- Promoters (60%)
- Other (12%)
- Missing, interpreted as 'none' (9%)

In the *Other* field, comments suggest that more stakeholders could be included, for instance, officials of enforcement agencies, occupational health and safety specialists, and those preparing or drafting legislation.

One topic that is regularly mentioned is working with local government agencies, which often demonstrate a lack of awareness of the issues at hand. Other groups that are mentioned regularly are Sound Guards (professionals engaged at larger events to measure and monitor sound levels as well as liaise with stakeholders), production managers (at venues and festivals) but also houses of worship.

8 Program Structure

From comments made in the survey, a picture emerges of what the scheme should look like:

[13] Professional Lighting & Sound Association https://www.plasa.org/about-us/

[14] A good example of a comparable scheme can be found in Australia targeting harmful behavior and sexual harassment at concerts. Venues display adhering to best practices with the 'Your Choice' logo in marketing and on the door.

- Inclusive
- Combining global and local stakeholders
- Independent
- Created by live sound engineers
- Designed and accredited globally, mandated locally
- Not for profit, low cost
- Addressing hearing health and noise issues separately
- Hand in hand with audience awareness programs

8.1 Structure

The scheme can have as few as four different components:

- Curriculum
- Learning and teaching
- Examination
- Certification

Different ways of realizing this can be foreseen, but AES (with industry representatives) and WHO could collaborate on the curriculum, translation of the curriculum into major languages, and periodic review every three to five years.

Examination, certification and registration could be hosted and overseen by AES to ensure it is in line with the curriculum. The curriculum could then be shared with tertiary and commercial education providers around the globe. Such providers can integrate and add (but not reduce) the content to tailor to their audiences. AES could, in parallel, also offer the basic module as part of its education programs. Future extensions to the program can be considered, for instance, creating different levels of certification, or incorporating sound system design.

8.2 Costs

External funding should be sought to initiate the scheme. Once up and running, this scheme could pay for itself by introducing fees for either education, examination or certification. Great consideration is required concerning cost to assure the largest possible roll-out and greatest global level of inclusivity. One positive outcome for the AES could be considered and that is providing every successful candidate with a basic AES membership for a year and so increasing the membership numbers.

9 Global outlook & access to tools

Technological innovation and operational heuristics in the live sound industry are driven largely in OECD countries, which make up only a small part of the world's population. The WHO has an obvious global agenda and consequentially we need to make sure that access not only to training in a variety of languages, but also to appropriate tools, is achievable in emerging economies. At the moment, appropriately certified tools are costly and rely on expensive hardware. Unsurprisingly many of the survey respondents indicate reliance on smartphones to measure sound levels [11, 12]. R&D partnerships with industry should be sought to develop innovative approaches that can help bringing down cost and improve access to certification of measurement tools.

10 Conclusion and further work

This paper outlines an initial proposal for a live sound engineers' certification scheme informed by the World Health Organization's Make Listening Safe initiative. The ideas in the paper are supported by an international survey and are presented to encourage discussions around this topic. The next steps, informed by these discussions, would be to create a formal proposal to the AES and WHO and to seek external funding to initiate the scheme. At the same time, a roundtable event could be organized with prospective industry partners as well as an additional survey amongst live sound engineers, who ultimately should be in the driving seat. Finally, from that last point it is relevant to mention that the authors' combined industry experience in live sound exceeds one hundred years.

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