

INSTITUTE OF ACOUSTICS

IOA Noise Working Group (Wind Turbine Noise)

Amplitude Modulation Working Group

Outline Scope of Work

INTRODUCTION

In response to a request from the Institute of Acoustics Noise Working Group (IOA NWG), and approved by IOA Council, the IOA has agreed to set up a working group to look at the issue known as 'Amplitude Modulation' (AM). The aim of this 'AM Working Group' will be to review the available evidence, and to produce guidance on the technical elements for the assessment of AM in wind turbine noise.

This document defines:

- the membership of the AM WG
- the schedule of meetings that the AM WG will hold
- the aim of the AM WG
- the criteria by which the different options available for analysis of AM will be assessed
- the work packages necessary to achieve these aims.

The Terms of Reference of the AM WG are defined separately, and should be read in conjunction with this document.

MEMBERSHIP

The IOA NWG reports to IOA Council and comprises the following members:

- Richard Perkins, Parsons Brinckerhoff (Chair)
- Matthew Cand, Hoare Lea Acoustics
- Bob Davis, R Davis Associates
- Chris Jordan, Northern Group Systems (Environmental Health)
- Malcolm Hayes, Hayes McKenzie Partnership.

The AM WG reports to the IOA NWG and comprises the following individuals:

- Gavin Irvine, Ion Acoustics (Chair)
- Matthew Cand, Hoare Lea Acoustics
- Bob Davis, Robert Davis Associates
- Dave Coles, 24 Acoustics
- Sam Miller, Xi Engineering
- Tom Levet, Hayes McKenzie Partnership
- John Shelton, AcSoft
- Jeremy Bass, RES
- David Sexton, West Devon Borough Council
- Geoff Leventhall

The membership of the AM Working Group (AM WG) is drawn from the membership of the IOA and CIEH and seeks to include different representatives of the consultancy, academic, development and local authority sectors.

It is anticipated that the IOA NWG will provide oversight to the AM WG and participate in meetings and discussions at their discretion.

SCHEDULE OF MEETINGS

It is planned that the AM WG will hold face-to-face meetings of all members on the following dates:

- Wed 10 Sep Kick-off meeting
- Wed 8 Oct 2014 Update #1
- Wed 12 Nov 2014 Update #2
- Wed 3 Dec 2014. Update #3

Between meetings, conference calls between AM WG members will be held at fortnightly intervals.

The timescale for the work of the group is set out in the Terms of Reference.

GOALS

The overarching aim of the group is to develop the technical elements of an assessment method for amplitude modulated noise from wind turbines and wind farms. This will be:

- based on best available science;
- based on the most up-to-date psycho-acoustic and technical information on modulation available;
- provided in the format to allow straightforward inclusion in 'standard' forms of planning conditions for wind turbines [subject to thresholds or penalties set by others];
- accompanied by software where necessary to allow the condition to be implemented by all parties.

To achieve this, the assessment method will need to contain a means of characterising a sample of amplitude modulated wind turbine noise data, with an agreed format and length, by means of a single metric uniquely defining the level of AM within it.

The results of the work of the AM WG will be communicated to the acoustics community via a Supplementary Guidance Note (SGN) or other document, thus providing additional information to that provided in the original IOA Good Practice Guide to 'The Assessment and Rating of Noise from Wind Farms' – ETSU-R-97.

WORK PLANS

To achieve the goals of the WG, it is anticipated that there will be a number of work packages.

WP1 AM Definition & Target Audience

To provide clarity surrounding the issue of wind turbine AM, current definitions of AM will be reviewed and/or combined.

The WP will also consider the respective needs for the target audience, and ensure the final guidance document is appropriate where possible.

WP2 Data Collation

The aim of this WP is to compile as much measured AM data as possible from as wide a range of wind turbine sites, in terms of terrain and meteorological complexity, and turbine types, hub height, as possible. Such data will be essential for identifying and testing the preferred AM metric.

WP3 Literature Review

A literature review will be performed of all known literature relevant to the assessment and rating of wind turbine AM. The aim of the task is to compile a list of the different 'rating' methods currently available for AM, this to include the following:

- the 'Den Brook' method – see Condition 20 in the planning conditions and the scheme proposed by RES to satisfy a planning requirement to implement the above condition
- Work by MAS Environmental
- the RenewableUK method, published in Dec 2013 and recent modifications to the RenewableUK method which would correct some of the shortcomings – see Tom Levet (metric) & Jeremy Bass (penalty scheme)
- the method published by Tachibana et al of Japan
- The German Impulsiveness Rating
- Australian research by Evans and Cooper, Acoustics 2013
- Lee et al, 2009 + 2012
- McCabe, WTN11, 2011
- McLaughlin, WTN11, 2011
- Gunnar Lundmark, WTN11, 2011
- Larsson & Öhlund, Internoise 2011 and WTN2013
- Gabriel, WTN2013
- Carlo di Napoli, WTN2009 & WTN2011.
- Any national standards such as those of South Australia and New Zealand
- Other AM information (non-wind turbine) eg psycho-acoustic effects, Zwicker Fastl

WP4 Critical Comparison of Available Methods

The intention is that the outcome of WP3 is an evidence basis on which to determine the preferred AM metric. This will comprise three elements:

- A review of the evidence of WP3 identifying common, desirable elements of the different methods available. This could include:
 - methods based in the time domain
 - methods based in the frequency domain or
 - a combination of the two.
- The review would also consider other hybrid methods to be developed from the above if appropriate
- The most promising method(s) will be implemented in software to allow a direct comparison of them based on the assessment of real-world data samples from WP2.

The content of subsequent work packages will be dependent on the outcome of WP3 and WP4

These could include the following potential work packages:

WP5 Data Requirements

To ensure a common, or at least a minimum level of fidelity, the minimum requirements for data loggers will be defined.

Parameters to be considered for data loggers could include:

- Instrument and windshield specifications
- the measurement index, L_{eq} , L_p , L_F etc
- short-term logging in 100 millisecond or 125 millisecond periods
- the maximum noise floor permitted,
- frequency weighting network, e.g. A, C or none
- 1/3rd octave band or octave band logging.
- Audio recording ability

For audio-recordings the following parameters could be considered

- minimum length, in seconds/minutes
- sample rate, in Hertz
- bit rate
- stereo or mono
- file format, e.g. WAV or MPG.

WP6 Data Reduction Definition

Given a suitable metric, the aim of this WP is to characterise an AM sample in terms of the following:

- the major time interval for analysis, e.g. 10 min

- the minor time interval for analysis,
- averaging or statistical analysis of AM samples.

WP7 Develop Software

So that all parties involved in the assessment of wind turbine AM noise can do so with equal facility, a software package will be developed for implementing the preferred AM methodology.

This could be provided as a stand-alone executable program running on PCs with the Windows operating system, but other options will be considered.

WP8 Batch Processing

It would be desirable that any AM methodology can be implemented in software which allows the 'bulk' processing of suitable data. This is because AM is typically only present in certain specific meteorological conditions, so that it may be necessary to screen large amounts of data to identify those periods which contain AM.

Ideally the software should discriminate wind turbine AM from other modulated noise sources, although it may be necessary for samples to be checked by listening where there is some doubt about their validity. The extent to which the software should do this must be defined. Where the software can only provide limited reliability, such that additional checks are required, then the process for checking and verifying data must be determined.

WP9 Psycho-Acoustic Significance

To be able to create a meaningful planning control for wind turbine AM noise, two elements are necessary: a metric, i.e. a number, which represents the level of AM present within a sample of wind turbine noise, and a scheme for providing a context for interpreting that number which encapsulates the typical psycho-acoustic response to AM.

This context might take a number of different forms, for example a stand-alone scheme, a penalty scheme or a hybrid of the two. For example, it might be:

- a stand-alone condition, which applies irrespective of overall wind turbine noise levels
- integrated into the overall compliance process for wind turbine noise via a penalty added to wind turbine noise levels
- a hybrid of the two. For example, a penalty scheme for low to moderate levels of AM and an automatic fail, irrespective of overall noise levels, for higher levels of AM.

The aim of this WP will be to collate papers relating to the psycho-acoustic response to AM, with a view to identifying possible ways forward. This may involve re-analysis, using the new metric, of the audio data used in the RenewableUK funded listening tests, at the University of Salford. The AM WG can make recommendations about the form, and nature, of the psycho-acoustic consequences of a given level of AM, if the available evidence supports a view, which might include:

- the nature of the test, i.e. stand-alone, a penalty or hybrid scheme
- if a penalty scheme is recommended, how this might be defined.

It should be stressed that the intention of this work package is to collate the information needed to help decision makers make an informed decision on how an appropriate threshold or penalty might be applied, if the available evidence supports this, or to recommend further work which would assist.

SUCCESS CRITERIA

A number of criteria will be considered by the group when assessing the output of each work package as follows:

- **Achievability** – using the equipment & software typically available to acoustic professionals
- **Reality** – work with samples of ‘noisy’, real-world data, not just, artificial simulated data created for testing purposes
- **Robustness** – minimising the influence of ‘noise’ in test data, which can make signal detection difficult, to ensure low rates of false positives and negatives
- **Location** – the chosen methodology will be applicable to measurements in free-field conditions, external to affected premises, so that it can be used in conjunction with current good practice in wind turbine compliance measurements.
- **Objectivity** – providing a unique number which characterises the level of AM in each case
- **Repeatability and reproducibility** – returning the same unique number for a given sample of test data irrespective of who runs the test, where or when or how
- **Specificity** – as AM is currently defined as ‘the modulation of the broadband noise emission of a wind turbine at the blade passing frequency (BPF)’, it is essential that the methodology is specific to the BPF and not sensitive to variation at any other frequencies
- **Automation** – the ability to process large data sets. This is necessary because AM is typically only present in certain specific conditions, so that it is necessary to screen large amounts of data to identify those periods which contain AM
- **Relativity** – relatable to the psycho-acoustic, or subjective, response of individuals to AM noise.