



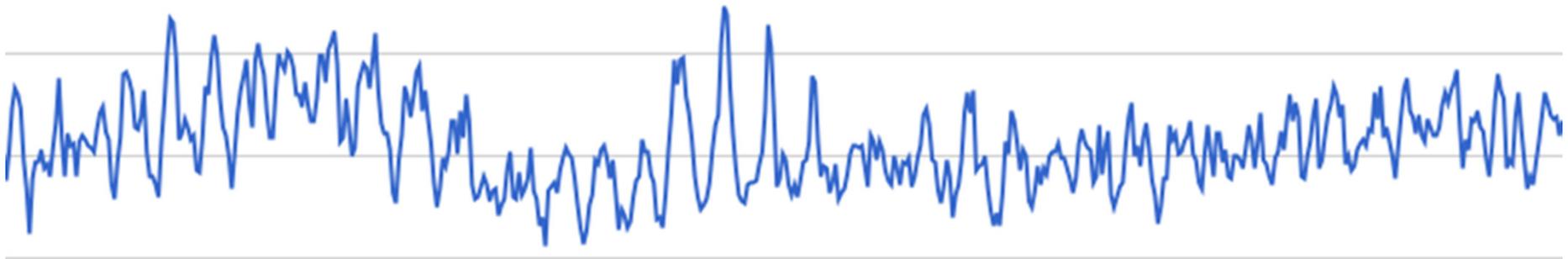
Independent Noise Working Group

# **Wind Turbine Amplitude Modulation and Planning Control Study**

**Institute of Acoustics Conference**

**Harrogate - 15 October 2015**

**Richard Cox**





Independent Noise Working Group

## Amplitude Modulation Study

- **Introduction**
- **Methodology**
- **Findings**
- **Recommendations**

**INWG report download:**

**<http://www.heatonharris.com/reports-publications>**

**INWG contact: [wind-noise@tsp-uk.co.uk](mailto:wind-noise@tsp-uk.co.uk)**



Independent Noise Working Group

## Amplitude Modulation Study Introduction

- **INWVG formed August 2014 by a diverse group of experts and non-experts**
- **To conduct an independent study into AM that is able to credibly challenge the IoA AMWG findings and methodologies**
- **Study objective: To provide reasonable protection for wind turbine neighbours from wind turbine noise including EAM**



Independent Noise Working Group

# **Amplitude Modulation Study Introduction**

- **Sponsored by**
  - **Chris Heaton-Harris MP**
  - **National Alliance of Wind Farm Action Groups**
- **Target customers:**
  - **Department of Communities & Local Government (DCLG)**
  - **Department of Energy and Climate Change (DECC)**
  - **Department for Environment, Food and Rural Affairs (DEFRA)**
  - **Department of Health**

**Total independence from the wind industry**



Independent Noise Working Group

# Amplitude Modulation Study Methodology

## The INWVG study investigated:

- **How AM affects people**
- **Legal remedies**
- **Community experience**
- **Science behind AM**
- **Control of AM**
- **Wind industry response**



Independent Noise Working Group

# Amplitude Modulation Study Methodology

## Work packages for completion summer 2015

| Work Package | Work Package Subject                       | Lead author    |
|--------------|--|----------------|
| 1            | Fundamentals of AM                         | John Yelland   |
| 2.1          | Literature review                          | Richard Cox    |
| 2.2          | AM Evidence review                         | Sarah Large    |
| 3.1          | LPA Survey                                 | Trevor Sherman |
| 3.2          | Health effects                             | Chris Hanning  |
| 4            | Den Brook                                  | Mike Hulme     |
| 5            | Draft AM planning condition                | Sarah Large    |
| 6.1          | Legal remedies                             | Richard Cowen  |
| 6.2          | Community experience of Statutory Nuisance | Bev Gray       |
| 7            | Test of the IoA AMWG methodologies         | Sarah Large    |
| 8            | Review of IoA AM study and methodology     | Richard Cox    |
| 9            | The Cotton Farm monitor experience         | Bev Gray       |
| 10           | Report summary                             | Richard Cox    |



Independent Noise Working Group

# Amplitude Modulation Study Findings

## How AM affects people: Occurrence

- **WP2.1 , WP2.2 and the LPA survey at WP3.1 show that EAM is a frequent occurrence, often for long periods of time**
- **The LPA survey results presented at WP3.1 shows that progress in resolving complaints is inconclusive with inconsistent approaches to dealing with it across the country**
- **Also anecdotal evidence of a ‘silent majority’ who suffer in silence without knowing how to complain, not wanting to ‘get involved’ or because of a fear of adverse implications**



Independent Noise Working Group

# Amplitude Modulation Study Findings

## How AM affects people: Health effects

- It is clear from the evidence examined at WP3.2 that **wind turbine noise adversely affects sleep and health at the setback distances and noise levels permitted by ETSU**
- **There is particular concern for the health of children exposed to excessive wind turbine noise**
- **The inadequate consideration of EAM is a major factor in the failure of ETSU to protect the human population**



Independent Noise Working Group

# Amplitude Modulation Study Findings

## Legal remedies: AM planning condition

- Wind industry claims that an AM planning condition is not necessary and that the legal remedy of statutory nuisance provides adequate protection are thoroughly discredited by the evidence presented in WP6.1, WP3.1 and WP6.2
- It is shown that without an AM planning condition there is no effective remedy for wind farm neighbours against excess noise



Independent Noise Working Group

# Amplitude Modulation Study Findings

## Community experience: Statutory nuisance

- **No requirement for WT operators to monitor noise or prove ETSU compliance except occasionally at the start of a development**
- **WP6.2 demonstrates the need to monitor wind farm noise to provide the evidence to pursue noise complaints and ensure ETSU compliance**
- **Long term monitoring is a recommendation of the Northern Ireland Assembly report, Jan 2015: *“the Department should bear responsibility for ensuring that arrangements be put in place for on-going long-term monitoring of wind turbine noise”***



Independent Noise Working Group

# Amplitude Modulation Study Findings

## Community experience: Cotton Farm monitor

- **WP9 provides a review of a rural community's experience setting up long term noise monitoring of wind farm noise**
- **Has provided a huge amount of data**
- **The wind farm noise data, including audio recordings can be accessed on line at:**  
[http://www.masenv.co.uk/~remote\\_data/](http://www.masenv.co.uk/~remote_data/)



Independent Noise Working Group

# Amplitude Modulation Study Findings

## Community experience: Den Brook

- **WP4 details the enormous effort RES, the developer for Den Brook has gone to over the last 8 years to oppose having an AM planning condition applied**
- **Den Brook became a test case for the wind industry to prevent the AM condition becoming the ‘standard’**
- **Den Brook will be subjected to a Cotton Farm type community noise monitoring**



Independent Noise Working Group

# Amplitude Modulation Study Findings

## Science behind AM: Literature review

- **WP2.1 reviews over 160 documents, of which at least 85 are technical. Note: the IoA AMWG literature review lists a total of just 35 documents**
- **The evidence confirms that EAM can and does occur frequently and often for lengthy periods for most, if not all wind turbines**
- **The evidence regarding LFN being a significant component of WTN including AM, is compelling**



Independent Noise Working Group

# Amplitude Modulation Study Findings

## Science behind AM: Literature review - ETSU-R-97

- There is irrefutable evidence presented at WP3.2 and WP2.1 to discredit claims that ETSU provides a robust noise assessment methodology
- This conclusion is supported by the Northern Ireland Assembly report, (Jan 2015) into wind energy where it recommends, *“review the use of the ETSU-R-97 guidelines on an urgent basis with a view to adopting more modern and robust guidance for measurement of wind turbine noise, with particular reference to current guidelines from the World Health Organisation”*



Independent Noise Working Group

# Amplitude Modulation Study Findings

## Science behind AM: Literature review

- **Noise complaints are often characterised by ‘*sensation*’ as being the major form of disturbance.**
- **Measurement using ‘A’ weighting may be unsuitable for WTN where low frequency components are present;**
- **Measurements should be made inside homes when investigating noise complaints;**
- **IEC 61672 compliant ‘Class 1’, instrumentation may be unsuitable for LFN measurement or where background noise levels are low as in typical rural areas**



Independent Noise Working Group

# Amplitude Modulation Study Findings

## Science behind AM: Evidence review

- **WP2.2 looks primarily for evidence of audible AM in support of its existence and prevalence**
- **This typically relates to audible AM typically up to around 1000Hz, with the higher frequencies being more dominant in earlier studies, smaller turbines and / or near field**



Independent Noise Working Group

# Amplitude Modulation Study Findings

## Science behind AM: Evidence review

- This evidence based report is conclusive that EAM exists and shows EAM is being generated by the majority of wind energy developments. It also shows that AM can be generated by all turbines regardless of size, model or type
- The evidence supports the prevalence of lower frequency AM and AM in infrasonic frequencies, including that which does and does not relate to blade pass frequency
- Whilst meteorology may not be the sole determinant, under certain meteorological conditions adverse AM can occur for long periods



Independent Noise Working Group

# Amplitude Modulation Study Findings

## Science behind AM: Blade stall at zenith

- **Stall at blade zenith has been declared by the wind industry to be the primary cause of EAM. This hypothesis is attractive and persuasive as dynamic control of the blade pitch to maintain the optimum angle of attack throughout the 360° of rotation would be an obvious solution**
- **Unfortunately the local stall hypothesis simply cannot explain the observed high levels of EAM, as is shown by Oerlemans in the first paper in the ReUK Dec 2013 AM study. It is of great concern that the ReUK report's interpretation draws the opposite conclusion**



Independent Noise Working Group

## Amplitude Modulation Study Findings

### Science behind AM: Blade stall at zenith

- **Oerlemans uses the well-established and reliable BMP aerofoil noise model to calculate the aerodynamic noise from wind turbine blades, and shows that the 2 – 3 dB modulation depth of normal AM increases by about 3 dB in stall**
- **However this falls short of the measured EAM modulation depths ranging from 10 dBA recognised by Oerlemans and values of 15dBA frequently occurring as reported by others**



Independent Noise Working Group

# Amplitude Modulation Study Findings

## Science behind AM: Mechanical resonances

- **Blade and tower resonances pose significant problems for the manufacturers of modern wind turbines but the concern has previously been structural integrity, not noise. WP1 shows how flexible and elastic turbine blades are and how tower resonances can be excited when synchronised to blade passing frequencies or their subharmonics**
- **WP1 also shows how vortex shedding can excite resonances in both towers and blades and how blades can produce very low frequency EAM without resonating. All of these proposed mechanisms would be expected to give rise to very low frequency resonances**



Independent Noise Working Group

# Amplitude Modulation Study Findings

## Science behind AM: Is there nothing below 100Hz?

- The wind industry has long ignored acoustic emissions below 20Hz, although frequencies below 20 Hz can be heard or otherwise perceived by the human ear
- With the emergence of the EAM problem the industry now ignores any acoustic emissions below 100 Hz. In the 513 pages of the ReUK 2013 report the only references to lower frequencies are emphatic assertions of their irrelevance
- The Salford University listening room tests described in the ReUK report use real wind turbine noise recordings but use a high pass filter to remove all traces of sound at frequencies below 100Hz; an extraordinary effort to remove something which, it is claimed, does not exist



Independent Noise Working Group

# Amplitude Modulation Study Findings

## Control of AM: WP5

Five methods were tested:

- ReUK template planning condition
- RES proposal for Den Brook
- Original Den Brook condition
- Japanese DAM rating method
- BS4142:2014



Independent Noise Working Group

# Amplitude Modulation Study Findings

## **Control of AM: ReUK template planning condition**

- **The ReUK template planning condition was found to be significantly flawed including imprecise wording, inability to filter extraneous noise and false negatives**
- **Application of a simple decibel penalty applied to existing ETSU limits was found not to enforce control over impact in the most serious and significant of cases**
- **Concluded that the ReUK method is unfit for purpose**



Independent Noise Working Group

# Amplitude Modulation Study Findings

## Control of AM: RES proposal

- Methodology proposed by RES for Den Brook like the ReUK method is flawed including imprecise wording, an inability to filter extraneous noise, false positives and also false negatives
- The values of AM that are derived by the RES method do not relate to the A weighted modulation depth or subjective impression
- **Concluded the RES method is unfit for purpose**



Independent Noise Working Group

# Amplitude Modulation Study Findings

## Control of AM: Original Den Brook condition

- The original Den Brook EAM condition was found to work well with the data from all six sites tested and successfully identified EAM without being influenced by extraneous noise
- Success depends on its interpretation and implementation. It is implicit that it should not be used as a simple trigger value and that an assessment of frequency and duration must be made
- This is consistent with other UK planning noise controls and guidance on enforcement policy



Independent Noise Working Group

# Amplitude Modulation Study Findings

## Control of AM: DAM method

- **The Japanese DAM rating method is not a condition but a rating method. Though influenced by extraneous noise, it works well to identify periods of EAM and periods of borderline AM**
- **It successfully identified EAM and distinguished between borderline periods of unobtrusive AM and EAM**



Independent Noise Working Group

# Amplitude Modulation Study Findings

## Control of AM: BS4141:2014

- **BS4142** has previously been dismissed, both in ETSU and by others, as an inappropriate means of control for wind farm noise. The issues raised to support this argument have been examined and found inapplicable to the new version of the standard (2014)
- **BS4142:2014** was found to work very well for assessment and control of cumulative wind farm noise and character impact, subject to the need for an additional mechanism where there is significant LFN which it does not address
- **BS4142 is advantageous over separate EAM assessment methods as it assesses noise level and character simultaneously and in context with the character of the area**



Independent Noise Working Group

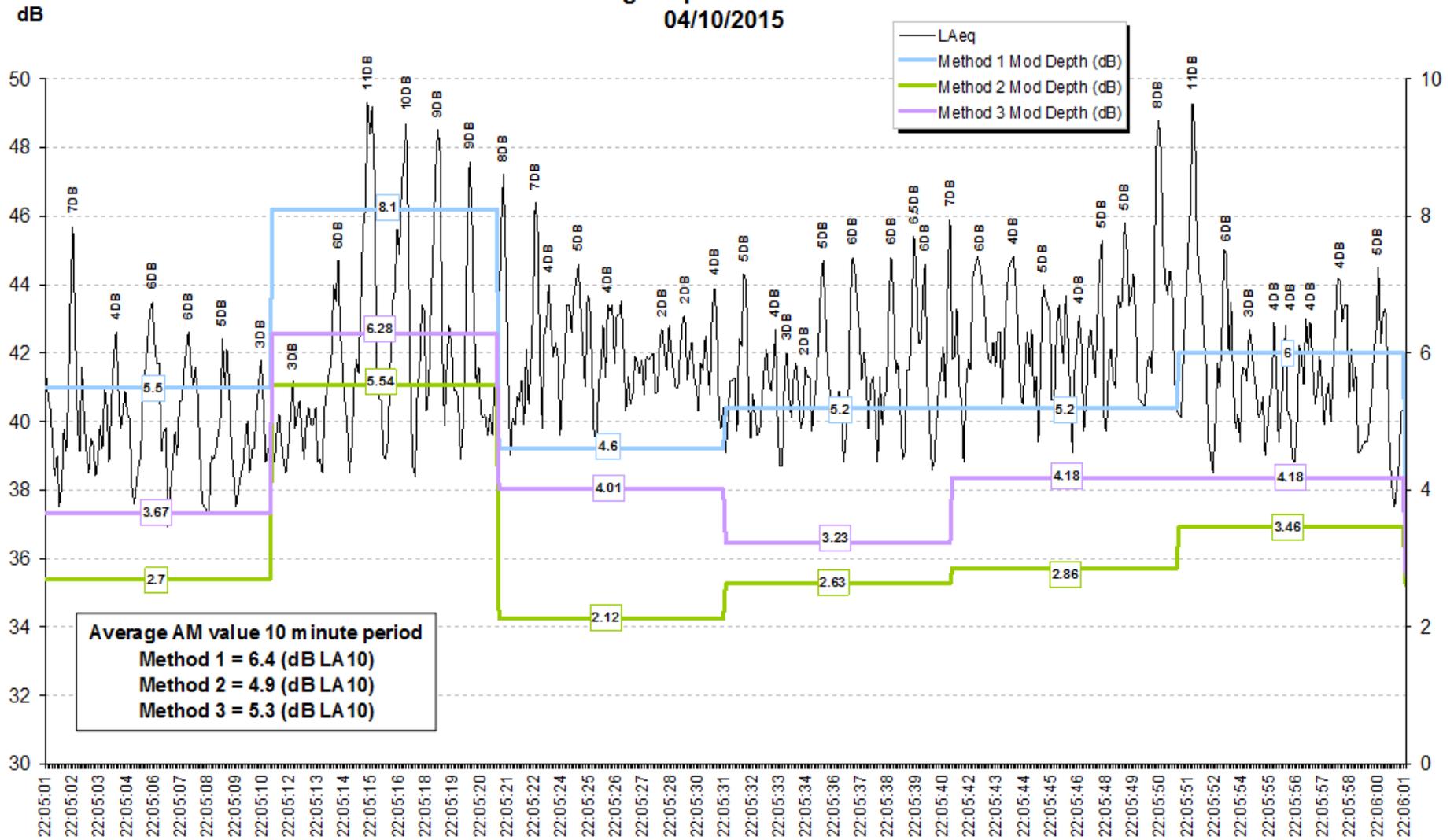
# Amplitude Modulation Study Findings

## Control of AM: IoA AMWG proposal

- **WP7 (to be released later)** tests the effectiveness of the AM rating methodology proposed by the IoA AMWG
- Despite acknowledging numerous characteristics of EAM that determine psycho-acoustical response including, modulation depth, rise time, frequency content, the AMWG have focused only on modulation depth
- **The results from preliminary testing indicate that all three methods proposed by the AMWG present significant problems where they do not reflect or mirror impact.** WP7 will also test in more detail the as yet to be released IoA AMWG final AM rating methodology

04/10/2015 22:05

### Noise Monitoring Graph - Cotton Farm Wind Farm 04/10/2015





Independent Noise Working Group

# Amplitude Modulation Study Findings

## Wind industry response

- **WP8 reviews the activities of the IoA Noise Working Groups with respect to WT noise AM**
- **Clear evidence that for two decades the NWGs now under the IoA have continued to operate for the benefit of the wind industry and to the detriment of local communities hosting wind turbines**
- **This is arguably against both the IoA Code of Ethics and that of the Engineering Council**
- **Whether or not this behaviour is carried forward into the future remains to be seen (Oct 2015)**



Independent Noise Working Group

## **Amplitude Modulation Study Recommendations**

- **ETSU noise guidance to be replaced with a code of practice based on BS4142:2014**
- **Independent research is required into the health effects of wind turbine noise including EAM and LFN**
- **An effective AM planning condition required for every wind turbine planning approval**



Independent Noise Working Group

## **Amplitude Modulation Study Recommendations**

- **Continuous noise monitoring (with data transparency) should be required for every medium & large wind turbine planning approval**
- **Effective remedy required for retrospectively dealing with noise nuisance including EAM from existing wind turbines**
- **Government should disassociate itself from the IoA until the conflict of interest and ethics issues are resolved and full transparency restored**



Independent Noise Working Group

## Wind Turbine Amplitude Modulation and Planning Control Study

INWG report download:

<http://www.heatonharris.com/reports-publications>

INWG contact: [wind-noise@tsp-uk.co.uk](mailto:wind-noise@tsp-uk.co.uk)

