ProPG PLANNING &NOISE

New Residential Development

Noise Events

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Birmingham

22nd June 2017

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Institute of Acoustics

Chartered Institute of Environmental Health

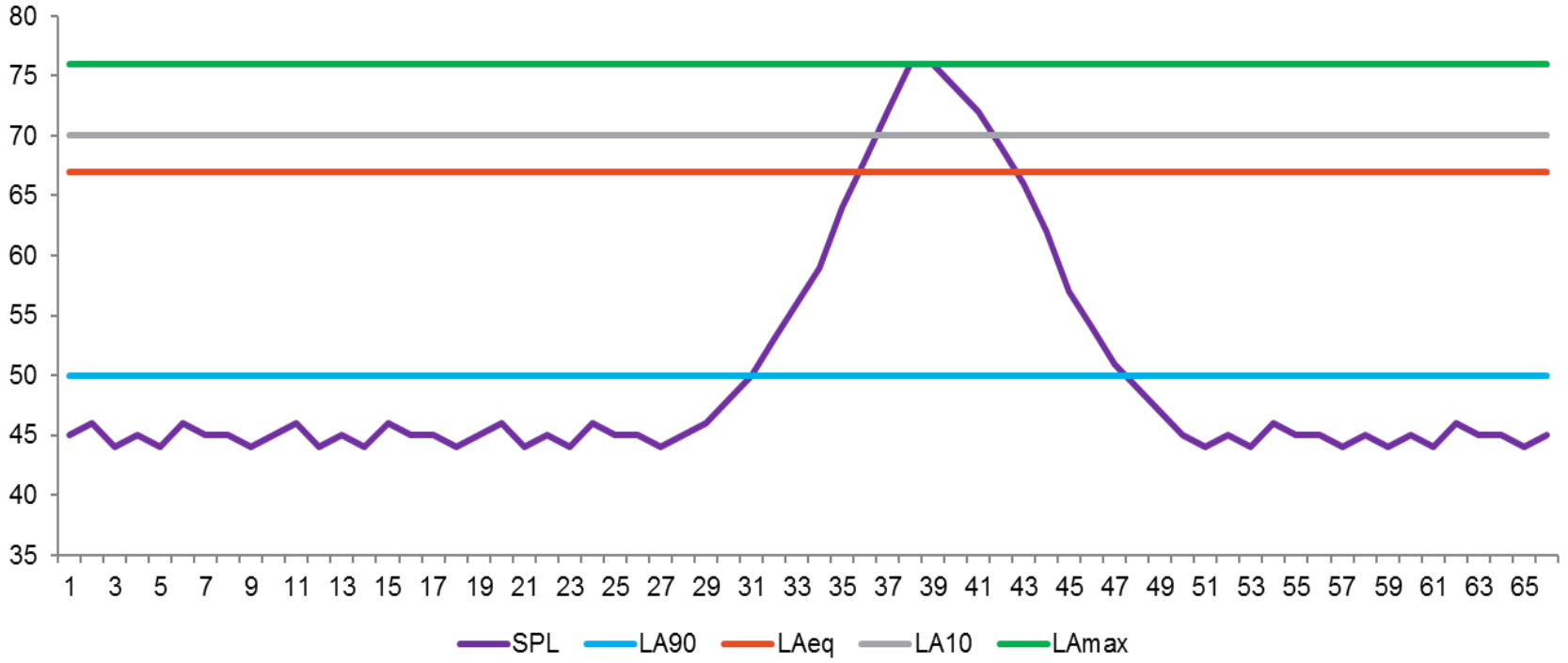
NOISE EVENTS

This presentation will cover

- WHAT IS A NOISE EVENT?
- WHY ARE NOISE EVENTS IN THE ProPG?
- SLEEP STRUCTURE AND CYCLE
- HOW DO NOISE EVENTS EFFECT SLEEP?
- RESEARCH ON NOISE EVENTS AND SLEEP
- POLICY AND GUIDANCE RELEVANT TO NOISE EVENTS
- HOW THE ProPG DEALS WITH NOISE EVENTS?

NOISE EVENT

"A DISCRETE ACTIVITY GIVING RISE TO A NOTICEABLE INCREASE IN SPL ABOVE, AND THEN A RETURN TO, TYPICAL AMBIENT CONDITIONS E.G. TRAIN OR VEHICLE PASS-BY, AIRCRAFT OVERFLIGHT ETC."



WHY ARE NOISE EVENTS IN THE ProPG?

THE SUBSTANTIAL MAJORITY OF RESPONDENTS TO THE 2016 CONSULTATION ON THE DRAFT PROPG AGREED WITH THE APPROACH TAKEN TO DEALING WITH NOISE EVENTS.

HOWEVER, A SMALL MINORITY EITHER:

- **DISPUTED WHETHER NOISE EVENTS WERE IMPORTANT.**
- **ALLEGED THAT THE APPROACH TAKEN IN THE DRAFT WAS TOO LENIENT.**
- **CLAIMED THAT THE APPROACH TAKEN IN THE DRAFT WAS TOO ONEROUS.**

IN RESPONSE TO THE CONSULTATION THE WORKING GROUP DECIDED:

- **THERE WAS NO NEED TO FUNDAMENTALLY DIVERT FROM THE APPROACH IN THE DRAFT; AND,**
- **TO PROVIDE AN APPENDIX EXPLAINING THE BACKGROUND TO THE APPROACH IN MORE DETAIL.**

WHY ARE NOISE EVENTS IMPORTANT?

THE WHO GUIDELINES FOR COMMUNITY NOISE AND BS 8223 RECOGNISE THAT RESEARCH SHOWS THAT ASSESSING THE EFFECTS OF NOISE ON SLEEP ONLY IN TERMS OF OVERALL ENERGY AVERAGING METRICS, SUCH AS THE $L_{AEQ,T,}$ CAN BE INSUFFICIENT TO ADDRESS ALL NOISE RELATED SLEEP IMPACTS. E.G.

"THE EQUIVALENT NOISE LEVEL SEEMS TO BE A SUITABLE PREDICTOR FOR SUBJECTIVELY EVALUATED SLEEP QUALITY BUT NOT FOR PHYSIOLOGICAL DISTURBANCES OF SLEEP"[1].

E.G. 1. B Griefahn, A Marks, C Kuenemund & M Basner, awakenings by road, rail and air traffic noise, forum acusticum, 2005.

WHY ARE NOISE EVENTS IMPORTANT?

MANY STUDIES[2] HAVE SHOWN CLEAR EXPOSURE RESPONSE RELATIONSHIPS BETWEEN THE MAXIMUM LEVEL OF INDIVIDUAL NOISE EVENTS AND IMPACTS DURING SLEEP.

IMPACT = AROUSALS, AWAKENINGS OR BODY MOVEMENTS.

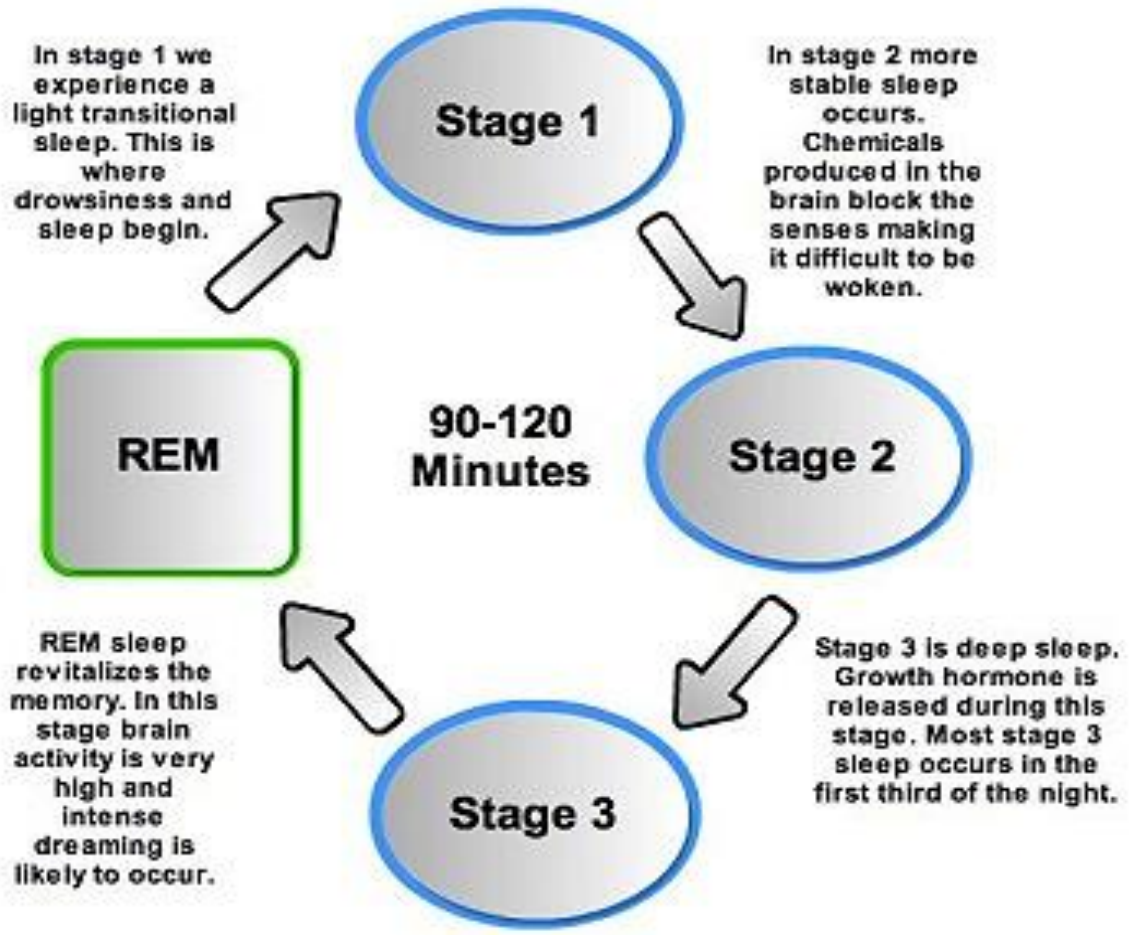
THEREFORE IT'S OFTEN APPROPRIATE TO SUPPLEMENT THE ASSESSMENT OF OVERALL NOISE LEVELS AT NIGHT MEASURED USING THE $L_{AEQ,T}$ INDEX BY ALSO CONSIDERING NOISE FROM INDIVIDUAL NOISE EVENTS

NOISE EVENTS ARE TYPICALLY DESCRIBED WITH EITHER THE $L_{A,F,MAX,T}$ / $L_{A,S,MAX,T}$; OR SEL NOISE METRICS.

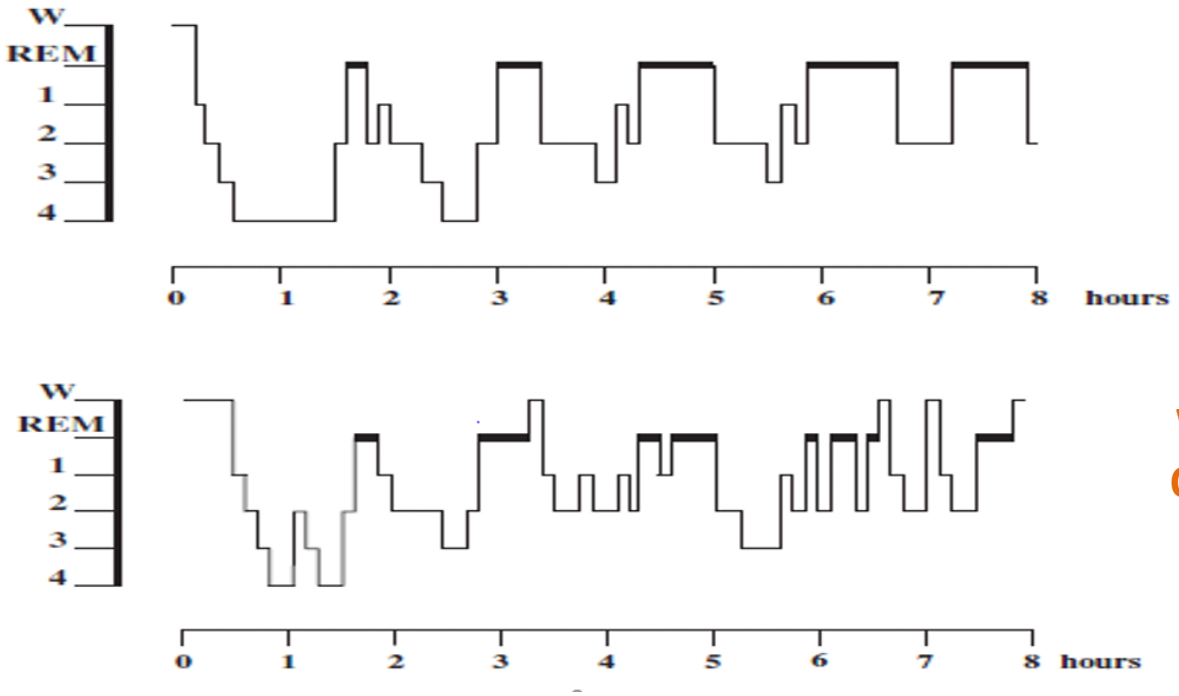
2. E.G. BASNER M, ISERMANN U, ELMENHOTRST D ET AL. EFFECTS OF NOCTURNAL AIRCRAFT NOISE (VOL1): EXECUTIVE SUMMARY. DEUTSCHES ZENTRUM FUR LUFT-UND RUAMFARHT (DLR) COLOGNE, GERMANY 2004:FB2004-07/E; MARKS A, GRIEFAHN B, BASNER M, EVENT RELATED AWAKENINGS CAUSED BY NOCTURNAL TRANSPORTATION NOISE. NOISE CONTROL ENG J, 2008; 31:569-77; AND, PASSCHIER-VERMEER, VOS H, STENBEEKEERS, J H M, VAN DER PLOEG FD, GROOTHUIS-OUDSHOORN K. SLEEP DISTURBANCE AND AIRCRAFT NOISE EXPOSURE EFFECT RELATIONSHIPS. TNO NETERLANDS 2002: REPORT 2002.027:1-245.

SLEEP CYCLE

THE NOISE LEVEL THRESHOLD FOR AWAKENING IS HIGHEST IN THE STAGE 3 AND REM STAGES OF HEAVY SLEEP, AND IS LOWER IN THE LIGHT SLEEP STAGES 1 AND 2 .



EFFECTS OF NOISE ON SLEEP

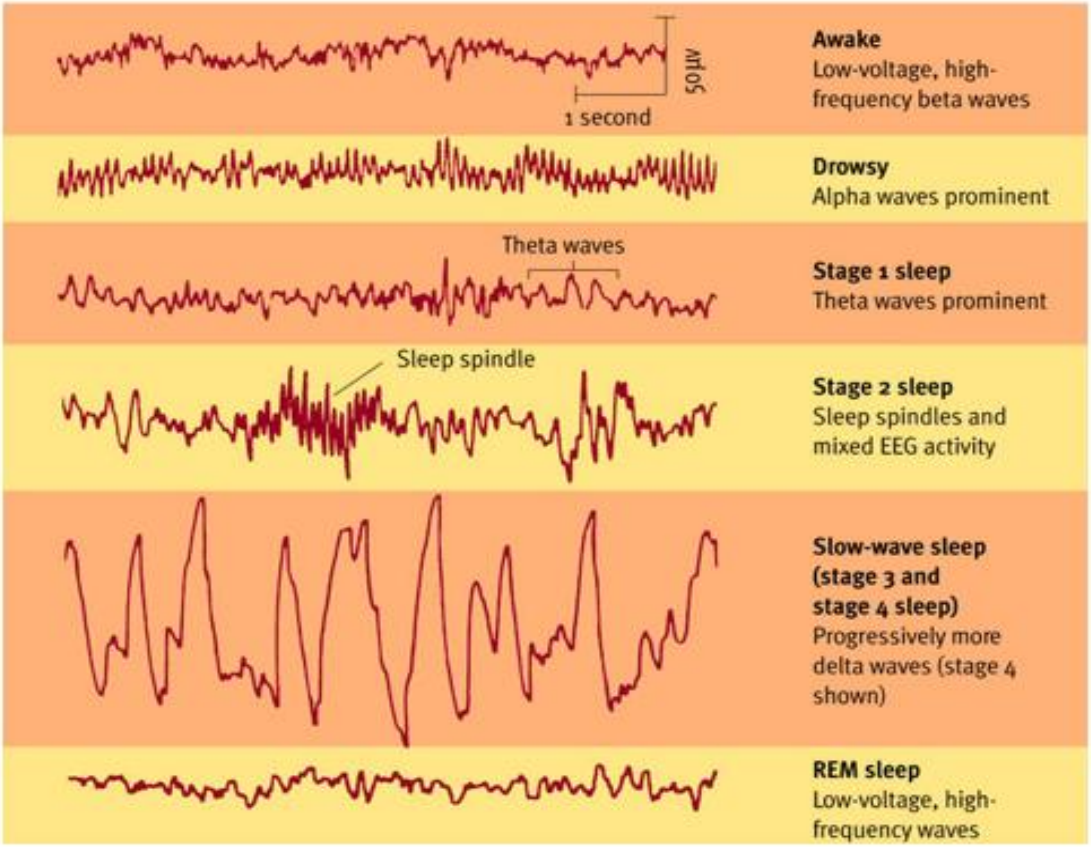


AS UNDISTURBED SLEEP PROGRESSES LIGHT SLEEP STAGES 1 AND 2 GET SHORTER, AND DEEP SLEEP STAGES 3/4 AND REM SLEEP LENGTHEN

WITH NOISE DISTURBED SLEEP ONSET IS DELAYED, DEEP SLEEP STAGES 3/4 AND REM ARE FRAGMENTED AND AWAKENING OCCURS

From - Alain Muzet, Environmental noise, sleep and health, Sleep Medicine Reviews (2007) 11, 135–142

MEASURING SLEEP



AWAKENING

IN ORDER TO UNDERSTAND THE EFFECTS OF NOISE ON SLEEP IT IS IMPORTANT TO DISTINGUISH BETWEEN VARIOUS KINDS OF AWAKENING, FOR EXAMPLE:

- **BEHAVIOURAL AWAKENING - EQUIVALENT TO THE EVERYDAY UNDERSTANDING OF CONSCIOUS 'AWAKENING', WHEN THE SUBJECT IS USUALLY AWARE OF BEING CONSCIOUS AT THE TIME AND CAN OFTEN RECALL BEING "AWAKE" THE NEXT DAY;**

- **PHYSIOLOGICAL AWAKENING - DEFINED BY CHANGES IN SLEEP STAGES MEASURED BY A POLYSOMNOGRAPH OR AN EEG, WHICH THE SUBJECT MAY NOT BE AWARE OF AT THE TIME OR RECALL THE NEXT DAY, AND;**

- **THE 'ONSET AND DEGREE OF "MOTILITY" I.E. BODY MOVEMENTS – TYPICALLY MEASURED USING WRIST WATCH LIKE ACTIMETERS TO RECORD MOVEMENT WHICH THE SUBJECT MAY NOT BE AWARE OF AT THE TIME OR RECALL THE NEXT DAY.**

AWAKENING

AT A PHYSIOLOGICAL LEVEL SLEEP DISTURBANCE DUE TO NOISE CAN OCCUR, ALTHOUGH BEHAVIOURAL AWAKENING MAY NOT RESULT.

IN OTHER WORDS, THERE ARE NOISE IMPACTS ON SLEEP THAT CAN BE MEASURED BY EXAMINING CHANGES IN EEG BRAIN WAVE PATTERNS OR A PERSON'S MOTILITY, BUT THE PERSON WOULD NOT NECESSARILY BE AWARE OF THESE IMPACTS, AND THESE IMPACTS MAY NOT HAVE ADVERSE OR SIGNIFICANT ADVERSE PATHOLOGICAL EFFECTS.

THEREFORE CARE SHOULD BE TAKEN WHEN CONSIDERING THE SIGNIFICANCE OF IMPACTS ON SLEEP DETECTABLE AT A PHYSIOLOGICAL LEVEL THAT MAY OCCUR OR APPEAR TO OCCUR AS A RESULT OF NOISE EVENTS, AS THEY CAN BE PART OF NORMAL SLEEP, AND MAY NOT REFLECT SIGNIFICANT PATHOLOGICAL EFFECTS OR EVEN THE IMPACT OF NOISE (BECAUSE THEY ARE PART OF NORMAL SLEEP).

POLICY AND GUIDANCE

THE DISTINCTION BETWEEN DETECTABLE IMPACTS AND THE ADVERSE AND SIGNIFICANT ADVERSE EFFECTS OF NOISE ON SLEEP IS HIGHLIGHTED IN THE GOVERNMENT'S PLANNING PRACTICE GUIDANCE WHICH STATES THAT:

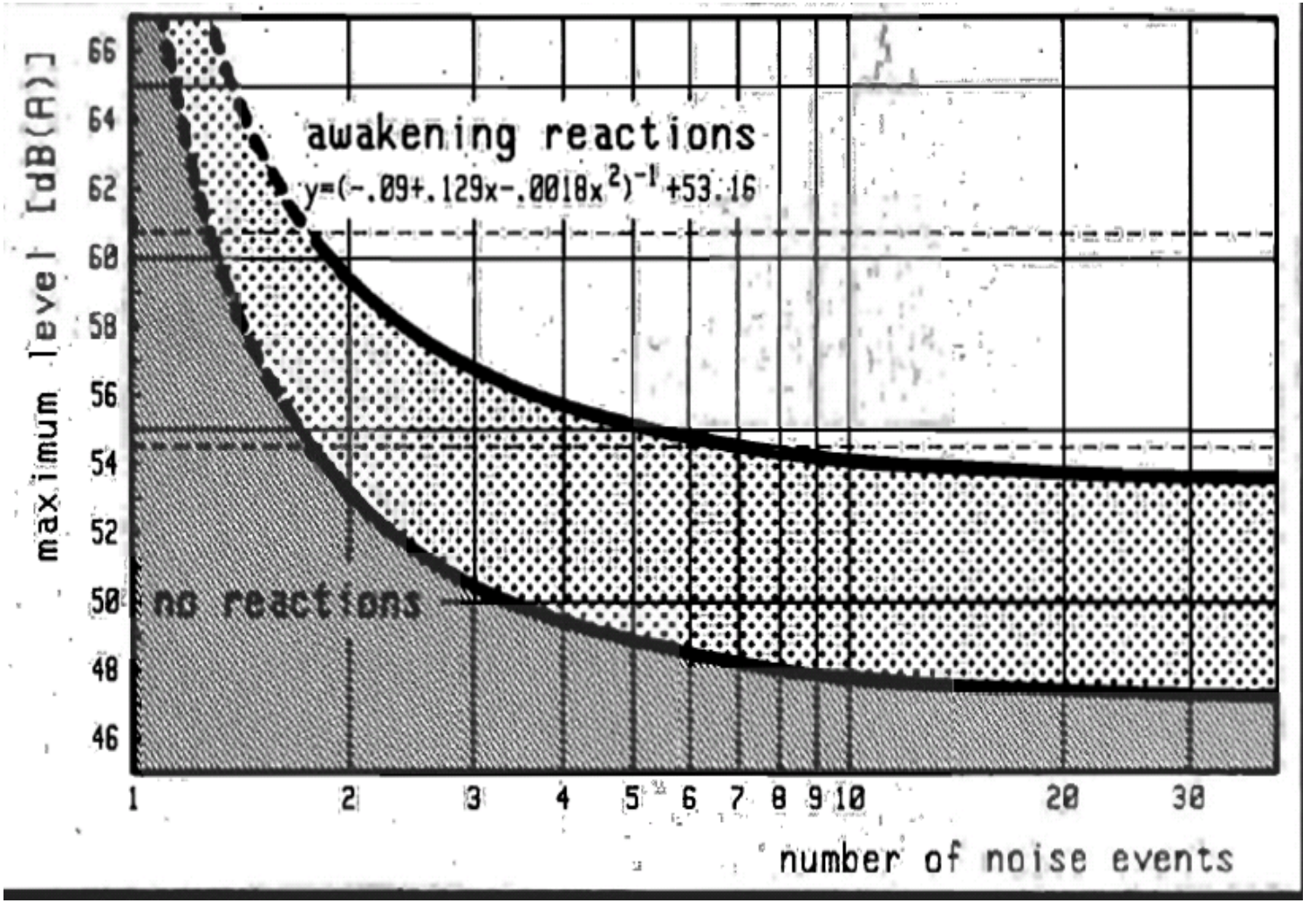
- **NOTICEABLE AND INTRUSIVE NOISE WITH THE "*POTENTIAL FOR SOME REPORTED SLEEP DISTURBANCE*" IS AN "OBSERVED ADVERSE EFFECT" THAT SHOULD BE MITIGATED AND REDUCED TO A MINIMUM, AND;**

- **NOTICEABLE AND DISRUPTIVE NOISE WITH THE "*POTENTIAL FOR SLEEP DISTURBANCE RESULTING IN DIFFICULTY IN GETTING TO SLEEP, PREMATURE AWAKENING AND DIFFICULTY IN GETTING BACK TO SLEEP*" IS A "SIGNIFICANT OBSERVED ADVERSE EFFECT" THAT SHOULD BE AVOIDED, AND;**

- **NOTICEABLE AND VERY DISRUPTIVE NOISE THAT CAUSES "*REGULAR SLEEP DEPRIVATION/AWAKENING*" IS A "SIGNIFICANT OBSERVED ADVERSE EFFECT" THAT SHOULD BE PREVENTED.**

NOISE EVENTS & SLEEP

From: B Grieffahn. Noise control during the night. Proposals for Continuous and Intermittent Noise. Acoustics Australia. Vol 20 No 2 43 -47; 1992



NOISE EVENTS & SLEEP

CONSEQUENTLY, THE L_{AMAX} OF NOISE EVENTS PLUS THE NUMBER OF EVENTS CAN BE USED AS THE BASIS OF ASSESSING IMPACT; ALTHOUGH THIS IS SUBJECT TO AN UPPER LIMIT E.G. $L_{AEQ,T}$.

E.G. THE WHO COMMUNITY NOISE GUIDELINES RECOMMENDATION THAT PEAK NOISE IN BEDROOMS SHOULD NOT EXCEED 45 DECIBELS $L_{A,F,MAX}$ MORE THAN 10 TO 15 TIMES PER NIGHT

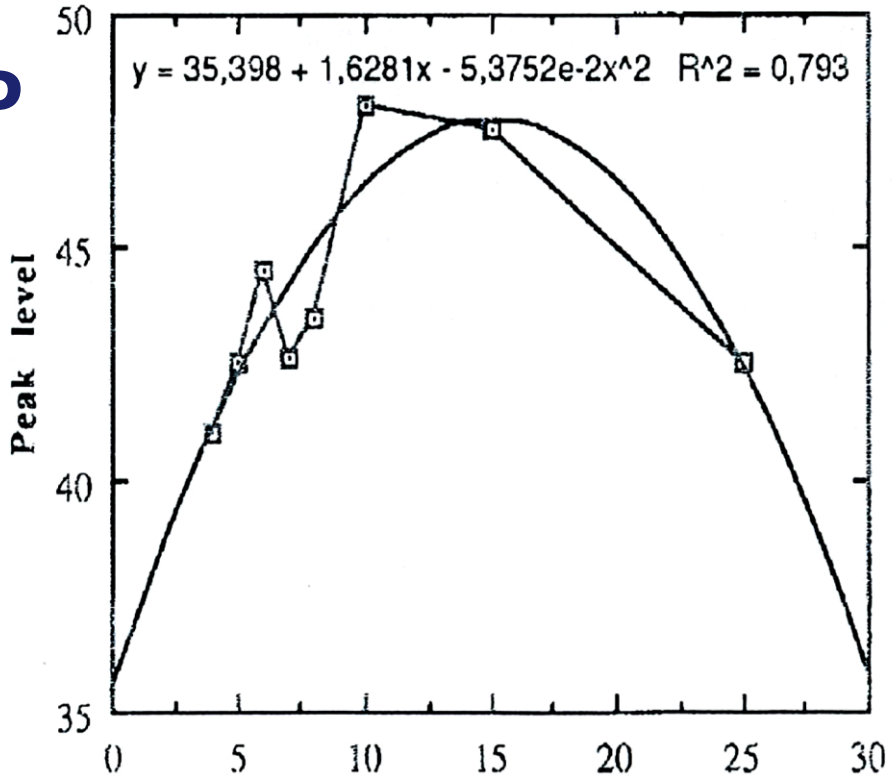
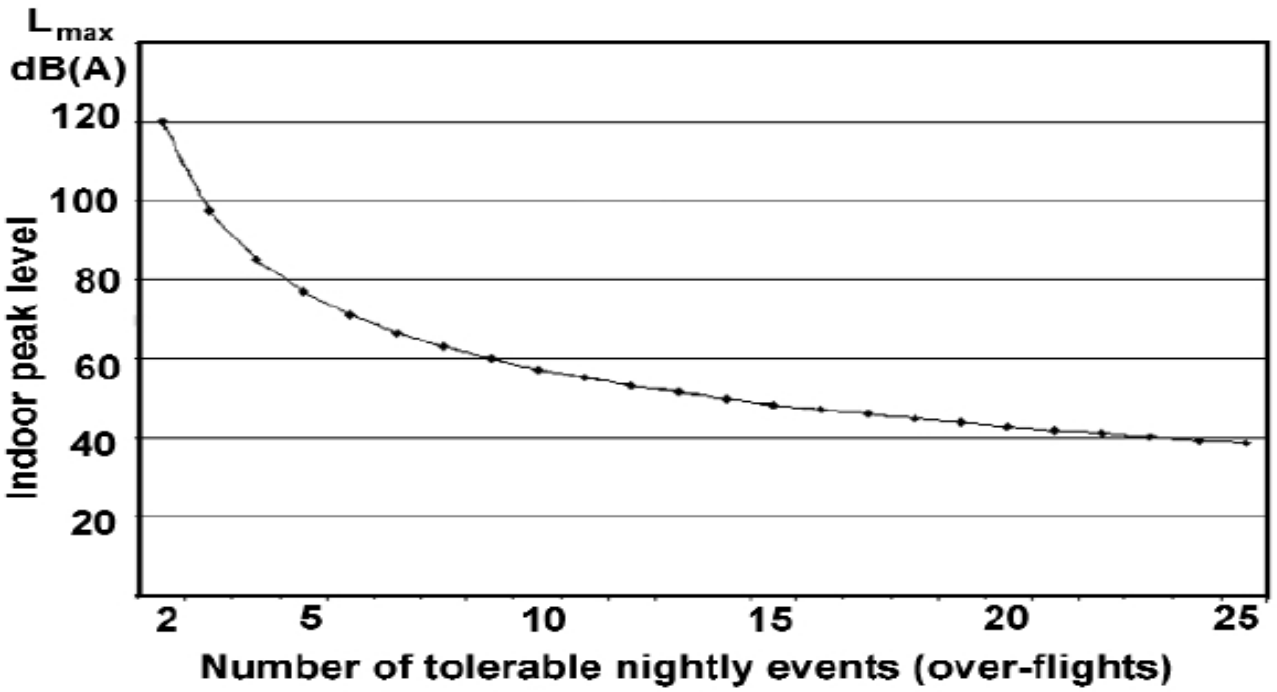


Figure : 2

From: Vallet M and Vernet, 1991, Night aircraft noise index and sleep research results. In A. Lawrence (ed.), Inter-Noise '91.

NOISE EVENTS & SLEEP



From: Spreng, M. (2002) Corticol excitation, cortisol excretion, and estimation of tolerable nightly overflights. Noise and health. (4) 39-46,

WORK HAS DEMONSTRATED THAT THE NUMBER OF TOLERABLE NIGHT NOISE EVENTS RANGES FROM 10 TO 15 PER NIGHT FOR INDOOR L_{AMAX} NOISE LEVELS OF AROUND 55 dB TO 45 dB RESPECTIVELY

NOISE EVENTS & SLEEP

"GIVEN A CERTAIN EQUIVALENT NOISE LEVEL, ADDITIONAL INFORMATION [I.E. L_{AMAX} DATA] *ON THE OVERALL NUMBER OF EVENTS DOES NOT IMPROVE THE PREDICTION OF SLEEP QUALITY. HOWEVER, THE NUMBER OF EVENTS ABOVE L_{AMAX} OF 60 DECIBELS WAS RELATED TO AN INCREASE IN MEAN MOTILITY, INDICATING LOWER SLEEP QUALITY."*

From: S.A. Janssen et al. The effect of the number of aircraft noise events on sleep quality. Applied Acoustics 84 (2014) 9–16

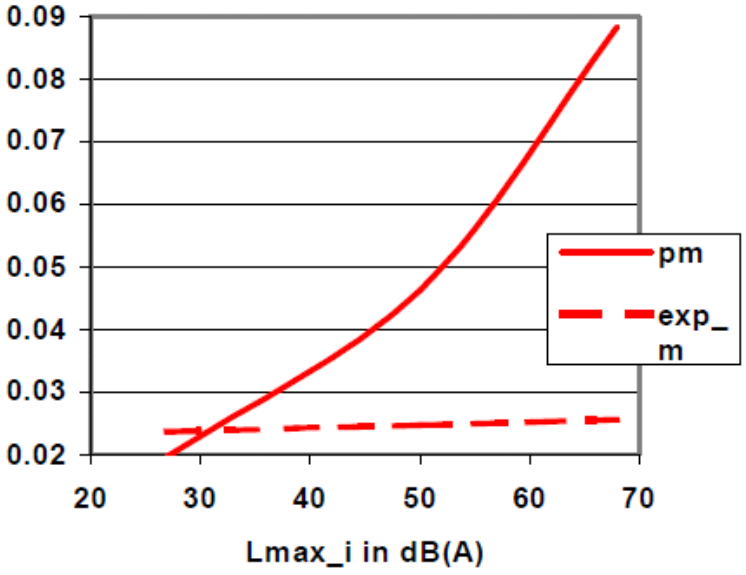
Number of events above L_{Amax} cut-off	*B*	−2 Log Likelihood
⩾25 dB	−0.001	–
⩾30 dB	−0.001	–
⩾35 dB	−0.001	–
⩾40 dB	0.001	–
⩾45 dB	0.002	–
⩾50 dB	0.005	–
⩾55 dB	0.011	–
⩾60 dB	0.056***	14145***
⩾65 dB	0.154***	14137***
⩾70 dB	0.876***	14135***

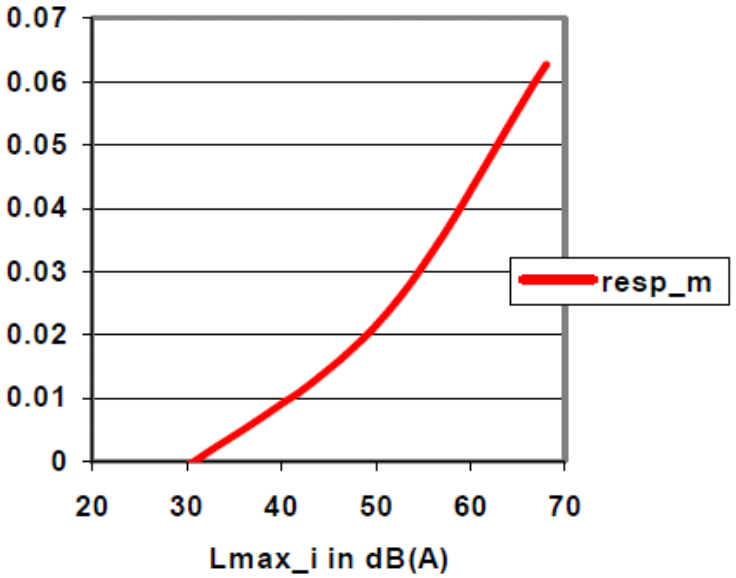
*** Significant at the 0.001 level (2-tailed).

NOISE EVENTS

HOWEVER, THERE IS RESEARCH THAT INDICATES IMPACTS OF INDIVIDUAL NOISE EVENTS ON SLEEP HAVE BEEN FOUND AT RELATIVELY LOW MAXIMUM NOISE LEVELS.

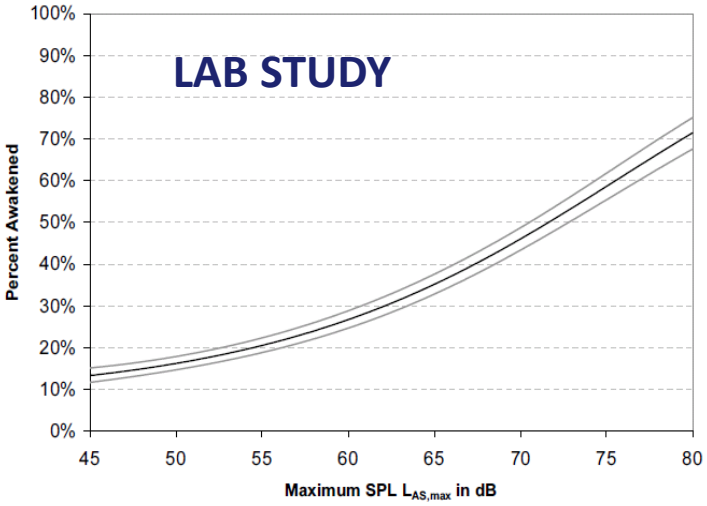
FOR EXAMPLE STUDIES HAVE FOUND THAT *"THE THRESHOLD OF AIRCRAFT NOISE-INDUCED MOTILITY DURING EVENTS IS L_{AMAX} INDOOR OF 32 DECIBELS,".*

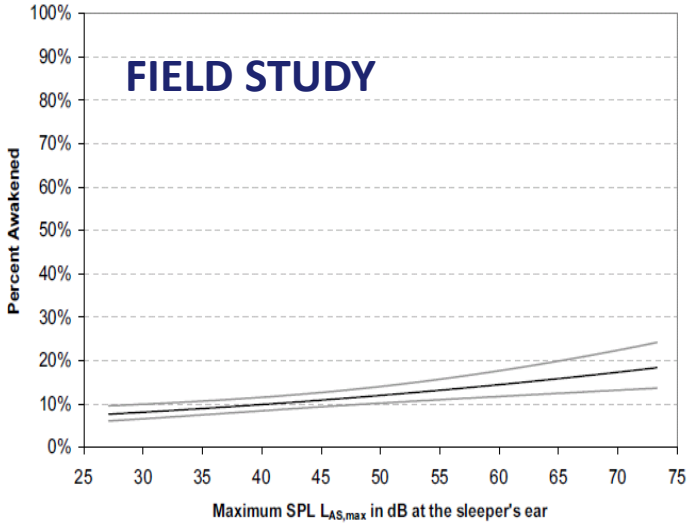




From: Passchier-Vermeer W. et al. 2002. Sleep disturbance and aircraft noise exposure, Exposure effects relationships, TNO report 2002-027;

NOISE EVENTS & SLEEP





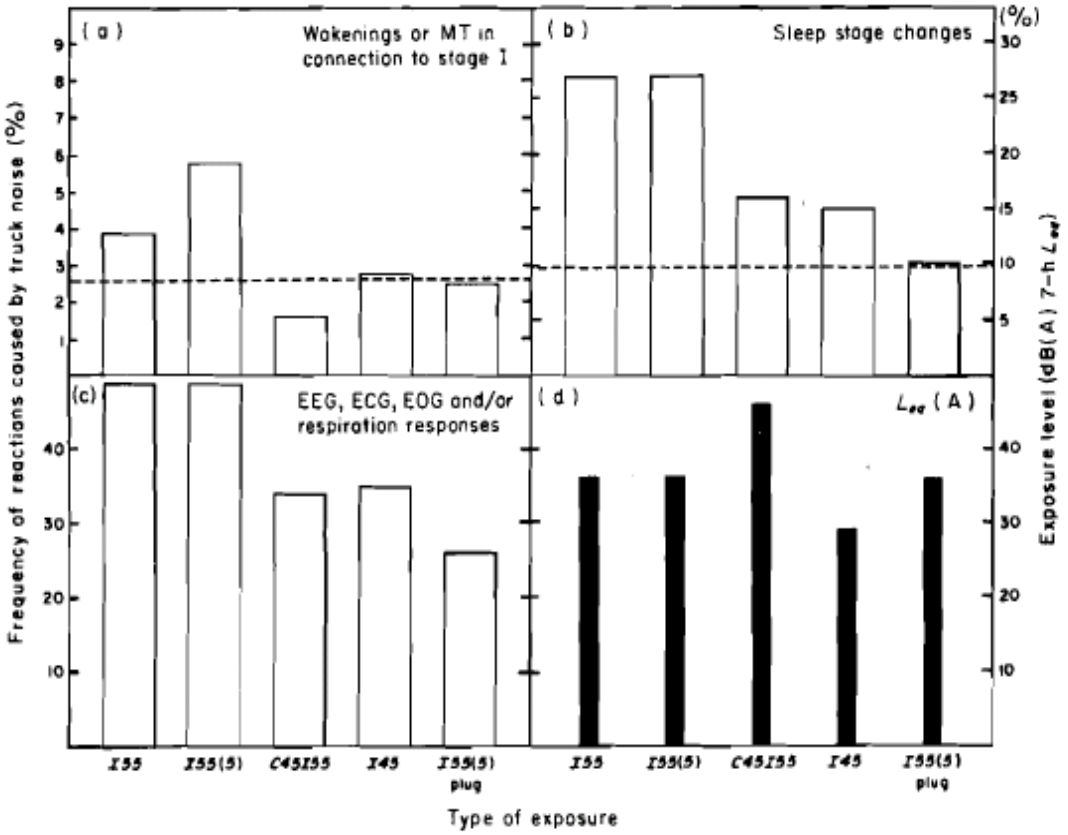
"IN THE FIELD THE PROBABLY OF AWAKENING AT AN L_{AMAX} NOISE LEVEL AT THE EAR OF AROUND 27 dB WAS 7.2% AND ROSE TO ONLY 18.4% AT AROUND L_{AMAX} 73 dB."

From: Basner. M et al. Aircraft noise effects on sleep: Final results of DLR laboratory and field studies of 2240 polysomnography recorded subject nights, 3rd International Congress and Exposition on Noise Control Engineering (Internoise 2004). Prague/Czech Republic . 2004

NOISE EVENTS & SLEEP

IN A LABORATORY STUDY ON THE EFFECTS OF BOTH INTERMITTENT AND CONTINUOUS ROAD TRAFFIC NOISE, THE NOISE OF 50 LORRY PASS-BYS OF BOTH 45 AND 55 dB L_{AMAX} WAS PRESENTED AND EEG TRACES EXAMINED.

- **CHANGES IN SLEEP STAGES WERE SEEN FOR THE 45 dB L_{AMAX} LORRY PASS-BYS,**
- **BUT IT REQUIRED THE 55 dB L_{AMAX} PASS-BYS TO INDUCE EEG AWAKENINGS.**



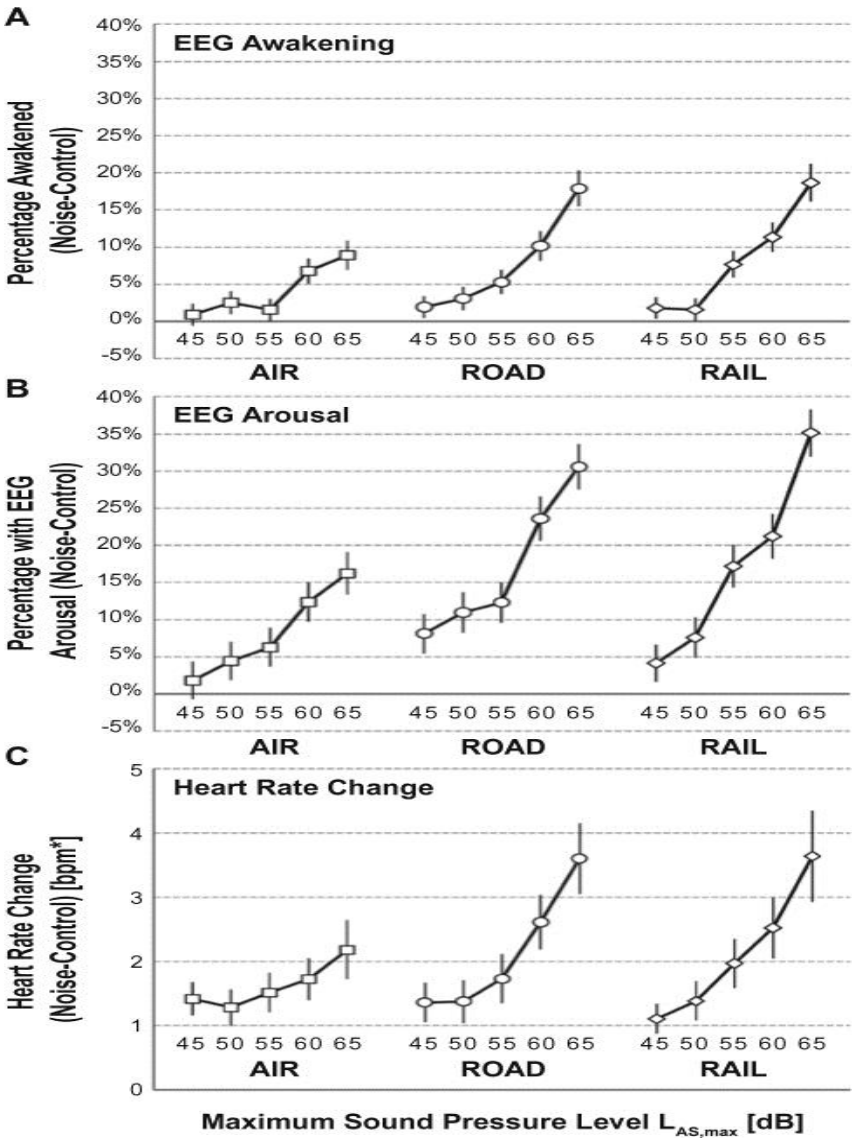
From: Eberhardt JL et al. The influence of continuous and intermittent traffic noise on sleep.. Journal of Sound and Vibration 116(3) 1987.

NOISE EVENTS & SLEEP

AWAKENING AND AROUSAL PROBABILITY DEPEND ON SPL AND TRANSPORT MODE.

- *FOR ALL 3 MODES BOTH EXCESS AWAKENING AND AROUSAL PROBABILITY WERE MORE PRONOUNCED FOR NOISE LEVELS ≥ 55 dB $L_{A,S,MAX}$*
- *AROUSAL PROBABILITY WAS ON AVERAGE 2.6 TIMES HIGHER THAN AWAKENING PROBABILITY.*
- *AWAKENING AND AROUSAL PROBABILITY OF ROAD AND RAIL TRAFFIC NOISE WERE HIGHER* COMPARED TO AIRCRAFT NOISE.

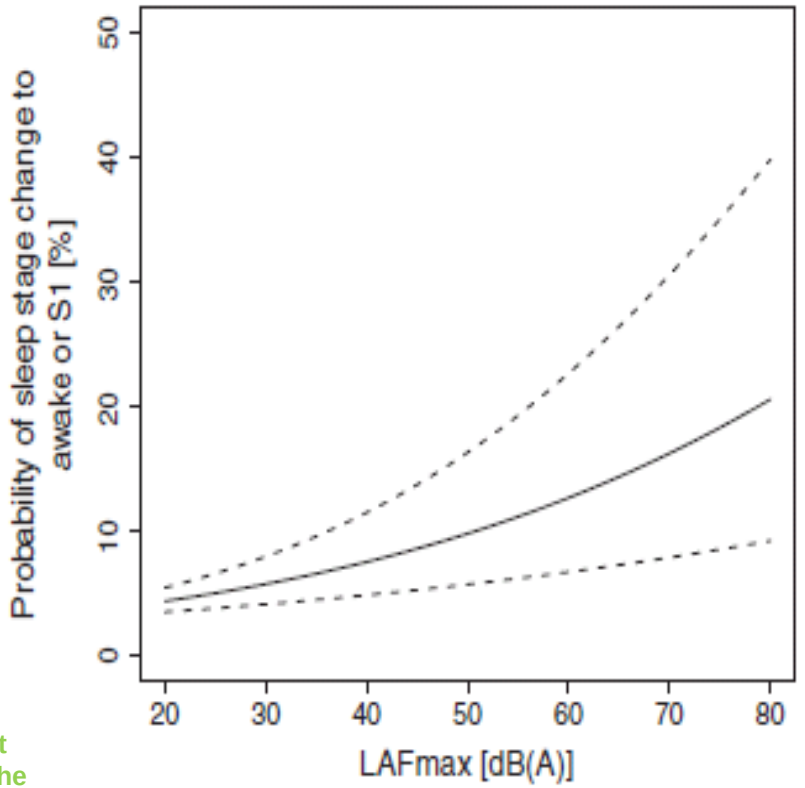
E.g. Basner M; Müller U; Elmenhorst EM. Single and combined effects of air, road, and rail traffic noise on sleep and recuperation. SLEEP 2011;34(1):11-23.



NOISE EVENTS & SLEEP

FOR RAIL NOISE BEHAVIOURAL AWAKENING, IS LIKELY TO OCCUR WHERE THE MAXIMUM SOUND LEVEL AT THE FAÇADE OF A BUILDING WITH PARTIALLY OPEN WINDOWS IS ABOVE:

- **85 dB $L_{P,A,F,MAX}$ (WHERE THE NUMBER OF EVENTS EXCEEDING THIS VALUE IS LESS THAN OR EQUAL TO 20); OR,**
- **80 dB $L_{P,A,F,MAX}$ (WHERE THE NUMBER OF EVENTS EXCEEDING THIS VALUE IS GREATER THAN 20).**



E.g. E-M. Elmenhorst, et al (2012), Examining nocturnal railway noise and aircraft noise in the field: sleep, psychomotor performance and annoyance. Science of the Total Environment, 424;

SUMMARY

- THE IMPACTS ON SLEEP CAN BE DETECTED FROM RELATIVELY LOW LEVEL MAXIMUM NOISE EVENTS. HOWEVER, THE RESULTING HARM MAY NOT BE SIGNIFICANT.

- 'EFFECTS' ON SLEEP OCCUR SPONTANEOUSLY IN THE GENERAL POPULATION MANY TIMES PER NIGHT REGARDLESS OF ANY IMPACTS DUE TO NOISE;

- THE SMALLER THE NUMBER OF NOISE EVENTS, THE LOUDER THE MAXIMUM NOISE LEVEL THAT CAN BE TOLERATED WITHOUT ADVERSE EFFECTS UPON SLEEP;

- THE EFFECTS OF NOISE EVENTS ON SLEEP DEPEND NOT ONLY ON THE MAXIMUM LEVEL BUT ALSO FACTORS INCLUDING:

    - TYPE OF NOISE SOURCE
    - THE SPEED OF ONSET ("RISE TIME") OF THE MAXIMUM LEVEL
    - THE UNDERLYING AMBIENT NOISE LEVEL

SUMMARY

- AT LOW LEVELS E.G. AROUND 45 dB $L_{A,F,MAX}$ INDOORS THE ADVERSE EFFECTS ARE LIKELY TO BE LIMITED TO CHANGES IN SLEEP STATE OR EEG AWAKENINGS;

- IT NORMALLY REQUIRES HIGHER NOISE LEVELS HIGHER THAN 45 dB $L_{A,F,MAX}$ INDOORS BEFORE SIGNIFICANT ADVERSE EFFECTS SUCH AS BEHAVIOURAL AWAKENINGS, DIFFICULTY GETTING TO SLEEP, PREMATURE AWAKENING OR DIFFICULTY GETTING BACK TO SLEEP OCCUR.

- MEASURING THE MAXIMUM NOISE LEVELS OF NOISE EVENTS AND THE NUMBER OF TIMES THEY OCCUR WILL REQUIRE THE USE OF PROFESSIONAL JUDGEMENT TO ENSURE THE MEASUREMENT PERIOD IS APPROPRIATE TO THE NOISE CLIMATE, AS:

    - TOO SHORT A TIME PERIOD MAY RESULT IN EXCESS $L_{A,MAXs}$ FROM THE SAME EVENT.
    - TOO LONG TIME PERIODS MAY NOT CAPTURE THE $L_{A,MAXs}$ FROM A NUMBER OF SEPARATE EVENTS IN A SINGLE PERIOD

WHAT DOES THE ProPG SAY?

APPENDIX A

"IT IS CLEAR, AS RECOGNISED BY BS 8233, THAT THE EFFECTS OF NOISE ON SLEEP FROM INDIVIDUAL NOISE EVENTS ARE AN IMPORTANT CONSIDERATION;" AND,

- *"THE INITIAL SITE NOISE RISK ASSESSMENT SHOULD INCLUDE THE CONSIDERATION OF THE INDIVIDUAL NOISE EVENTS WHEN THE EXTERNAL $L_{A,MAX,F}$ EXCEEDS 60 dB."*
- *"A SITE SHOULD NOT BE REGARDED AS NEGLIGIBLE RISK IF THE $L_{A,MAX,F}$ EXCEEDS, OR IS LIKELY TO EXCEED 60 dB MORE THAN 10 TIMES A NIGHT."*
- *"A SITE SHOULD BE REGARDED AS HIGH RISK IF THE $L_{A,MAX,F}$ EXCEEDS, OR IS LIKELY TO EXCEED 80 dB MORE THAN 20 TIMES A NIGHT."*

WHAT DOES THE ProPG SAY?

APPENDIX A (CONT)

"IN MOST CIRCUMSTANCES IN NOISE-SENSITIVE ROOMS AT NIGHT (E.G. BEDROOMS) GOOD ACOUSTIC DESIGN CAN BE USED SO THAT INDIVIDUAL NOISE EVENTS DO NOT NORMALLY EXCEED 45 DECIBELS $L_{A,MAX,F}$ MORE THAN 10 TIMES A NIGHT.

HOWEVER WHERE IT IS NOT REASONABLY PRACTICABLE TO ACHIEVE THIS GUIDELINE THEN THE JUDGEMENT OF ACCEPTABILITY WILL DEPEND NOT ONLY ON THE MAXIMUM NOISE LEVELS BUT ALSO ON FACTORS SUCH AS THE SOURCE, NUMBER, DISTRIBUTION, PREDICTABILITY AND REGULARITY OF NOISE EVENTS.

IN SUCH A CASE IT IS RECOMMENDED THAT A MORE DETAILED ASSESSMENT SHOULD BE UNDERTAKEN USING AVAILABLE DOSE-RESPONSE RELATIONSHIPS APPROPRIATE FOR THE TYPES OF NOISE SOURCES BEING CONSIDERED, IN LINE WITH THE WHO NNG PUBLICATION AND ANY OTHER RELEVANT RESEARCH.

THIS ASSESSMENT SHOULD ADVISE DECISION MAKERS TO WHAT EXTENT ADVERSE EFFECTS FROM INDIVIDUAL NOISE EVENTS ON SLEEP WILL BE MITIGATED AND MINIMISED, AND REPORT THE LIKELY RESIDUAL EFFECTS ON SLEEP OF AFFECTED PERSONS"

WHAT DOES THE ProPG SAY?

"FURTHER ADVICE FROM THE WHO (E.G. TABLE 1 IN THE WHO NIGHT NOISE GUIDELINES FOR EUROPE) AND THE RELEVANT UNDERLYING STUDIES INDICATES THAT MORE STRINGENT CONTROL OF MAXIMUM NOISE LEVELS COULD ELIMINATE ALL RISK OF ANY DETECTABLE PHYSIOLOGICAL EFFECT I.E. ACHIEVE NOEL – NO OBSERVED EFFECT LEVEL.

HOWEVER, CONTROLLING TO THESE VALUES IS NOT AT PRESENT REQUIRED BY POLICY IN ENGLAND; OR, CONSIDERED TO BE A REALISTIC OR ACHIEVABLE GOAL GIVEN:

- *THERE IS SUBSTANTIAL UNCERTAINTY REGARDING ANY RESULTING SIGNIFICANT PATHOLOGICAL EFFECTS AT THESE LOWER MAXIMUM NOISE LEVELS; AND,*
- *IN THE CONTEXT OF THE CURRENT NIGHT TIME ACOUSTIC ENVIRONMENT ACROSS MOST OF ENGLAND WHICH SHOWS THAT SUCH LOW VALUES ARE LIKELY TO BE EXCEEDED IN BEDROOMS WITH WINDOWS PARTIALLY OPEN IN ALL BUT THE MOST REMOTE AND QUIETEST PARTS OF THE COUNTRY."*