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ADVERSE EFFECTS OF NIGHT-TIME AIRCRAFT NOISE: REVIEW OF 1992 UK FINDINGS AND INTRODUCTION TO NEW UK WORK

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ABSTRACT
This paper considers the potentially adverse effects of night-time aircraft noise on people, compares previous UK findings with more recent research, and identifies a number of issues for further research.

1 - INTRODUCTION

Aircraft noise can adversely affect people living near airports in many ways and concern that night-time noise is detrimental to public welfare is understandable. Employing the broad WHO definition of health, it is evident that night-time environmental noise adversely affects health by causing chronic subjective reactions. However, as yet, there appears to be no hard scientific evidence of clinically significant health impairment, i.e. chronic objective effects. Nevertheless, the possible existence of cause-effect relationships cannot be rejected and it seems that two fundamental questions need to be addressed in the longer term:

- Can night-time aircraft noise cause clinically significant health impairment directly through physiological effects?
- Accepting that night-time environmental noise adversely affects well-being by causing chronic subjective reactions, can these reactions also give rise to objective effects and thus impair health indirectly?

The UK Government continues to support research into the effects of aircraft noise. The Department of the Environment, Transport and the Regions (DETR) are considering if there is a case for a new large-scale study of the adverse effects of night-time aircraft noise (no decision has yet been taken). To help inform a decision NATS Ltd (now CAA) were commissioned to examine the potential adverse effects of noise and future research needs. This paper gives some highlights of the full report [1]. It presents a model that can be used as a framework against which to devise future research and to consider the key questions above, compares previous UK findings with more recent work and identifies issues for future research.

2 - MODEL FRAMEWORK

Figure 1 links various causes and effects of night-time aircraft noise on people living near airports in a conceptual "model framework". This is a considerable simplification of what in reality is a complex web of interactions; it shows what are thought to be the principal elements and connections. It shows the effects developing in four stages:

1. acute responses that include immediate or direct disturbances caused by noise events,
2. total night effects that are aggregations of (1) over the whole night,
3. next day effects that are a result of (1) and (2), and

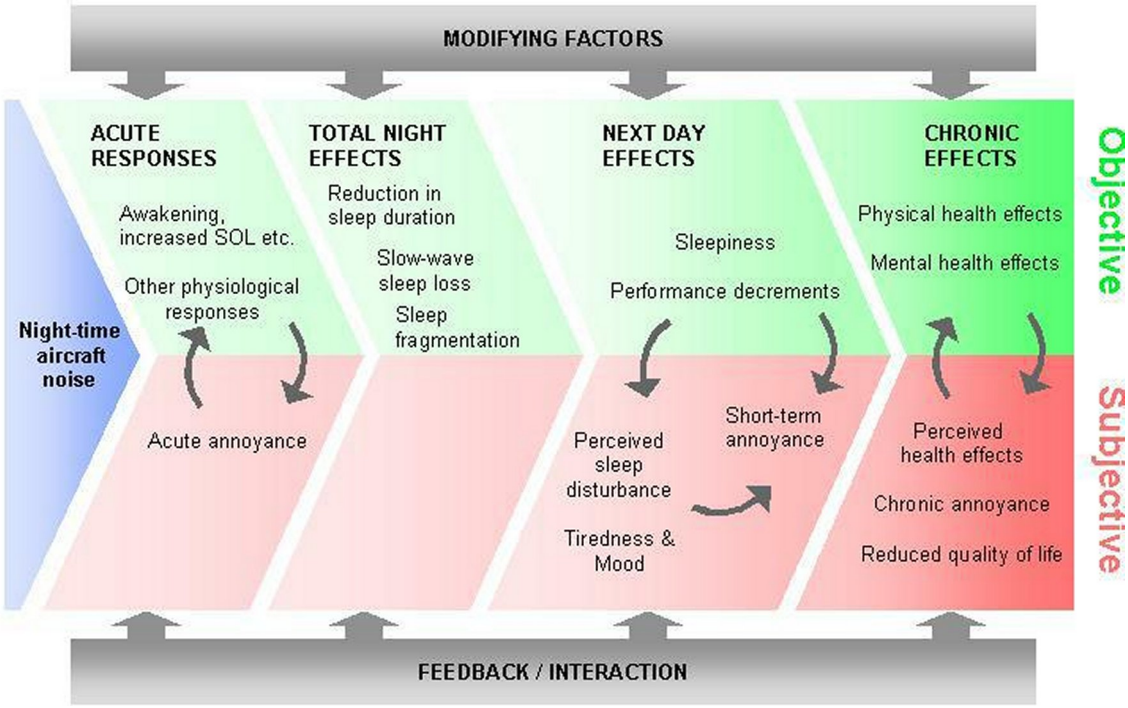

Figure 1: Potential impact of night-time aircraft noise: model framework.

4. chronic effects that are pervasive long-term consequences of (1), (2) and (3).

The model recognises that all of these effects are dependent on many modifying factors − demographic, behavioural, sociological, situational and so on. Modifying factors have a substantial, sometimes dominant influence. The elements of this model are interdependent and overlap; their boundaries are somewhat blurred. Although the principal cause-effect sequence is noise ⇒ acute ⇒ total night ⇒ next day ⇒ chronic, noise can cause next day and chronic effects directly and there is substantial potential for feedback, interaction and reverse causality. A key question is whether an indirect route from noise to health impairment is more significant than the possible consequences of sleep disruption upon which so much past research has focused.

3 - COMPARISON OF UK 1992 FINDINGS WITH MORE RECENT RESEARCH

The majority of research has focussed on the acute response of direct sleep disturbance and in particular awakenings from sleep. In 1990, a major study on aircraft noise and sleep disturbance was conducted and is often referred to as the "1992 UK field study" [2]. The key finding was that at outdoor noise events below 90 dBA SEL (approximately 80 dBA Lmax), average sleep disturbance rates were unlikely to be affected and, at higher noise event levels (mostly in the range 90 − 100 dBA SEL), the chance of the average person being wakened by an aircraft noise event was about 1 in 75.

Since the 1992 UK field study, a number of similar studies have been conducted in the USA [3,4,5]. The UK and US results are compared with each other and with other data previously reviewed by Pearsons and co-workers [6] in Figure 2. There is one conspicuous disparity between the UK and US results that raise a question concerning cause and effect. The noise-awakening relationship inferred from the UK study levels out as indoor SEL falls below 65 dBA, while no such trend is obvious in the US data. This is related to the principal conclusion drawn from the UK study; that below 90 dBA SEL outdoors (equivalent to above about 65 dBA indoors), aircraft noise would be unlikely to disturb sleep. This followed from the observation that, in the absence of aircraft noise, the probability of awakening − due to all other causes − remained at around 2%. The question this raises is whether the 1992 UK field study data should be adjusted to account for this residue before comparing it with the US results. The effect of doing so − the "Oll92 Adjusted" data in figure 1 − is to move the UK mean wakening rates towards the lower end of the range. Despite being derived by different methodologies, the US and UK results, and indeed the results from the "previous" studies, all convey the same message − that, in the home, awakenings are infrequent and only weakly correlated with noise.

Overlaid on Figure 6 are some currently quoted criteria regarding noise and sleep disturbance [7,8]. Also

shown is a dose-response curve intended to replace a curve previously recommended by FICAN, the US Federal Interagency Committee on Aviation Noise, labelled "Elias and Finegold" [9]. Included for comparison is the awakening threshold identified in the UK 1992 study. The various guidelines are in broad accordance with the observations; the evidence suggests they are sufficiently conservative that adherence to the guidelines should ensure little or no noise-induced awakening from sleep. Thus there appears to be reasonable agreement between the 1992 UK field study results and other comparable evidence that relates to aircraft noise and sleep in the home.

4 - FUTURE RESEARCH DIRECTIONS

Effective noise limitation and understanding of how best to specify controls requires reliable "dose-response relationships". The pathways linking noise exposure and its effects are complex and subject to many extraneous influences; this paper has identified some of the key elements and noted the research aimed at quantifying some of the links. However, research evidence suggests a disparity between subjective perceptions of noise-induced disturbance and objectively measured disturbance. Subjective reactions are strong whereas noise has a relatively small effect on the incidence of physiological disturbance. This raises the question of whether previous UK studies have focused too strongly on sleep disturbance, especially noise-induced awakenings during the night, as this is only one of many effects of night-time aircraft noise as depicted in figure 1.

A goal of continuing research is to establish whether night-time aircraft noise can lead to clinically significant impairment of health either directly, or indirectly as a result of chronic subjective reactions. Given that present understanding of the cause-effect web of night noise impact is fragmentary, it is evident that achievement of this goal remains some way off. It can only be viewed as a long-term objective; first, it is necessary to disentangle some of the intermediate relationships.

The 1992 UK field study indicated that aircraft noise, even at high levels, has a relatively small effect on awakening from within sleep during the night. This appears to have been corroborated by subsequent studies in the USA. But uncertainties remain about the shoulder hours: would similar conclusions apply to the beginning and end of the night? Could aircraft noise during these periods delay sleep onset and/or hasten final awakening – in other words, shorten the duration of sleep? And, if so, are there compensatory biological mechanisms that would, on average, change the sleep pattern in order to maintain the same quantity (e.g. product of depth and duration) of sleep? Can residual loss of sleep be determined and, if so, how and to what extent could this directly impair health?

The 1992 UK field study focused mainly on sleep disturbance. Acknowledging the importance of annoyance as a significant effect that could separately affect health and well-being, is this independent of sleep disturbance or primarily a consequence of it? How do other effects compare as potential health risks?

Most field studies of environmental noise impact have highlighted the profound significance of the "intervening factors" that modify individual reactions and responses to mask the underlying noise-effect relationships. Can these be successfully identified, quantified and "controlled" to allow those relationships to be isolated reliably?

These were among many questions that were put to advisory groups convened to assess possible UK research studies. Four options were considered:

- *Option A: Extend the 1992 UK field study to the shoulder hours.* The key objective would be to answer the question: could aircraft noise delay sleep onset and hasten final awakening and thus reduce quantity of sleep?

- *Option B: Compare sleep patterns in communities with high and low levels of noise exposure.* This study would be designed to test the null hypothesis that aircraft noise does not cause harmful loss of sleep or, expressed in a different way, a degree of sleep disturbance that, in the longer term, could be directly detrimental to health. It may be regarded as axiomatic that if this study led to an acceptance of the null hypothesis, then subsequent research would be more effectively directed at other pathways between noise exposure and possible health impairment, particularly on those involving annoyance.

- *Option C: Study sleep disturbance among noise sensitive people.* In view of the relatively low incidence of noise-induced disturbance, it was suggested that any study along the lines of options A or B might be focused on highly sensitive individuals in order to maximise the chance of detecting significant noise effect relationships.

- *Option D: Survey opinions of airport neighbours.* A need was seen to look more closely at the subjective aspects of figure 1, especially the interrelationships and the role of the modifying factors.

The DETR decided to commission two short research studies to investigate the options further. The first is concerned with methodology and is being conducted to evaluate options A to C. The second is a public attitude survey to explore the public's perceptions of the effects of aircraft noise at night. It is recognised that either study (or both) might point to further research options. These are reported separately in other papers in this session. After considering the results, DETR will decide whether there is a case for a full scale study on the adverse effects of night-time noise.

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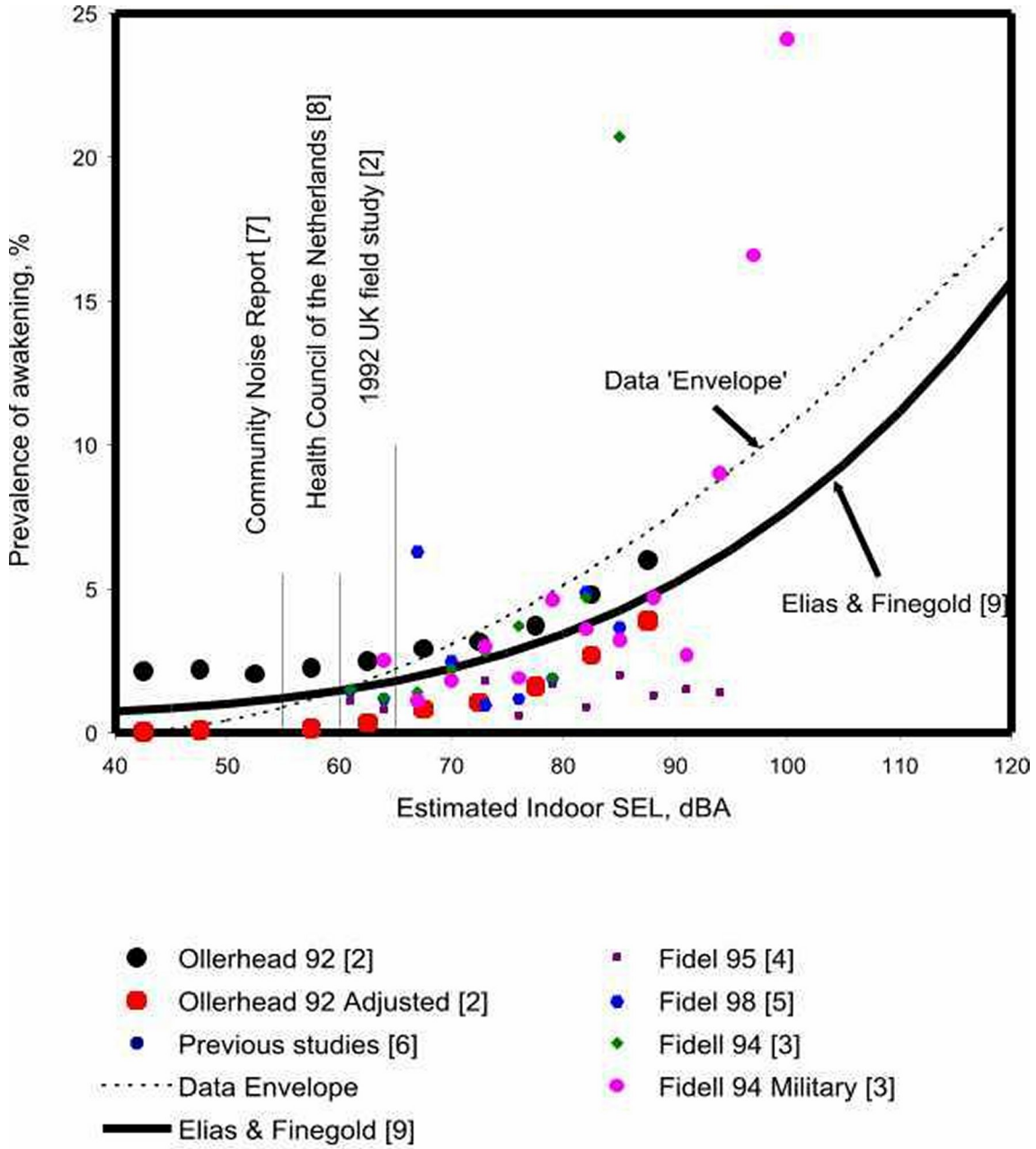

Figure 2: Comparison of 1992 field study findings with similar field studies and currently quoted criteria.