UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF NOISE DATABASE FOR NOISE IMPACT ASSESSMENT EXPERT SYSTEM

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By

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
CLIPS	C Language Integrated Production System
dBA	decibel (A-Weighted)
DOE	Department of Environmental
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ES	Expert System
GUI	Graphical User Interface
NASA	National Aeronautics and Space Administration
NADES	Noise Assessment Database Expert System
PTS	Permanent Threshold Shift
TREES	Tree Recommendation Expert System
TTS	Temporary Threshold Shift

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Faculty: Engineering

The Noise Assessment Database Expert System (NADES) was designed to identify the characteristic of changes in the existing noise environment as a result of the a proposed development, noise effects and proposed mitigating measures to reduce these impacts. The NADES was developed using the C Language Integrated Production System (CLIPS) version 6.04, an Expert System Shell which is designed by NASA (National Aeronautics and Space Administration). The development of NADES was based on Environmental Impact Assessment (EIA) reports submitted to Department of Environment (DOE) and also on three assumptions: all reports are subjected to the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1978, project activities are as listed under the Checklist of Project Activities for Prescribed Activities and all EIA reports reviewed were approved by DOE. The NADES have the basic components of a typical expert system and it was developed to produce an EIA report in a much shorter time.

Abstrak tesis diserahkan kepada Senat Universiti Putra Malaysia sebagai memenuhi syarat-syarat yang diperlukan untuk ijazah Master Sains.

DATABASEE BAGI SISTEM PAKAR PENILAIAN KESAN KEBISINGAN

Oleh

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Oktober 1998

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Database bagi Sistem Pakar Penilaian Kesan Kebisingan (NADES) direka bagi mengenalpasti ciri-ciri perubahan pada keadaann sedia ada bunyi bising yang disebabkan oleh sesuatu projek, impak-impak dan mencadangkan langkah-langkah tebat. Ia direka menggunakan program 'C Language Integrated Production System' (CLIPS) versi 6.04, iaitu satu sel sistem pakar yang telah dicipta oleh NASA. NADES in dicipta berdasarkan kepada maklumat-maklumat yang telah diekstrakkan daripada laporan-laporan Penilaian Kesan-kesan Impak (EIA) dan dengan tiga andaian: semua laporan tertakluk kepada Akta Kualiti Alama Sekeliling 1974 untuk aktiviti-aktiviti yang tersenarai dalam Arahan Aktiviti Terjadual, 1987, projek aktiviti adalah seperti yang tersenarai dalam senarai "Checklist of Project Activities for Prescribed Activities dan yang ketiga, semua laporan ini telah diluluskan oleh pihak Jabatan Alam Sekitar (JAS). NADES ini mempunyai komponen-komponen asas suatu sistem pakar and yang mana ianya direka supaya penyediaan laporan EIA akan menjadi lebih cepat.

CHAPTER I

INTRODUCTION

Prologue

Types of environmental impacts can be expected to include population growth; high-density urbanisation; industrial expansion; resource exploitation; air, water and noise pollution; undesirable land use patterns; damage to life systems; and other consequences adverse to environmental goals. The assessment, both qualitative and quantitative, of these impacts require the use of many disciplines.

Environmental Impact Assessment (EIA) is a study to identify, predict, evaluate and communicate information about the impacts on the environment due to a proposed project and to detail out the mitigating measures prior to project approval and implementation. EIA is essentially a planning tool for preventing environmental problems due to an action. It seeks to avoid costly mistakes in project implementation. In Malaysia, EIA is used as a tool to integrate environmental considerations into project planning. Activities subject to EIA are prescribed under the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987.

Land developments may affect noise levels in the short term by construction, and in the long term by changes in vehicular and pedestrian traffic, industrial processes, and other activities (Rau, 1980). One way to incorporate noise control considerations into land use planning is the Environmental Impact Assessment. Preparation of noise impact assessment requires environmental assessment topics such as description of existing noise environment; physical description of noise; assessing noise impacts for various noise-sensitive land uses; and designing mitigating measures to alleviate potential community noise problems (Mestre and Wooten, 1980). For a more detailed assessment and a more technical reader, noise assessment will include the fundamentals and equations necessary to project noise levels for a variety source under a variety of conditions.

Noise assessment in an environmental impact assessment includes considerations of the potential damage to hearing, potential physiological responses, annoyance and general community responses. Nevertheless, a typical noise assessment in an EIA will take the form of a comparison between the existing noise level and anticipated noise levels with the criteria established by various agencies and the local government. Typical considerations in environmental noise assessment can be divided into two separate categories: those relating to the noise source and those relating to potential receivers.

Noise level in sensitive area such as schools, hospitals and residential areas were found to be high and exceeded the noise level recommended by the World Health Organisation (Leong, 1982). Goh (1983) indicates in his study that the number of complaints received by the DOE can reflect the public attitude towards

noise pollution. He concluded that the number of complaints even though small, are increasing every year and most complaints were made by residents whose houses are located near factories or main roads.

Statement of Problem

There are two major factors that contribute to the ineffectiveness of EIA in environmental conservation: prolong approval process and lack of expertise. Initially, all preliminary EIA Reports are processed and approved by the State DOE except for Kedah and Perlis. This will take approximately one to two months from the date of report submissions. Currently, the procedures have been changed where the DOE headquarters issue the final approval for an EIA Report. This will take another two weeks thus prolonging the approval process of an EIA study. Hence, this indirectly will slow down the proposed project, as well as cause pilling up of EIA reports that need to be reviewed and evaluated by the DOE headquarters and also will degrade the quality of an EIA report.

Lack of expertise is one of the major problems faced by EIA consultants and has contributed to the costly price of an EIA study. An EIA study requires the involvement of multiple experts and gathering of relevant data. Gathering of data is always considered to be time consuming, expensive and introduces unnecessary delays in the implementation of a project. For example environmental noise; environmental noise is one component of the physico-chemical environment required in an Environmental Impact Assessment (EIA) report. Lately, noise pollution has attracted the authority's attention especially community noise. In the

1993 Environmental Quality Report (EQR), noise was ranked third after air and water pollution in terms of number of complaints received by DOE.

Noise impact assessment requires a person who has the knowledge on the characteristics of noise pollution and its impacts to the existing environment. There is a valid need to develop techniques and tools for performing environmental noise impact analyses that can be used by both the environmental analysts and the viewers of environmental impact assessments. The introduction of Noise Assessment Database Expert System (NADES) for noise expert system will assist all EIA consultants, project initiators and approving authorities in gathering, describing and evaluating the existing noise level, its impacts and mitigating measures to control these impacts. Besides for description of the existing noise level and prediction of noise impacts, this NADES can be used by the approving authority as cross-references in reviewing the submitted EIA reports.

Research Objectives

The objectives of this research are as follows:

(a) To develop a noise assessment database expert system for the development of noise expert system.

(b) To develop a more clearly ambient noise measurement and monitoring for an EIA study.

(c) To design rules for noise impact assessment and recommendation of mitigating measures.

Organisation of the Study

The structure of this study is as illustrated by Figure 1.1 and is divided into six chapters.

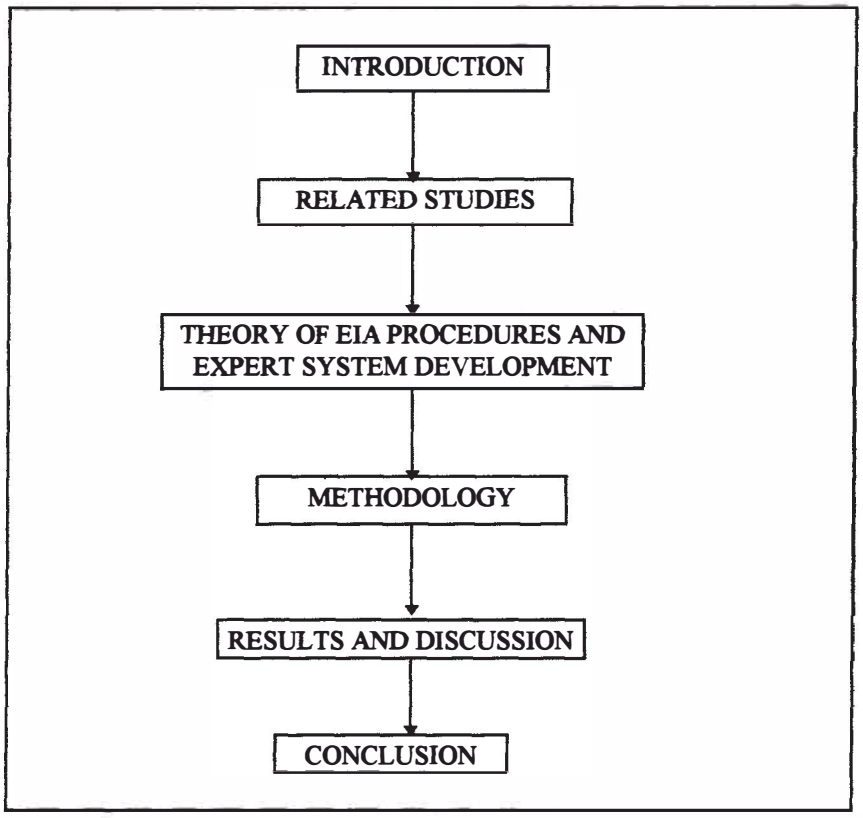

Figure 1.1 : Organisations of this Study

(a) **Introduction** - This chapter gives the introduction to this study, which includes objectives, statement of problems and organisations of the study.

(b) **Related Studies -** This chapter discussed some related studies on noise impact assessment and application of expert systems in environmental field.

(c) **Theory of EIA and Expert System Development -** This chapter is divided into two parts: the first part explained theory of EIA study in Malaysia and second part discussed the typical stages of expert systems development.

(d) **Methodology -** This chapter gives the method used for data collection, analysis and the development of the NADES prototype. Method used was based on the typical procedure of developing an expert system.

(e) **Results and Discussion -** This chapter discussed results obtained from the data collection and analysis; and output of the NADES. The final output of the NADES is discussed and presented in this chapter.

(f) **Conclusion -** The chapter presents the final conclusion of this study and recommendation for future development of a more comprehensive noise expert system.

CHAPTER II

RELATED STUDIES

This chapter discussed some related studies on noise impact assessment and expert systems application in environmental field. Noise is a very wide topic to study therefore, for the purpose of this study, literature review was limited to noise impact assessment. This is to obtain a clearer vision on effects of noise, which is the major component of an EIA study in relation with noise pollution. For the same reason, related studies on expert systems application are limited to environmental field.

Characteristics of Noise

Noise has been recognised as an important area of research, along with other forms of pollution, in determining the quality of our environment. This is evident from a number of studies, which have been carried out in various parts of the world (Kumar and Jain, 1994). Noise is defined as unwanted sound, annoying or even damaging sound. Sound by itself is not pollution but when it interferes with a person's 'territory', it can create nuisance to the receptor. In order to mitigate adverse effect cause by this unwanted sound, one has to understand the

characteristics of noise. Characteristics of noise are discussed in term of its transmission and measurement.

How Noise Is Transmitted

Noise generally varies with the time of day-relatively quiet at night, when people's activities are at minimum, and noisier in the morning and late afternoon during the commuter-traffic rush hours (Eldred, 1975). Noise reaches a listener by several of paths (Harris, 1979). It first must propagate or travel at some distance through air, before it can reach the ear. Briefly, the diagram in Figure 2.1 explained the transmission of sound from a source to the listener. The diagram also shows the interaction between the source, path and receiver, as shown by the broken lines. The source represent more than one sound generator point and the path in which the sound is transmitted consist of one or many paths (Harris, 1979). Receiver who is affected by the sound or noise may refer to single person, group of people, community or equipment where the operation is affected by noise. These three elements are not always constant but it depends on the path and receiver.

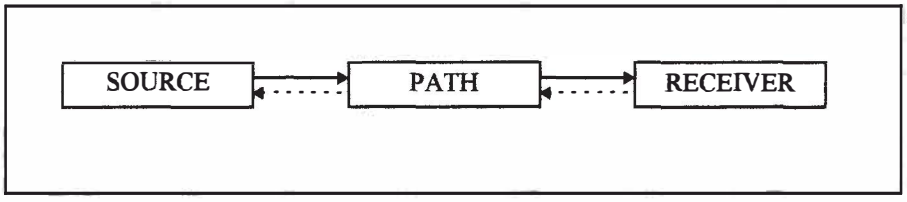

Figure 2.1: Schematic Diagram of Transmission of Noise

Noise Measurement

Methods used to measure noise depend on several factors but the most important one is the purpose of noise measurement. There are many reasons why noise measurement is made for example, for occupational safety purposes, to evaluate complaints from affected elements, to determine if a given environment condition is acceptable or for legal purposes. Community noise surveys have been carried out in numerous countries over the past 30 years (Brown and Lam, 1987). Generally, basic factors that should be taken into considerations during noise measurement are selection of noise instruments, microphone positions, and reflections from nearby surfaces.

Besides these factors, selection of appropriate noise descriptor is also important (Garcia and Faus, 1991). This will lead to a much simpler short time measurement techniques, without producing a serious loss of any relevant information. The equivalent continuous A-weighted sound pressure level is recommended as a measure of any environmental noise (Makarewicz, 1991). The calculation was made under the assumption that many buildings (interference) affect the noise propagation. The Noise Advisory Council in United Kingdom are concerned about the multiplicity of noise emission measures used. Hence, a recommendation was made, which is the use of Leq for quantification of the noise environment due to each source and from all sources together.

Basic instrument for noise measurement is the sound level meter and it is normally positioned so that an adequate sampling is obtained of the sound field in

the area of concern (Harris, 1979). The number of sampling locations should be sufficient to describe the ambient level or the existing noise environment. It is important to take note that environmental conditions either indoors or outdoors have a considerable effect on measured sound. The choice of measurement site, microphone height and position may be dictated by particular circumstances but care should be taken to avoid the influence of obstructions and reflecting surfaces. For the purpose of comparison study, it is important that all noise measurements are made according to the same standards following the same rules. This is important when noise measurement is conducted for Environmental Impact Assessment studies.

Effects of Noise Pollution

The problem with noise is not only that it is unwanted but also that it negatively affects human health and well being. Noise pollution can be defined as unwanted sound, which discharge into the atmosphere without considering the adverse effect it may be having (Chattwal *et. al.*, 1989). Several surveys and opinion polls have shown that noise is a major disturbances and source of complaints in the daily life of citizens in the Organisation for Economic Co-operation and Development (OECD) countries. However, all noise effects should be considered as health hazards. This is because "health is a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity (WHO, 1960).

Impacts can be defined as the striking of one body against another (Urdang and Flexner, 1968). There are various effects of noise on people and they are often interrelated. These effects can be categorised into three categories: physiological effects, effects on activities and psychosociological effects. The effects of exposure to noise depend on the noise level, the length of exposure to noise, and the type of noise (Kirk-Othmer, 1981). The developmental process of noise effects can be simplified as in Figure 2.2 (Osada, 1988). Based on this figure, the direct and indirect noise effects lead to a perception of annoyance (a type of psychosiological effects) and behavioural response. Both perceived annoyance and behavioural reactions are the integrated and composite effects of noise.

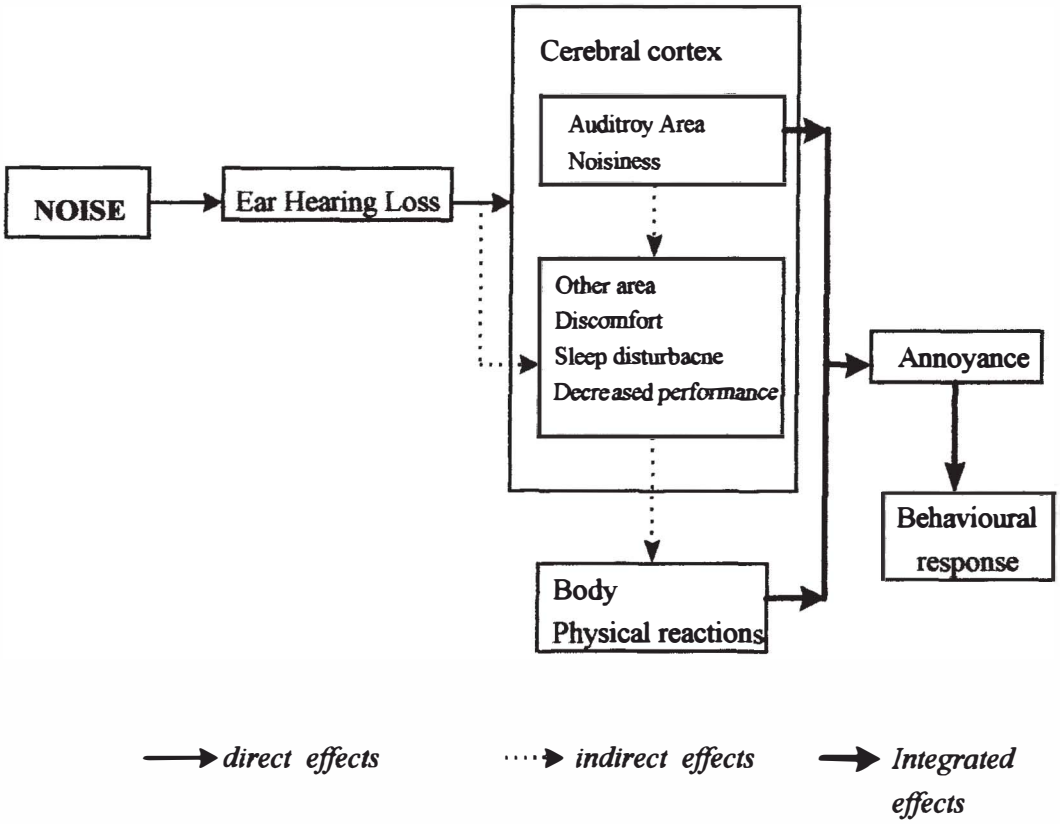

Figure 2.2: Process of the Development of Health Effects of Noise

Physiological Effects

Physiological effects of noise can be categorised as auditory and nonauditory. Auditory effects referred are those related to human auditory system. Example of auditory effect is hearing loss. It is well known that long-term exposure to high noise levels can result in permanent hearing loss (ANON, 1980). The earliest reference to noise-induce hearing loss was the noise of water falling over falls and rapids in the Nile River cause hearing loss in the natives who lived and fished near the river (Kirk-Othmer, 1981). It is feared that noise levels experienced in the day-to-day environment may cause, in the long term, loss of auditory acuity (partial hearing loss). There are two types of auditory effects: temporary threshold shift (TTS) and permanent threshold shift (PTS). TTS refers to hearing loss as a result of exposure to intense noise over a short period and which is follow-up by partial recovery. The amount of TTS is related to the exposure duration (Smith, *et. al.*, 1982). PTS refers to any hearing loss, which is persistent.

Nonauditory effects usually occur after auditory effects. It occurs when other parts of the cerebral cortex are stimulated by impulses excited from the auditory area through nervous connection within the cortex (Osada, 1988). Examples of non-auditory physiological effects are such as: increase in blood pressure, heart rate and breathing speed, muscles tense, and hormone are released into the bloodstream. It is considered plausible that some disorders, especially cardiovascular disorders and increased susceptibility to diseases are accelerated by higher levels of noise.

Effects on Activities

Effects of noise on activities are the most significant and best identified ones. Activities that are likely to be affected by noise are sleep, communication and performance. Sleep interference is probably the most important in terms of its potential effects on human health after long-term exposure. Effects on sleep depend on the type and level of noise, on the psychophysiological state of the person and the time of at night when noise is produced. Sleep disturbances or interference are defined as measurable and/or experienced deviations from the usual or from the desired sleep behaviour and they are indicated by primary and after effects (Griefahn, 1991).

A study was conducted to elucidate the importance of number of noise events with a high maximum noise level for sleep disturbance effects in terms of body movements, subjective sleep quality and performance (Öhrström and Rylander, 1990). In this paper, one of the most important environment noise sources for sleep disturbance is road traffic noise. Based on this study, to protect people from sleep disturbance effects it is not sufficient to base the noise criteria on 24 hour the equivalent continuos level. It is necessary then to consider the number of vehicles over a certain maximum noise level. When the maximum noise level is 60 dB(A) and the number of noise events is around 16 per night the sleep quality as well as performance is reduced. The maximum noise level between 45 dBA and 55 dBA is critical with regard to noise disturbance during sleep (Öhrström and Rylander, 1990).

The most obvious of environmental noise is its interference with communication. This is because at a certain level noise masks the sound one is listening to. The fundamental nature of speech and listening, and the frequency of their use in almost all-human activities, make it clear that interference with speech and listening is one of the worst effects of noise. Noise can distract a person involved in a specific task, this distraction depends on the meaningfulness of the noise and on the psychophysiological state of the person. Possible indicators of the effects of noise on performance are identified as (Canter, 1977):

(a) An increase of accidents in very noisy places

(b) A less than average language development and reading ability among children exposed to high noise levels at school and at home.

Psychosociological Effects

In addition to the direct effects of noise, there are indirect and more ill defined effects of annoyance which result from these direct effects (Anon, 1980). These effects are influenced by various psychological and social factors. In several surveys concerning living conditions, noise is one of the most frequently cited sources of annoyance in the neighbourhood. The annoyance due to road traffic noise was studied in 18 areas in five countries by Rylander, *et. al.*, (1986). Their study indicates that the number of events above a certain limit will not increase the extent of annoyance: the highest noise level from single vehicles determines it. A model