n-96-01
II-A-669

EPA ONAC
NOISE DECISION MODEL
USER's GUIDE

PREPARED FOR:

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1 August 1983

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SECTION 1
INTRODUCTION

INTRODUCTION

The Environmental Protection Agency, Office of Noise Abatement and Control, developed and used a tool to analyze and select regulatory options for all products considered for noise emission regulation. This tool, the Noise Decision Model (NDM), is a computerized analytical cost-benefit model. The NDM was designed to bring together and integrate the results of technology assessment, cost and economic impact analysis, and health and welfare benefit analysis, into a single consistent decision-making framework. The model operates on data representing the results of these studies and generates an array of feasible regulatory options that are individually analysed to quantitatively determine effects of the regulation. The information on the potential effects of each option is then assessed and displayed using criteria provided and selected by the decision-maker, to provide the identification of the most cost-effective options for regulation.

The objectives of this report are to present a clear, concise description of the Noise Decision Model and to provide a detailed guide for potential user's of this model. The most recent version of the NDM was designed to utilize the WYLBUR computer system.

This user's guide is formated in several individual sections which are briefly described below. Section one (1) presents a brief statement on its development under the auspices of the Office of Noise Abatement and Control, a general overview of key concepts of the model (including the model's data requirements and output) and a discussion on how to interpret the output generated from the NDM. Section two (2) contains basic instructions for accessing the computer program via the WYLBUR computer system. The input data requirements to execute the model are specified in Section three (3). Section four (4) presents a detailed description of the model's output formats which will be helpful to decision-makers in the interpretation of results generated through applying the model. Finally, Section five (5) describes the overall structure and design of the NDM computer program, including the computer logic, algorithms, and analytical functions incorporated in its computer program.

1.1 BACKGROUND OF THE NOISE DECISION MODEL

The Environmental Protection Agency, Office of Noise Abatement and Control, initiated development of the NDM in August 1975. Contractor support was used for this developmental effort. The spirit of this work was to make a preliminary assessment of the workings of the regulatory development process within the Agency and to explore ways to facilitate this process through the design of a comprehensive framework which potentially could be used to analyze all product regulations on a consistent basis.

As a result of the initial work, the contractor was detailed to examine the information that was being captured through the on-going product regulatory studies related to product noise abatement and control technology assessments, health and welfare benefit analysis, cost and economic impact analysis, etc. This effort was undertaken to ensure that the decision framework incorporated, to the extent practical, the nature of the information of these required product regulatory studies. While this work was being pursued, the contractor initiated efforts to develop a design of the NDM. The first version of the NDM was completed in the latter part of 1976.

Shortly after the model was fully automated, it was introduced into the regulatory development process and used to assist in the development of noise emission standards for the following products: Wheel and Crawler Tractors, Mobile Earth Moving Equipment, Paving Breakers and Rock Drills, Railroad Equipment, Buses, Motorcycles, and Truck Mounted Solid Waste Compactors. Since its introduction, the basic conceptual framework of the NDM has remained essentially the same. However, the information demands of the various product regulatory programs from a decision-making point of view required several refinements to be made in the computer program. In the time period between 1977 and 1980, the NDM's computer program was rewritten to improve its efficiency and to incorporate additional information that was consider useful to decision-makers. The most recent revisions to the model were made in 1980 when the model was converted to the WYLBUR computer system.

1.2 INFORMATION NEEDS

To execute the Noise Decision Model, certain information must be obtained from a variety of data sources which would be readily available from the following product regulatory development activities:

- Cost analysis and economic impact analysis.
- Health and welfare impact analysis.
- Survey of manufacturers.
- Technology assessment studies.

These listed activities are carried out and, for all intents and purposes, are completed and documented prior to any undertaking involving the NDM. Since the model design and conceptual framework was based on the nature of the information developed through performance of these individual activities, as opposed to specifying explicit requirements for development of the information to run the model, there are instances where the user must develop some of the data inputs to the model. As a general rule, all information needed to specify the input data of the model is captured in the existing product-related documentation. However, these documents <u>do</u> <u>not</u> earmark information for use in the model. The user <u>must</u> study the documentation and extract the required data for use via the NDM. In some cases, the user may need to undertake some additional analysis of the existing data sources to satisfy the specification of the input data model's.

The data and information that are required from each activity are briefly outlined in the following below.

<u>Cost Analysis and Economic Impact Analysis</u>

- Cost Analysis
  - Identification of alternative possible time phases of regulation.
  - Description of expected changes in the product and the effect on noise emission levels.
  - Identification of the cost implications of proposed changes in each class of product.
- Economic snapshot concerning the identification of key structural relationships in the affected industry(s) and those areas most likely to be affected by the product regulations, leading to an estimation of the elasticity of supply parameters.

- Baseline forecast, without product regulations, that consists of the development of a framework to forecast the expected industry sales growth for the future.

- Economic impact analysis that includes a detailed description of the difference between the baseline forecast and the forecast with regulations.

- Estimation of the elasticity of consumer demand with respect to increases in product prices.

<u>Health and Welfare Impact Analysis</u>

- Baseline forecast of the expected impact of unregulated noise emissions on the public over an appropriate time period, including;

  - Demographic studies.

  - Noise propagation studies.

- Benefit analysis due to product regulation, including;

  - Effect of possible time-phasing of regulation on noise exposure of the public

  - Benefits of the alternative regulatory noise emission levels on noise exposure to the public.

- Net impact analysis that includes a detailed description of the differences between the baseline forecast and the forecast with product regulations.

<u>Survey of Manufacturers</u>

Some of the information that is required to utilize the decision model is usually obtained directly from manufacturers. These data include;

- History of sales over an appropriate timeframe (e.g., 5-year period).

- Impact of varying levels of regulation on unit costs of producing the product.

- Impact on increased end-user maintenance costs.

- Investment by the industry in research and development in (R&D) and retooling to meet alternative noise emission levels by product type, class and basic model, as applicable.

- Average lifetime (obsolenscence factor) for each product class, with and without regulation.

- Impact on industry employment and plant closings if sales and/or profits decrease after regulation.

Technology

- Development of types, and classes within types, of the products on the market, and modifications required by noise emission regulations.

- Examination of methodologies for measuring performance of the product.

- Measurement of noise emission of each class of product considered.

- Determination of the state-of-the-art of technology for the product under regulation.

- Measurement of the variation of noise emissions of performance among classes of the product due to regulation.

1.3 KEY OUTPUTS OF THE NDM

The NDM operates on user input data and generates candidate product regulatory scenarios representing various possible combinations of noise emission levels and the time-phasing of these levels. For each scenario, the model calculates the net present values of the costs and benefits for each year of the time horizon considered.

The NDM then applies a "graph-theoretic" approach to compare alternative scenarios (i.e., each scenario is represented by a point in a two-dimensional space of benefits versus costs). In addition, the NDM computes the ratio of benefits to costs for each scenario.

The interpretation of these key results that are outputs of this model are discussed in Section 1.4 below.

1.4 INTERPRETATION OF NDM OUTPUTS IN LIGHT OF THE DECISION PROBLEM

Decision-makers in regulatory agencies constantly are faced with the problem of only selecting one regulation from an array of possible candidates. The NDM does not and can not completely solve this problem, but does provide a tool to aid in its resolution.

Although it may not be possible to place a dollar value on the benefits, classical cost/benefit economic analysis can still contribute much to the explanation of the nature of the problem. Consider Figure 1-1 that displays the results of an analysis in which product regulatory scenarios are shown as points in a two-dimensional diagram with benefits on the Y-axis and costs on the X-axis. Each dot represents a possible regulatory scenario which is defined by a sequence of time-phased regulatory levels for each product. Several observations can be made about the nature of the decision problem from this diagram.

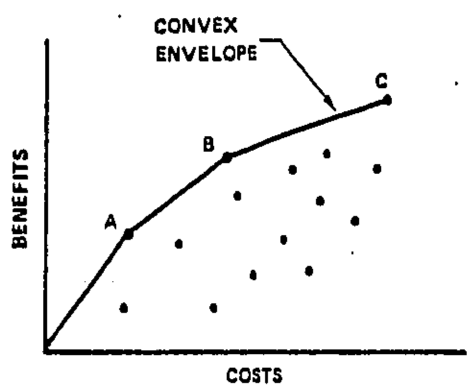


Figure 1-1. CONVEX ENVELOPE OF BENEFITS VS. COSTS

The first observation is that several regulatory scenarios may have approximately the same cost but different benefits. This results in the existence of a set of options that are better than the other options no matter what method might be used to relate benefits to dollars. Using the convex envelope technique, such an envelope can be formed through the most economically efficient scenarios which would capture only points A, B, and C.

The maximum benefit to cost ratio occurs for the cases which lie on the convex envelope irrespective of the dollar value of the benefits. Therefore, it is possible to choose the regulatory scenario with the maximum benefit to cost ratio without converting benefits to dollars.

The NDM has the capability to provide the decision maker with the following information on each regulatory scenario to assist in the selection process:

- Benefit/cost ratios
- Convex envelope of efficient points
- Monotonically increasing envelope
- The benefit and cost of each scenario
- Unemployment
- Plant closings.

The above information can then be compared to any other constraints that the decision maker considers important in the decision process. Possible constraints would be: limitations on total cost of the regulation; setting of a lower threshold on benefits to be achieved by regulation; or other limitations on unemployment or plant closing impacts.

Other considerations that can be made by the decision maker may involve the relative importance of each element of information processed by the model if more than one regulatory option remains after imposing various constraints.

It should be noted that the NDM can not completely solve the decision maker's problem. Other factors that are important to the decision process, such as environmental impacts and political feasibility, are not part of this model. Therefore, while the NDM can be of immense help to decision makers in presenting net present value benefits and costs of regulation and other economic impacts in a decision making format, the regulator must also consider a number of other factors that can not be quantified in this or any other model.

SECTION 2

USER INSTRUCTIONS

USER INSTRUCTIONS

To access and use the EPA ONAC Noise Decision Model, computer program, a potential user must complete the registration requirements of the EPA National Computer Center which are described in the On-line Business Systems (OBS) WYLBUR User Guide. After these requirements are fulfilled, a potential user will be granted authorization to utilize the OBS WYLBUR computer system.

To gain access to this computer program via a remote terminal workstation, the user must follow the appropriate WYLBUR procedures for LOGON and LOGOFF. These procedures are presented in Table 2-1 at the end of this section.

After connecting with the WYLBUR computer system, the user must provide the following information:

USER IDENTIFICATION ?__________ Press carriage Return (CR)
KEYWORD ?__________________ (CR)
ACCOUNT NUMBER ?_____________ (CR)

The above information will be supplied to each authorized user by the WYLBUR Access Manager of the EPA National Computer Center.

After this information is correctly supplied by the user, the user will be asked to respond to specific WYLBUR computer system prompts. This dialogue with the system should be answered as follows:

COMMAND ? SET TERSE (CR)
? COLLECT (CR)

The last query and response will enable the user to create a datefile. This datafile must be developed by the user in order to supply the input data needed to execute the Noise Decision Model. The datafile contents must be created in accordance with the specifications provided subsequently in Section 3 of this document.

When the datafile containing the inputs to the computer model is completed according to specification, the datafile is saved for use in the computer model by typing the WYLBUR command:

? SAVE (CR)

This command instructs WYLBUR to save and write an active file for this program. Further, WYLBUR will assign a dataset name to this active file and provide this information to the user.

After the active datafile has been created and verified, the user is now ready to run the Noise Decision Model. To prepare the workspace and ensure delivery of output (hard copy) the user should adher to the instructions contained in the National Computer Center (NCC) - IBM User's Guide. Specific information should be provided by the user to WYLBUR for this purpose, including the dataset name, destination (users delivery code), and number of copies required. The following Job Control Language (JCL) is required to be typed into operating systems' processing of the created datafile related to this computer program.

```
//     JOB
//     EXEC  PGM=DECMODEL
//SYSPRINT DD SYSOUT = A
//DD1        DD DSN=EPAXYZ (User's Account No.), Datafile
             name), DISP = SHR
//           DD DUMMY
```

After completion of the JCL, press the (ATTN) or (Break) key on the remote terminal device and type in the RUN command. This command instructs WYLBUR to submit the active file to the central computer's input queue for processing. After the RUN command is issued, WYLBUR will show you the job name and number. The job output can be looked at in its entirety or only in part by instructing WYLBUR through use of certain commands and other relevant information. The printed listing of the job will be delivered to the user based on the earlier instruction requirements. The user may now LOGOFF the system according to the OBS WYLBUR procedures shown in Table 2-2.

The datafile which was constructed by the user can be saved for future use. The same job may be rerun or the datafile may be edited for subsequent runs using different data elements.

For more information on generating a datafile, text editing procedures, submitting and retrieving jobs, etc., the user is referred to the following reference materials:

- OBS WYLBUR USER GUIDE, 6th Edition, April 1980.
- OBS WYLBUR REFERENCE GUIDE, 6th Edition, December 1981.
- NCC-IBM USER's GUIDE, February 1982, U.S.EPA Management Information and Data Systems Division, National Computer Center.

TABLE 2.1 OBS WYLBUR LOGON PROCEDURE

Prepare Terminal for Remote Job Entry.

Turn on the terminal and set it for communication (REMOTE or LINE). For terminals with a built-in data set, the ORIGINATE switch turns the terminal on as well as sets it for communication. The terminal is now set to Half-Duplex and the data set is set to Full-Duplex.

Dial via the telephone the On-line Business Systems WYLBUR System or OBS WYLBUR. Consult the Washington Support Center (WSC) OBS WYLBUR User Guide for appropriate telephone numbers.

Receive Response. A high-pitch tone indicates that the system is available and the user may proceed to execute the next steps in the LOGON procedure. A fast busy signal indicates a temporary overload in local telephone circuits. Wait several minutes and try again. If this condition persists, notify your local telephone company. A slow busy signal indicates that all lines into the system are busy. Once again, wait a few minutes and try again. If this condition persists, notify the WSC User Support group of WSC at (202) 488-5960 for corrective action. An unanswered ringing signal indicates that the system is in the midst of a status change. Try again after a few minutes. If the condition persists, after checking that the number dialed was correct, etc., call the WSC User Support group and report the problem. The System Status Recording telephone number is (919) 541-4732 or (FTS) 629-4732.

USER RESPONSE AT COMPLETION OF CONNECTION WITH WSC.

The following interaction between the user and the system occurs during the logon process of a OBS WYLBUR session. The user's response is indicated by lower case characters and the system response is indicated by upper case. After circuit connection is made, the system will begin the session as follows:

TABLE 2.1 OBS WYLBUR LOGON PROCEDURE (CONT'd.)

(Note: Users in the Washington, D.C. area will not normally encounter the dialogue shown below on the first five lines. They should type at least the carriage returns to receive the message "ENTER TSO or OBS" and then proceed with line six.)

```
PLEASE TYPE YOUR TERMINAL IDENTIFIERt
-NNNN-PPP-
PLEASE LOG IN:*ibmepal;ncc(CR)
P ###
IBMà IS ON LINE
OBS(CR)
enter logon
logon epaiii/kkkkkkkk acct(aaaaxxxxmuuu) (CR)
ICH7000 epaiii LAST ACCESS AT HH:MM:SS ON DAY-OF-WEEK
  MONTH DAY, YEAR
EPAIII LOGON IN PROGRESS AT HH:MM:SS ON MONTH DAY, YEAR
MM/DD/YY:SYSTEM  BROADCAST MESSAGES       SEE NEWS ALERT#
READY
```

where:

t - Appropriate terminal identifying character

NNNN - Number of the remote access node to which the terminal session is connected.

PPP - Number of the port of that node.

* - Control H. Before the user keys in the characters in this line, the control key must be depressed while striking the H key. This causes a backspace and suppresses echoing of the characters being typed on this line.

(CR) - Carriage return.

- Number of the host computer port.

à - Number of the COMTEN.

epaiii - Assigned User-ID

kkkkkkkk - Password associated with the User-ID. The user may be prompted to reenter the password because it has expired. To change it, he should enter the new password in response to the reenter prompt. The password may be from 1 to 8 characters long.

acct(aaaaxxxxmuuu) - indicates account number and ADP utilization identifier.

TABLE 2.1 OBS WYLBUR LOGON PROCEDURE (CONT'd.)

- Number of the news alert to reference for more details about the message. To reference the alert, the user may issue the following command:

news alert#

A user is given three (3) times to logon correctly, after the third unsuccessful attempt to logon, the user will be disconnected automatically.

TABLE 2-2 LOGOFF PROCEDURE

User response to terminate an OBS WYLBUR session:

? logoff (CR)

NOTE: When terminating a WYLBUR session, make sure the workspace (i.e., active file, including the datafile(s) is saved by using the SAVE command.

System response:

OK TO CLEAR ?

USER response:

yes (CR)

NOTE: Any response other than "yes" or (CR) to the WYLBUR prompt CLEAR ? will cause the logoff request to be aborted.

After the 'yes' response is accepted by WYLBUR, the editing time will be shown to the user. This editing time represents the actual time used by the computer processing unit during editing. In addition WYLBUR will record the elapsed time in hours, minutes, and seconds, to indicate the period of time that the terminal was connected to the computer system. Billing for the use of the OBS WYLBUR computer system is done in accordance with a formula which includes both of these factors as well as for the amount of on-line disk storage used.

WYLBUR will display this information, as follows:

```
Ø.ØØ SECONDS EDITING TIME
NN PAGE READS, NN PAGE WRITES
NN DISK READS, NN DISK WRITES
ELAPSED TIME - HH:MM:SS
END OF SESSION
```

WYLBUR AUTOMATIC LOGOFF

The WYLBUR computer system keeps track of the activity at a terminal. After ten minutes of inactivity, WYLBUR will prompt for an indication that the user is still there.

TABLE 2-2 LOGOFF PROCEDURE (CONT'd)
? *** ARE YOU STILL THERE? ? If no reply is made after another five minutes, WYLBUR will automatically logoff the terminal.

SECTION 3

INPUT DATA

INPUT DATA

A description of the data required to construct the NDM input data file on a line-by-line basis is presented below. Each row of the input data file represents a line in this data file. If there are more data than the format indicates, continue on to the next line. It is recommended that the user refer to a FORTRAN manual for detailed explanation of the formats. It should be noted that I and E formats must be right justified.

Variable Name	Format	Description
TITLE	10A4	Name of product to be required
IGRO	I2	Type of product sales growth anticipated over time period of interest IGRO = 1 arithmetic growth 2 exponential growth 3 tabular input growth
SG	F5	Rate of growth (fraction) where IGRO = 1 or 2
RLØ	F5	Unregulated noise level (baseline)
ANRØ	E10	Original number of units in fleet replaced at start of timestream (sales must equal replacements at the beginning of timestreams)
NRL	I2	Number of regulatory levels
RL(I)	4F5	Regulated levels (≤4)
NLT(I)	4I2	Number of lead times for each regulatory level (≤4 for each level
PO,OØ	2E10	Original total cost of the product per year; original total operating and maintenance cost of the products per year
ANØ	E10	Total product population at beginning of timestream
NYØ,NDUR1,NFY	3I5	First year of timestream Number of years in timestream Number of years required to finance purchase of new product

Variable Name	Format	Description (cont.)
RB,RC,RU,RP	4F5	Benefit discount rate; Cost discount rate; Unemployment discount rate; Manufacturer's profit rate (return on sales).
IYRØ	15	Regulation announcement year which establishes the base year for which the lead times available to comply with regulation

The following set of input is to be repeated for as many times as the number of regulated levels.

LT(I,K)	4I2	Lead times for regulation, I, (in years counting from announcement year)
FSAL(I,K)	4F10	Fraction of sales resulting from regulation, I, for each lead time
UCI(I,K)	4F5	User cost increase per unit due to regulation, I, for each lead time
UOPI(I,K)	4F5	User operating and maintenance cost increase per product machine or unit due to regulation, I, for each lead time
FSCR(I,K)	4F10	Fraction of product population replaced due to regulation, I, for each lead time
AMI(I,K)	4E10	Total manufacturer investment cost increase due to regulation, I, for each lead time
NPC(I,K)	4I2	Number of plants closed due to regulation, I, for each lead time
BEN(I,K)	4E10	Benefit due to regulation, I, for each lead time
UE(I,K)	4E10	Unemployment due to regulation, I, (number of people) for each lead time

The above set of input is to be repeated as a block for each regulatory level. The input below is to follow the blocks above:

WB	25F3	Benefit weighting factors, one for each

Variable Name	Format	Description (cont.)
		year in timestream; continue on to next line if more than 25 years
WU	25F3	Unemployment weighting factors, one for each year in timestream; continue on to next line if more than 25 years

If IGRO = 3, the following is required; otherwise skip the line.

GAND	10F8	Product sales growth factor for each year in timestream; continue on to next line if more than 10 years

The following line is required for the program to run.

ICC	I2	Output switch ICC = 1 convex envelope output 2 monotonic envelope output 3 options

A sample input data set is shown in Table 3-1.

SECTION 4

OUTPUT DATA

OUTPUT DATA

The computer output obtained from a run of the NDM is presented in Appendix A. This NDM output represents the results for the sample data set or data file depicted in Table 3-1. A summary description of the data output from the NDM is presented below, along with cross-references to the contents of Appendix A.

Input Data Specification (pages and)

The first page of the computer run display the input data used for that particular run of the NDM. A brief description of each input, in the order shown, is presented below.

- User selected title of the product to be regulated
- Type of sales selected (in this case tabular sales growth is used)
- Rate of growth (irrelevant in this case)
- "No regulation" information consists of the following:

  Original noise level

  Number of products replaced in first year of timestream (must equal product sales)

  Fraction of product population replaced (number replaced divided by total fleet size)

  Total product population (i.e., fleet size)

  Total user cost to replace the products in first year of timestream

  Total operating and maintenance cost of the entire product population in first year of timestream
- Number of regulatory levels considered
- Timestream start year or regulation announcement year
- Duration of timestream (number of years)
- Finance period: Number of years to finance purchase of new products assuming that a fixed sum is paid at the end of each finance year

  Special cases: Finance period = 0 cash payment at purchase at the beginning of the year

  Finance period = 1 payment at the end of the year simple interest

  In general: Fixed payment $= rP/(1 - 1 + r)^n$

  where r = discount rate

  P = amount borrowed

  n = finance period

- Regulation announcement year (year from which lead times are counted)
- Discount rate for benefit
- Discount rate for cost
- Discount rate for unemployment
- Manufacturer's profit return rate

For each regulatory level, the following information is printed:

- Regulation noise emission level
- Number of lead times
- For each lead time

    Fraction of projected product sales sold due to regulation

    Fraction of product population replaced due to regulation

    User cost increase per product unit due to regulation

    User O&M cost increase per product due to regulation

    Number of plants closed due to regulation

    Benefit resulting from regulation

    Unemployment due to regulation
- Weights for benefit for each year in timestream
- Weights for unemployment for each year in timestream

<u>Option Generation</u> (pages and)

Table of all possible regulatory scenarios or options from the combination of all the regulatory levels, with possible lead times. (Note that the first "regulatory level," 90 dB in 1980, is actually the unregulated level.)

<u>Timestream for Each Regulatory Option</u> (pages and)

A listing of the "timestream" is presented for each candidate regulatory option. The timestream includes the value of the following variables for each year of the timestream:

- Year in timestream
- Benefit attained
- Total user price increase (from all the new products bought that year)
- Total user price outlay increase due to financing the price increase due to regulation
- Total operating and maintenance (O&M) cost increase for all regulated products (all years) in the population (product fleet size)
- Total user outlay increase (total user price outlay plus total O&M)
- Umemployment
- Manufacturer's capital increase

- Total population size
- Number of old products replaced at the beginning of year
- Number of new regulated products bought at the beginning of year
- Number of plants closed
- Total change in manufacturer's profit relative to no regulation case (Option 1)

Benefit Summaries (pages and)

A summary of the benefit measures is shown for each option. The benefit measures are summed and averaged over the timestream. The following benefit measures are displayed:

- Cumulative benefit
- Average benefit
- Cumulative discounted benefit
- Average discounted benefit
- Cumulative weighted benefit
- Average weighted benefit

Price Outlay Summaries (pages and)

A summary of the price outlay increase measures is shown for each option. The measures are summed and averaged over the timestream. The following price outlay measures are displayed:

- Cumulative price outlay increase
- Average price outlay increase
- Cumulative discounted price outlay increase
- Average discounted price outlay increase
- Uniform annualized price outlay increase
- Average percentage price increase (average total price increase divided by total cost of replacement at beginning of timestream)

Operating and Maintenance Cost Summaries (pages and)

A summary of the operating and maintenance cost increase measures is shown for each option. The measures are summed and averaged over the timestream. The following operating and maintenance cost measures are displayed:

- Cumulative operating and maintenance cost increase
- Average operating and maintenance cost increase
- Cumulative discounted operating and maintenance cost increase
- Average discounted operating and maintenance cost increase

- Uniform annualized operating and maintenance cost increase
- Average percentage operating and maintenance cost increase (average operating and maintenance cost increase divided by total operating and maintenance cost for entire population at beginning of timestream)

Total Outlay Summaries (pages and)

A summary of the total outlay increase measures is shown for each option. These measures are summed and averaged over the timestream and consist of the following measures:

- Cumulative total outlay increase
- Average total outlay increase
- Cumulative discounted total outlay increase
- Average discounted total outlay increase
- Uniform annualized total outlay increase
- Average percentage total price increase (average total price increase plus average total O&M increase divided by total cost of replacement plus total O&M for fleet at beginning of timestream)

Unemployment Summaries (pages and)

A summary of unemployment measures is shown for each option. These measures are summed and averaged over the timestream and consist of the following measures:

- Cumulative unemployment
- Average unemployment
- Cumulative discounted unemployment
- Average discounted unemployment
- Cumulative weighted unemployment
- Average weighted unemployment

Manufacturer's Capital Increase Summaries (pages and)

A summary of manufacturer's capital increase measures is shown for each option. These measures are summed and averaged over the timestream and consist of the following measures:

- Cumulative manufacturer's capital increase
- Average manufacturer's capital increase
- Cumulative discounted manufacturer's capital increase
- Average discounted manufacturer's capital increase
- Uniform annualized manufacturer's capital increase

Manufacturer's Profit Increase Summaries (pages and)

A summary of the changes in manufacturer's profit measures is shown for each option. These measures are summed and averaged over the time-stream and consist of the following measures:

- Cumulative change in manufacturer's capital increase
- Average manufacturer's capital increase
- Cumulative discounted manufacturer's capital increase
- Average discounted manufacturer's capital increase
- Uniform annualized manufacturer's capital increase

<u>Manufacturer's Profit Increase Summaries</u> (pages and)

A summary of the changes in manufacturer's profit measures in shown for each option. These measures are summed and averaged over the time-stream and consist of the following measures:

- Cumulative change in manufacturer's profit
- Average change in manufacturer's profit
- Cumulative discounted change in manufacturer's profit
- Average discounted change in manufacturer's profit

<u>Additional Summary Tables</u> (pages through)

The following quantities are presented in summary tables, which are sorted by various criteria (i.e., ascending or descending order):

- Average discounted benefit
- Uniform annualized price outlay increase
- Uniform annualized operating and maintenance cost increase
- Uniform annualized total outlay increase
- Average percentage total price increase
- Uniform annualized manufacturer's capital increase
- Average discounted unemployment
- Benefit-to-cost ratio
- Uniform annualized change in manufacturer's profit

<u>Listing of Regulatory Options on Convex Envelope and Monotonically Increasing Envelope</u> (pages and)

The following quantities are presented for each option that lies on the convex or monotonically increasing envelope:

- Options on the respective envelopes by number (refer to the table of all possible options to identify the option)
- Average discounted benefit (benefit)
- Uniform annualized total outlay increase (cost)
- Benefit-to-cost ratio

- Cost-to-benefit ratio
- Marginal benefit increase per unit cost increase (equals Δ benefit divided by Δ cost)

SECTION 5

COMPUTER LOGIC, FLOW CHARTS, AND ALGORITHMS

COMPUTER LOGIC, FLOW CHARTS, AND ALGORITHMS

INTRODUCTION

The Noise Decision Model computer program is designed to perform a benefit/cost analysis on all the possible combinations of regulatory options arising from user specified regulatory levels and lead times associated with these levels. The computer program is written in FORTRAN IV for the IBM 370 computer. This program is divided into seven parts, i.e., input, option generation, timestream enumeration, sums and averages, rankings, convex envelope, and monotonic envelope, which are subsequently described below.

5.1 INPUT

The following input data are necessary:

Sales growth of the equipment to be regulated under normal conditions (i.e., no regulations); there are three choices:

- Arithmetic growth -- each year's sales is a fixed percentage of the baseline year's sales higher than the previous year
- Exponential growth -- each year's sales is a fixed percentage of previous year's sales.
- Tabular growth -- the sales of each year expressed as a ratio of the baseline year stored in a table.

Original product specific population in baseline year (first year of timestream).

Original replacement rate -- the fraction of the product population that has to be replaced annually; for the baseline year, it is assumed that the sales of new products is the same as the replacement rate of old products.

Number of regulatory levels to be examined (a maximum of four).

Number of lead times for each regulatory level (a maximum of four each).

Total product sales cost and total operating and maintenance (O&M) cost in baseline year.

Baseline year.

Total number of years in timestream.

Finance period: it is assumed that the end-user finances product purchases by borrowing at the discount rate; the finance period is the number of years the user has to pay off the price of the product.

Discount rate: the discount rate is used to discount the value of money in subsequent years.

For each regulatory option or study level and each lead time, the following is required.

Fraction of sales resulting from price increase due to regulation (this number is to be computed from the price elasticity of demand).

End-user price increase per unit.

End-user operating and maintenance cost increase per unit.

Manufacturer's investment cost increase (the additional capital the manufacturer requires in order to comply with the regulation).

Number of plants closed due to regulation.

Benefit resulting from the total product population being replaced by new, quieted products in terms of total population of people no longer exposed to adverse noise emissions.

Unemployment resulting from regulation.

5.2 OPTION GENERATION

This part of the code is rather complicated, but the idea is fairly simple. Given a number of noise emission levels (five maximum, including the original unregulated level) and a number of lead times for each level (four maximum per level), the program generates the no regulation option as option number 1. Then it goes out and selects one regulation at a time (for the sample run, there are four regulatory levels with the number of lead times as 2, 3, 2, 1, respectively, for each level. Therefore, the total number of options with one regulated level = 2 + 3 + 2 + 1 + 8). Next, it looks at all possible combinations of two noise emission regulatory levels (e.g., 86 dB with lead time 1 year, 83 dB with lead time 2 years, 86 dB with lead time 1 year, 83 dB with lead time 3 years, etc.), then three regulatory levels, and then four regulatory levels.

The total number of options is dimensioned at 100 to save computer file storage. It is conceivable, in some cases, that the total number of options could exceed 100. In that event, the program will have to be altered to accommodate the larger number.

5.3 TIMESTREAM ENUMERATION

The following conventions are used in computing the values presented in the timestream table for each option:

New product equipment is purchased and old equipment is replaced at the beginning of each year in the timestream.

Benefits are calculated at the end of each year.

Manufacturer's capital increase is computed at the beginning of each year, as is operating and maintenance cost.

The end-user price increase is paid at the end of the year unless the finance period is zero, in which case cost is assumed to be paid at the beginning of the year.

Manufacturer's profit is computed at the end of each year.

The product population is computed at the end of each year.

The following quantities are presented in the timestream tables:

Year of the timestream.

Benefit from the noise emission regulation measured in terms of people no longer exposed to adverse noise emission due to lower noise emission levels of regulated products.

Benefit for 1 year is computed by summing the total benefit for each regulated level and multiplying by the ratio of the population at each regulatory level to the total population size. The idea is that when all the products are replaced with regulated products, the benefit input value will be achieved. For the case of constant product population size and constant replacement rate, the benefit is linear with time before the full benefit is reached. The formula used is:

$$B = \sum_{i=1}^{n} w_i B_i$$

where n = number of noise emission regulatory levels

B_i = total benefit for regulatory level i

w_i = population at regulatory level i divided by total population at all levels.

The total price increase to the user due to regulation in a given year is the price increase per unit multiplied by the number of units sold that year

Price outlay increase is the amount the user pays per year over the number of years for which the purchase is financed. If the purchase is not financed, the price outlay increase equals the total price increase. (Note: If the user buys new products again the next year, the outlay increase from the last year has to be paid in addition to a new outlay increase for the new year's purchase.)

Operating and maintenance increase is the total additional O&M cost for the new products produced each year; it is assumed to be paid in cash and not financed.

Total outlay increase is the sum of the price outlay increase and the O&M increase.

Unemployment due to the regulation.

Manufacturer's capital increase: It is assumed that manufacturers of regulated products make preparations to comply with the regulation coming in a lead time of LT. The needed extra capital for compliance is divided into LT equal portions, investing 1/LT of the total for each year between regulation announcement and enactment. If there is more than one regulatory level, then the capital increase for a year will be the sum of the total capital increase for each regulatory level weighted by the reciprocal of the respective lead times.

Total number of products in the population at the end of the year after old products have been replaced and new products purchased.

Number of old products replaced per year.

Number of new products sold per year.

Number of plants closed due to the regulation.

Change in manufacturer's profit is the difference between the manufacturer's profit for a given regulatory option and that of the baseline option, i.e., how much the manufacturer suffers or gains from the regulation by comparing his profit with what he would obtain if there were no regulation. By definition, this will be zero for Option 1 (i.e. no regulation). Profit is calculated as follows:

$$P_i = (C_i)(PR)(S_i)$$

where C_i = cost per unit in year i

PR = profit rate (percentage)

S_i = total product sales in year i.

5.4 SUMS AND AVERAGES

Summary data are presented for the following quantities:

Benefit.

Total price outlay increase.

Total operating and maintenance cost increase.

Total outlay increase.

Unemployment.

Manufacturer's capital increase.

Change in manufacturer's profit.

For each of the above, one or more of the following is applicable:

Cumulative: Sums quantity over all years in timestream

The formula used is:

$$\sum_{i=1}^{n} q_i$$

where n = number of years in timestream

q_i = benefit or cost in year i.

Average: Cumulative divided by number of years in timestream.

Cumulative discounted: Discounted by a factor for each year in the timestream and then summed.

The formula used is:

$$\sum_{i=1}^{n} q_i/(1 + r)^{i-1}$$

where r = discount rate.

Average discounted: Cumulative discounted divided by number of years in timestream.

Cumulative weighted: Each year weighted by a weighting factor and then summed (used for unemployment and benefits only).

The formula used is:

$$\sum_{i=1}^{n} w_i q_i$$

where w_i = weighting factor for year i.

Average weighted: Cumulative weighted divided by number of years in timestream

Uniform annualized: Assumes that the end-user is going to finance the cumulative discounted total by putting a fixed sum yearly into a finance account, so that, at the end of the timestream, an amount equal to the cumulative discounted total is available.

The formula used to compute the uniform annualized cost is:

$Pr/[1 - 1/(1+r)^n]$

where r = discount rate

P = cumulative discounted cost

n = number of years in timestream.

Average percentage increase: Average cost increase divided by total original cost.

5.5 RANKINGS

The options are ranked by:

Decreasing average discounted benefit

Increasing uniform annualized cost (total outlay increase)

Decreasing benefit/cost ratio.

The following quantities are presented in the ranking tables:

Option number

Average discounted benefit

Uniform annualized price outlay increase

Uniform annualized operating and maintenance increase

Uniform annualized total outlay increase (hereinafter referred to as uniform annualized cost)

Average percentage total increase

Uniform annualized manufacturer's capital increase

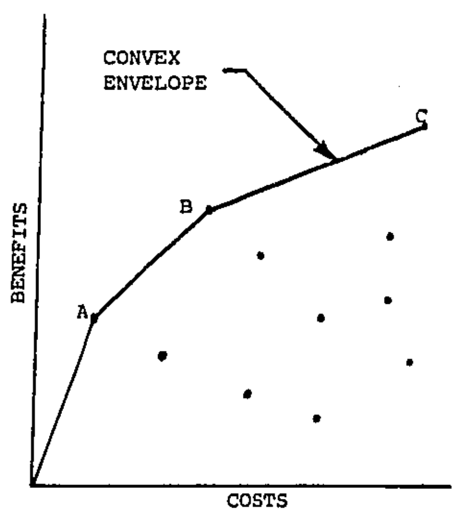
Average discounted unemployment

Benefit/cost ratio

Uniform annualized change in manufacturer's profit.

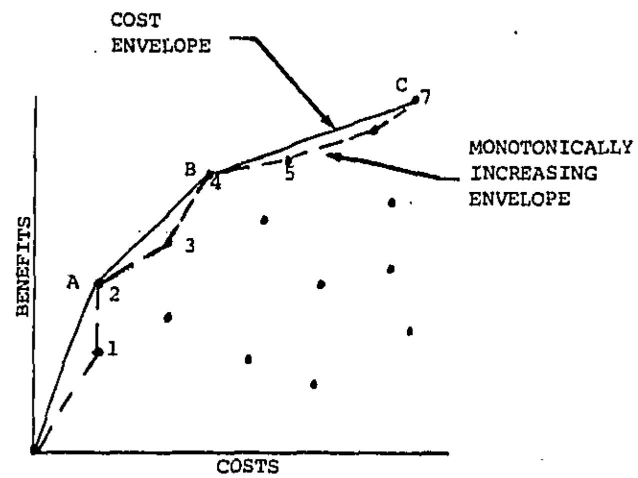
5.6 CONVEX ENVELOPE

The convex envelope consists of those options, plotted in cost-benefit space, which are "best" from the vantage point that, for a given cost, these options offer the most benefit. In practice, these options are arrived at by finding the option with the highest benefit/cost slope using the previous point as the origin of the rectangular coordinate system. An example of the convex envelope is shown below.



5.7 MONOTONIC INCREASING ENVELOPE

The monotonically increasing envelope can be plotted in the cost-benefit space also. The example shown below presents the same data as the previous figure with the addition of the dashed line curve which is the monotonic increasing envelope. It is derived as follows. Starting from the origin, find the point to the right with the least cost. If there is more than one, pick the point with the highest positive slope. Use this point as the origin and continue the procedure until no more points are left to the right or the slope becomes zero or negative. It is clear that the convex envelope points (solid line curve) are a subset of the monotonic increasing envelope points, as shown below.



5.8 COMMON BLOCKS

There are three common blocks in the Noise Decision Model computer program. These blocks are used to transfer variables to different points of the program. They are named BLOCK1, BLOCK2, and BLOCK3. There are four subroutines (OPGEN, SORT, CONVEX and MONOTO), one function (FACT) and the main program. The usage of the common blocks in the subroutines, program, and function is presented in the cross-reference table below.