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AIRPORT NOISE REDUCTION FORECAST

VOLUME I — SUMMARY REPORT FOR 23 AIRPORTS

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OCTOBER 1974

FINAL REPORT

DEPARTMENT OF TRANSPORTATION
OFFICE OF NOISE ABATEMENT
WASHINGTON, D.C. 20590

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16. Abstract

A detailed analysis of cost effectiveness of two aircraft noise reduction alternatives was carried out and the final results are summarized in this report. The alternatives consisted of: (1) modification of all civil air carrier aircraft having JT3D and JT8D engines, using quiet nacelles (SAM) treatment, and (2) modification of all JT3D-powered civil aircraft using SAM treatment plus all JT8D-powered civil aircraft using new front fan (REFAN) treatment. Both alternatives also assumed standard use of a two-segment approach procedure incorporating a 6°/3° glide slope for landing.

The analysis included a detailed evaluation of noise impact at 23 airports for the years 1972, 1978, 1981, and 1987 along with a detailed cost analysis of implementing the alternatives. Based on a time-integrated measure of relative reduction in number of people or land area impacted within NEF 30 or NEF 40 contours, the cost effectiveness of the SAM 8D/3D alternative is more than twice that of the SAM 3D/REFAN 8D alternative.

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PREFACE

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ABSTRACT

A detailed analysis of cost effectiveness of two aircraft noise reduction alternatives was carried out and the final results are summarized in this report. The alternatives consisted of: (1) modification of all civil air carrier aircraft having JT3D and JT8D engines, using quiet nacelles (SAM) treatment, and (2) modification of all JT3D-powered civil aircraft using SAM treatment plus all JT8D-powered civil aircraft using new front fan (REFAN) treatment. Both alternatives also assumed standard use of a two-segment approach procedure incorporating a 6°/3° glide slope for landing.

The analysis included a detailed evaluation of noise impact at 23 airports for the years 1972, 1978, 1981, and 1987 along with a detailed cost analysis of implementing the alternatives. Based on a time-integrated measure of relative reduction in number of people or land area impacted within NEF 30 or NEF 40 contours, the cost effectiveness of the SAM 8D/3D alternative is more than twice that of the SAM 3D/REFAN 8D alternative.

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CORRECTION!

THE PREVIOUS DOCUMENT(S) MAY HAVE BEEN FILMED INCORRECTLY . . .

RESHOOT FOLLOWS!

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1.0 INTRODUCTORY SUMMARY

1.1 Introduction and Organization of Report

Major changes to the civil aviation system have been initiated over the past few years which have helped to counteract the gradual increase in noise impact around air carrier airports. These changes have included the instigation of a noise certification rule for jet aircraft (FAR Part 36) and the resultant infusion of quieter wide body aircraft into the air carrier fleet. While continued progress toward alleviation of noise impact around airports would be achieved by continuing this natural transition to the quieter and more efficient wide body aircraft, the rate of progress is insufficient, considering continued growth in civil aviation operations dictated by ever-increasing passenger capacity demand. From a number of additional noise abatement alternatives that could be applied to further reduce airport noise impact, two have been selected for detailed evaluation in this unique study involving analysis of noise impact around 23 of the nation's largest airports.

This report presents the detailed results of this study. This volume describes the study method (Chapter 2), presents all of the significant findings on noise impact effectiveness of the alternatives (Chapter 3), the economic costs (Chapter 4), and presents the conclusions and recommendations (Chapter 5). These are also summarized in this chapter. Volume II (Report DOT-TST-75-4) describes the special computer program developed for carrying out the noise impact analysis and Volume III, on file with the Department of Transportation, is the single archival copy of detailed backup data.

1.2 Results

Noise Abatement Alternatives

The two noise abatement alternatives analyzed consisted of the following:

1. Quiet nacelle (SAM) retrofit of turbofan aircraft equipped with JT3D engines (707, DC-8) and JT8D engines (727, 737 and DC-9).

2. SAM retrofit of JT3D aircraft combined with new front fan (REFAN) retrofit of all JT8D aircraft.

For purposes of this study, the two-segment approach procedure, wherein a 6°/3° glide slope is used by all aircraft, is assumed to be in standard use for all future-year analyses.

Noise Impact Analysis

The noise impact was analyzed at the 23 major airports shown in Figure 1-1. Daily jet operations from these airports represent 53 percent of the total jet aircraft operations by all principal U.S. carriers in 1972 and are expected to represent about 46 percent of the total by the year 1987.

The noise impact was analyzed for present (1972) and projected future (1978, 1981, and 1987) operations at the 23 airports taking into consideration potential changes in the air carrier fleet mix for each alternative studied.

The costs of implementing each alternative were estimated in terms of both current dollars and present value using a 10 percent discount rate to 1974. Costs were based on:

- Initial Capital Investment
- Lost Time During Retrofit
- Change in Direct Operating Costs
- Lost Productivity

The effectiveness of the noise abatement alternatives was measured by computing:

- The decrease in impacted area within Noise Exposure Forecast (NEF) 30 and NEF 40 contours, and

Figure 1-1. Location of 23 Airports Used for Airport Noise Reduction Forecast Study

- The decrease in estimated number of people (based on 1970 census data) residing within the NEF 30 and NEF 40 contours.

The impacted area represented the total land area within a given contour excluding airport property.

As illustrated in Figure 1-2, this change in impacted area or number of people impacted was evaluated over the 15-year time period (1972-1987) considered in the study and expressed, for each analysis year, as a percent relative to the baseline impact (two-segment approach) for the same year if neither retrofit alternative was implemented. Thus, the shaded area in Figure 1-2 represents a measure, relative to the total area under the baseline curve for 15 years, of the effectiveness of each noise reduction alternative. This relative effectiveness, expressed as a percentage, is listed on the second and third column of Table 1-1 for NEF 30 and NEF 40. The upper table defines relative reduction in impacted land area while the lower table presents corresponding measures of effectiveness for people residing within the NEF 30 or NEF 40 contours. For example, application of SAM retrofit to JT3D and JT8D aircraft reduces the number of people within the NEF 30 contour integrated over the period from 1972 to 1987 by 14 percent. The total cost in current dollars of each alternative is shown in the next column.

Thus, the cost-effectiveness of each alternative can be evaluated simply in terms of the percent effectiveness divided by the total dollar cost to "buy" the corresponding benefit denoted by the shaded area in Figure 1-2 (see the last two columns).

Interpretation

The relative cost-effectiveness of the two alternatives is clearly defined by comparison of values between rows of either of the last two columns in either table. Based on the cost-effectiveness figures in %/$B for reduction in population within the NEF 30 contours, the alternatives differ by the following ratios:

Alternatives	%/$B	Ratio
• SAM 3D/8D	14.5	2.1
• SAM 3D REFAN 8D	6.8	1.0

The other measures of cost-effectiveness show higher ratios of relative effectiveness and in the same ranking.

The in-depth analysis carried out in this study has provided additional new insight into the evaluation of airport noise impact. In particular, the study shows that substantial variations in impact occur among airports and only by examining a substantial aggregate sample can one reliably predict the effectiveness of any given noise reduction alternative. However, once a detailed study such as this has been carried out, one can explore the ability to apply the results to the development of more efficient means of evaluating cost-effectiveness of other aviation oriented environmental control systems. Some specific recommendations to this end are summarized at the end of this report.

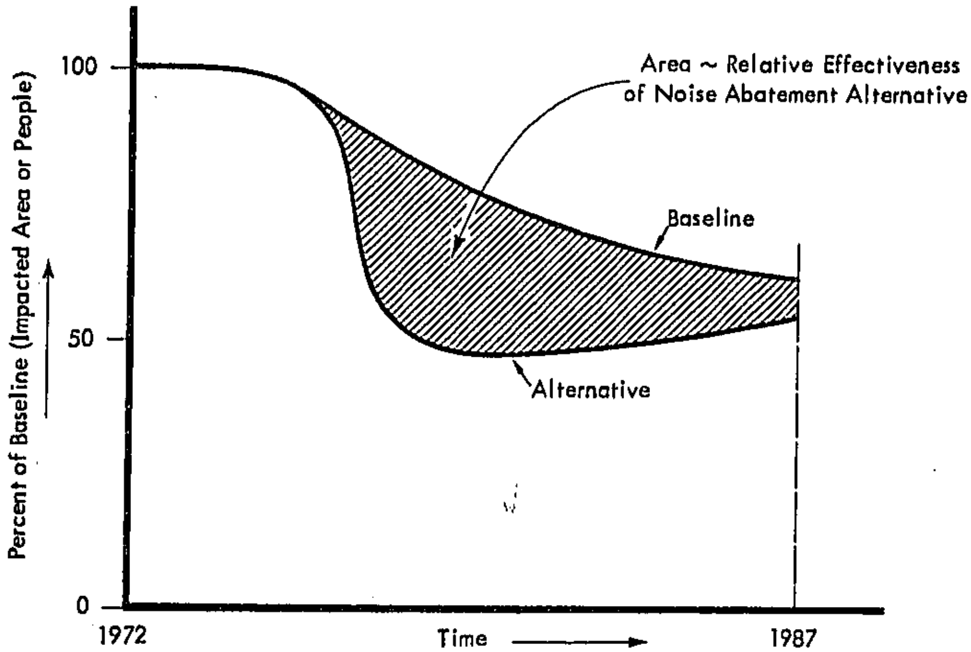

Figure 1-2. Conceptual Illustration of Time Variation in Effect of Noise Abatement Alternative and Time-Integrated Measure of Effectiveness

Table 1-1

Summary of Cost-Effectiveness for 23 Airports
(6°/3° Baseline)

Impacted Land Area

Alternative	Effectiveness % Reduction		Cost* $B	Cost-Effectiveness %/$B Reduction	
	NEF 30	NEF 40		NEF 30	NEF 40
6°/3°, SAM 3D/8D	17	24	0.967	17.6	24.8
6°/3°, SAM 3D REFAN 8D	34	35	5.001	6.8	7.0

Population

Alternative	Effectiveness % Reduction		Cost* $B	Cost-Effectiveness %/$B Reduction	
	NEF 30	NEF 40		NEF 30	NEF 40
6°/3° SAM 3D/8D	14	22	0.967	14.5	22.8
6°/3° SAM 3D REFAN 8D	34	37	5.001	6.8	7.4

*Current dollars for total program.

2.0 STUDY METHOD

2.1 Study History

Noise impact created by aircraft operations at busy airports is a complex phenomenon. The impact depends on a vast number of interrelated factors, involving the number and type of aircraft in operation, their flight paths and procedures, the arrangement of the airport, its runways and neighboring areas, weather patterns, and changing aviation demands. This study was undertaken to analyze in considerable depth these factors for the U.S. carrier airports, and to predict the changes which should result if certain noise abatement actions were to be taken.

Analysis of complex systems is, by necessity, an iterative process. As this study progressed, some of the assumptions made at the initial stages of the investigation were modified or discarded.

These reexaminations and revisions were made on the effectiveness as well as the cost side of the analyses pertaining to the study. In addition to changes brought about by insight into the problem gained from initial results, other factors led to revision of some of the initial assumptions. For example, some changes took place in potential aircraft noise reduction technology as the study progressed. Changes in economic factors and energy considerations also occurred during the course of the study. The major elements of these changes in the study are summarized in this section.

2.1.1 Initial Approach to the Study

The basic objectives of this study have not changed since its inception — namely, to provide quantitative information necessary to evaluate the cost-effectiveness of aeronautical and operational alternatives to reduce airport/community noise incompatibility.

The initial plan for the study was generally as follows:

- Estimate the base level noise exposure at 23 U.S. airports, which encompass the majority of the population impacted by noise from civil aircraft, and forecast the change in noise exposure due to a number of noise abatement alternatives. As initially planned, these alternatives consisted of a matrix of six operational procedure alternatives and eight aeronautical alternatives.
- Estimate the total cost of each noise abatement alternative, including investment, direct operating costs, and other related costs.
- Relate the cost of these alternatives in terms of the reduction in noise impacted area and in estimated number of people residing within the noise contours to the total cost of the alternatives.

Except for changes in the number and type of alternatives analyzed and minor changes in the list of specific airports included in the study, the study has generally followed this initial plan.

Previous Studies

Studies have been made in the past of noise impact around a number of specific airports throughout the nation including, in some cases, evaluation of noise reduction alternatives for current or projected airport operations.[1-5] No one single study provided the necessary depth or detail required to meet the objectives of this program. None has been able to include the detail necessary to assess effects at a sufficiently representative sample of actual airports, nor examined these effects in terms of number of people impacted. Indeed, previous studies were often generalized in nature and considerably limited in scope. Recognizing these limitations, the present study was undertaken to gain the depth of detailed analysis necessary to provide valid comparisons of cost-effectiveness. While two of these studies evaluated costs of proposed noise reduction alternatives, the alternatives analyzed were not suitable or the supporting measures of effectiveness (i.e., reduction in noise impact) were not adequate.[4,5]

Nevertheless, these prior studies provided very important and valid background information in the following areas to guide the direction of this study.

- The variation in the degree and controlling source of noise impact from one airport to another was clearly demonstrated so that a substantial sample of airports was required to evaluate effectiveness of any scenario of noise reduction alternatives.[2,3]

- A more sophisticated computer program would be required for evaluating efficiently the detailed noise impact at such a large number of airports.

- A more accurate assessment of noise impact at any one airport should be made to account more realistically for aircraft performance characteristics, airport flight operations, and number of people.

- Estimating costs of implementing any alternative would require a detailed evaluation of all pertinent economic factors involved, and should be based, again, on a substantial sample of airports.

- Relative effectiveness of a set of noise reduction alternatives does not appear to be sensitive to reasonable perturbations in fleet mix, level of operations, or day-night split.[3] Thus, unavoidable uncertainties in projections of aviation operations to future years would not inhibit the ability to make valid relative rankings of noise reduction alternatives.

In summary, then, the prior studies indicated the need for improved analysis methods or more detailed engineering and economics data to accomplish the purpose of this study. Therefore, the initial effort in this study was directed toward the development of improved noise impact analysis methods and a detailed economic and engineering data base for application to the program. The next sections of this report summarize the results of this work before presenting the details of the final results.

In addition to the initial definition of study methods, several basic assumptions or ground rules were established at the beginning of the program. These included:

- Selection of the 23 airports
- Selection of the years for future projections
- Selection of the candidate noise reduction alternatives
- Selection of a measure of effectiveness for aircraft noise reduction
- Definition of economic criteria for the cost studies

These initial considerations or ground rules are discussed in the following paragraphs or later on in Section 2.

2.1.2 Airport Selection

From a preliminary examination of airport noise impacts, 23 major U.S. continental airports were selected to represent a majority of the people residing within the NEF 30 and 40 noise exposures (see Section 2.3 for definition of NEF contours).

This list of 23 airports excluded several major airports which are primarily surrounded by compatible farm land and woods, or are in the process of transferring to a new compatible site. The list included a few smaller airports which are partially surrounded by residential neighborhoods, together with Washington - Dulles and Chicago - Midway, which may be of special interest in future years. It is estimated that the 23 airports selected accounted for a majority of the people and impacted land within the NEF 30 contour in the United States as of 1972. The 23 airports selected are listed alphabetically in Table 2.1-1, along with their daily air carrier operations and airport area. Their geographic locations were shown earlier in Figure 1-1. Table 2.1-2 summarizes the relative proportion of total operations of the principal U.S. air carriers that occur at the 23 airports.

Table 2.1-1
Summary Characteristics of the 23 Airports

No.	Airport	(Code)	Daily Operations No. *	Daily Operations Rank	Airport Area sq mi **
1	Atlanta - Hartsfield	(ATL)	1136	2	6.56
2	Boston - Logan	(BOS)	590	10	3.72
3	Buffalo	(BUF)	204	33	1.56
4	Chicago - Midway	(MDW)	114	55	1.0
5	Chicago - O'Hare	(ORD)	1592	1	14.06
6	Cleveland - Hopkins	(CLE)	366	17	2.30
7	Denver - Stapleton	(DEN)	522	12	6.21
8	Dulles - International	(IAD)	168	38	15.59
9	John F. Kennedy	(JFK)	874	4	8.12
10	La Guardia	(LGA)	798	5	0.91
11	Los Angeles - International	(LAX)	1018	3	6.0
12	Miami - International	(MIA)	658	8	4.21
13	Minneapolis - Wold Chamberlain	(MSP)	338	19	4.58
14	Newark	(EWR)	478	15	3.38
15	New Orleans - Moisant	(MSY)	300	21	2.34
16	Philadelphia - International	(PHL)	476	16	3.90
17	Phoenix - Sky Harbor	(PHX)	212	31	2.55
18	Portland - International	(PDX)	222	30	4.69
19	San Diego - Lindberg	(SAN)	208	32	0.76
20	San Francisco - International	(SFO)	780	6	8.13
21	Seattle - Tacoma	(SEA)	300	22	2.81
22	St. Louis - International	(STL)	504	13	2.89
23	Washington - National	(DCA)	600	9	1.01
	Total		12458		107.3

*Annual Average Daily Air Carrier Operations - CY 1972 (See Section 2.6).

** Land Area inside Airport Property Boundary - FAA Airport Facilities Records.

Table 2.1-2

Proportion of Daily Operations of Principal U.S. Carriers Represented by 23 Airport Sample

Year	Percent of Operations (Jet Aircraft Only)
1972	53
1978	52
1981	50
1987	46

It is apparent that the 23-airport sample will represent more than 50 percent of the total U.S. air carrier jet operations for the years 1972 through 1981 and will tend to represent slightly less than 50 percent in the year 1987.

2.1.3 Selection of Future Years

As discussed in more detail in Section 2.7.2, the projected implementation schedule of the two principal noise reduction alternatives called for:

- Completion of quiet nacelle retrofit with sound absorption material(SAM) for all civil air carrier aircraft operating from U.S. airports by the end of 1978.
- Completion of refan retrofit of all turbofan civil air carrier aircraft equipped with JT8D engines, operating from U.S. airports by the end of 1981.

Thus, the years 1978 and 1981 were used as intermediate future years for the analysis. A reasonable projection of 6 years beyond 1981 was provided with the selection of 1987 as the final year — a span of 15 years from the initial starting year of 1972.

2.1.4 Selection of a Measure of Effectiveness of Noise Reduction Alternatives

For purposes of this study, the impact of aircraft noise around U.S. airports was represented in terms of Noise Exposure Forecast (NEF).[8] This scale is generally accepted as the best representation of civil aircraft noise impact, and has evolved over the past decade specifically for this purpose. Several other concepts were considered for use as a measure of effectiveness to compare noise reduction alternatives. For example, an NEF-to-annoyance transfer function was considered for establishing a single integrated measure of impact for an airport.[9,10] However, this approach was considered premature for adoption to this study. A "single number" measure of impact can therefore be provided by any of the following quantities:

- Impacted area within the NEF 30 or the NEF 40 contour
- Number of people residing within the NEF 30 or NEF 40 contours
- Decrease in area or number of people impacted relative to a baseline condition.

For this program, impacted area consisted of all land area within a given contour exclusive of area within airport boundaries. Areas over major bodies of water were therefore excluded. The numbers of people impacted were based on 1970 census data without provision for change in future population density or distribution.

For any 1 year, the effectiveness of any noise abatement alternative was to be evaluated in terms of the change in total impact for all 23 airports relative to the baseline value. For the final cost-effectiveness evaluation, an integrated measure of the estimated effectiveness over the 15-year time period of the study was used. This is discussed in more detail in Section 2.8.3.

2.1.5 Study Review and Redirection

A basic element of this study was the substantial exposure of initial assumptions and input data on economics, aircraft noise, and performance for review by other government agencies and industry. The sequence and general content of some of these reviews are summarized in Appendix A. This outside review provided a useful channel for constructive recommendations concerning the direction of the study in its early stages.

Following completion of preliminary noise impact analyses[11] on the six largest airports and preliminary analyses of the cost of the various alternative,[12] the study was modified. This redirection was based, in part, on the above preliminary results and outside review and in part, on results of changes in associated Federal research and development programs and airline industry planning. The major effects of these changes were to:

- Change the scenario of noise abatement alternatives analyzed to those discussed in detail in the next section (2.2).
- Replace the year 1985 employed in the initial study with the years 1981 and 1987.
- Replace any outmoded noise or performance data with the most recent available data. The final sources of data are identified in Section 2.3.
- Revise a substantial portion of the input data or ground rules for the cost analysis and airport operations. (The procedures used for this report are outlined in detail in Sections 2.4 through 2.7.)

The general intent and content of these changes were communicated by DOT to affected government and industry groups for comment prior to their adoption.[13]

2.2 Noise Reduction Alternatives

There are a number of alternative methods of reducing the noise impact of aircraft operations in the vicinity of airports. They can be subdivided into three categories:

- Operational Alternatives (flight procedures which minimize noise)
- Aeronautical Alternatives (quieter aircraft)
- Airport Alternatives (airport design and adjacent land use)

This study was concerned only with the first two categories, both of which are subject to research and development and regulatory actions by the Federal Government, and involve implementation by a combination of the air transportation and aircraft manufacturing industries. The third category involves optimizing both the development of the airport and its surrounding land use and the operational utilization of its facilities to minimize noise impact. It is primarily subject to local control and was not considered an appropriate variable for analysis of the national air transportation system. By neglecting any possible noise reduction achievable by "fine tuning" operations at each airport, the results of this study are on the conservative side. More importantly, the results will provide a valid relative ranking of the effect of the alternatives considered.

2.2.1 Operational Alternatives

Originally, the operational alternatives to be considered in this study were as follows:

- Current operational procedures
- Approach altitude at 3000 feet to a 3° glide slope
- Approach altitude at 3000 feet to a two-segment ($6^{\circ}/3^{\circ}$) glide slope
- Noise abatement takeoff
- Combinations of the above

For the initial studies with the first six airports, the number of operational alternatives was reduced to the first three in the preceding list.[11] These three alternatives were defined for each of the principal aircraft types. The results of the preliminary analyses indicated that use of a 3000-foot minimum approach altitude did not provide sufficient effectiveness to justify its further inclusion in the study. This report contains the results of applying only the standard approach procedure for the 1972 baseline cases and the 6°/3° two-segment approach for all future-year cases. Two special considerations should be pointed out. (1) Standard approach procedure at some airports involves the use of a constant vectoring altitude before intercepting the 3° glide slope. This was used only for those airports where it was applicable. (2) The 6°/3° approach procedure, which assumed a transition altitude between 6° and 3° of 690 feet, was applied uniformly at all airports without regard to possible limitations or modifications that might be required for safety reasons at some airports if the 6°/3° approach procedure were actually used routinely. It was assumed for this study that the necessary ground and aircraft equipment could be installed and the 6°/3° procedure fully implemented as the standard air carrier approach procedure by 1978.[14] Specific details on operational parameters assumed for this procedure are discussed later in Section 2.3 along with a description of the procedure used for takeoffs.

2.2.2 Aeronautical Alternatives

A list of the preliminary aeronautical alternatives which were considered for inclusion in this study is presented in Table 2.2-1. As with the operational alternatives, subsequent changes in research and development programs plus the results of the preliminary six-airport study reduced the number of aeronautical alternatives to the two identified in Table 2.2-1. This report contains the results of the application to all 23 airports of these aeronautical alternatives which are under active consideration.[15-18]

2.3 Noise Impact Analysis

Recent reviews of methods for characterizing community noise levels have generally agreed that desirable attributes of a valid scale for assessing noise impact around airports should include the following:[19,20]

Table 2.2-1

Aeronautical Noise Reduction Alternatives Initially Considered, Including Those Analyzed for Preliminary Study for Six Airports[11]

Alternative	Approximate Percentage of U.S. Fleet Retrofitted and in Operation in 1981**
Baseline *	100 (3217 Aircraft)
SAM 3D	11
SAM 8D	37
SAM 3D and 8D *	48
REFAN 8D	26
REFAN 727, SAM All Else	40
SAM 3D, REFAN 8D *	36
REFAN 3D and 8D	38

* Alternatives used for this study on 23 airports

**Estimated from Table 2.7-1 and Reference 11

- Relate accurately to human response to noise
- Provide a cumulative measure of exposure over a long period of time
- Be suitable for application to mathematical modeling
- Relate to noise scales or criteria used in regulatory action for the noise source
- Be consistent with noise scales for which a suitable data base on aircraft noise is available.

Other attributes related to ease of measurement or understandability to the layman do not necessarily apply for this study, since noise assessment is to be predicted analytically and represented in comparative terms.

Although there have been a large number of different schemes developed over the years for evaluating aircraft noise,[8,20,22,23] the Noise Exposure Forecast (NEF) scale was considered the most suitable for application to this study. It is based on a time-integrated measure of the noise level for each single event or aircraft flyby expressed by the Effective Perceived Noise Level (EPNL). The latter has been shown to provide a valid objective measure of subjective response to aircraft noise under controlled laboratory conditions.[24] It appears to account well for the frequency response characteristics and time duration sensitivity of human audition for aircraft sounds. Furthermore, since EPNL is the noise scale used in FAR Part 36 for aircraft noise certification, an extensive data base of aircraft noise in terms of EPNL versus slant range was available for this program. Well documented or experimentally validated data, based on other noise scales, were generally not available.

In addition to the preceding reasons, further support for using NEF contours for this program is provided by the following rationale:

- NEF values, like other time-integrated measures of noise, represent smoothed long-term measures of the noise exposure

- NEF contours are relatively insensitive to small changes in traffic volume
- Total airport activity is relatively stable over periods lasting several months
- Available information seems to point to the use of long-time average noise levels rather than noise levels based on relatively infrequent peak periods to assess community response to aircraft noise.

2.3.1 Aircraft Operations and NEF

The NEF 30 and NEF 40 contours were selected as criterion levels for this study based on the following generally accepted interpretation of these values for land use planning:

- Less than NEF 30 – Essentially no complaints expected; noise may interfere with community activities.
- NEF 30 to NEF 40 – Individuals may complain; group action possible.
- Greater than NEF 40 – Repeated vigorous complaints; group action expected.

For any point on the ground, the value of NEF can be conveniently expressed as:

$$NEF = \overline{EPNL} + 10 \log (N_d + 16.7 N_n) - 88$$

where

$\overline{EPNL}$ = energy average EPNL of all aircraft contributing to the noise input

N_d, N_n = number of flights during the day (7 AM- 10 PM) and night (10 PM-7 AM) respectively

Thus, NEF increases as the logarithm of the number of operation increases.

The total aircraft operations established for this study are representative of a long-term (annual) average day. The numbers of aircraft movements forecast for each of the airports are given in Section 2.6.

2.3.2 The NEF Computer Program Model

The development of NEF contours (isopleths of equal NEF value) representative of the aircraft operations in and around an airport complex requires the evaluation of a large number of parameters. With this in mind, a computer program was developed to model the aircraft activity associated with an airport and to perform the necessary calculations to determine the locations of the NEF contours. A program developed earlier by DOT to perform these calculations was available at the start of the study. This initial computer program was modified and expanded to provide the more complex computations for this study, which were beyond the capabilities of the initial computer program. A detailed description of the method employed for the program, and its use, is given in Volume II of this report.[30] Brief descriptions of the basic parameters necessary for the program to determine the locations of the NEF contours are given in the following paragraphs. The development of these parameters is described in following sections of this report.

The Airport System Definition.

The definition of an "airport system" for the purpose of assessing noise impact involves several parameters. These are:

- Airport Altitude

  The altitude of an airport is defined as its elevation above mean sea level. Airport altitude can influence aircraft flight performance.

- Runway Definitions

  The runways at each airport are defined by describing the locations of their endpoints with X-Y coordinates in a Cartesian coordinate system relative to an arbitrary origin. Typically, the origin is conveniently located near the center of the airport with the positive Y-axis in the direction of true north. The airport is assumed to lie in a horizontal plane, at the altitude defined above.

- Ground Tracks

  A ground track is the locus, in the plane of the airport, of the points directly beneath the flight path of departing and arriving aircraft. The ground tracks are defined by straight line and circular segments as they emanate from the associated runways. The runway and track definitions for Chicago - O'Hare are shown graphically in Figure 2.3-1, as an example. Practical limitations dictate that average ground tracks normally specified for flight control be used and effects of path dispersion be ignored. This simplification will not affect relative changes in impact area between various noise abatement alternatives.

- Approach Procedures

  The procedures followed by an aircraft on landing approach will normally vary from airport to airport in the areas leading to final descent on glide slope. The approach procedure (e.g., pattern altitudes, descent points, etc.) are termed "airport specific" and must be defined for each individual airport.

- Takeoff Restrictions

  Any variance from normal takeoff procedures must be defined for each individual airport. Standard takeoff procedures may be modified by the imposition of area ceiling altitudes, noise abatement procedures, or safety considerations.

- Aircraft Operations

  The numbers and types of aircraft operating into and out of the airport must be specified in terms of day/night distribution and ground track

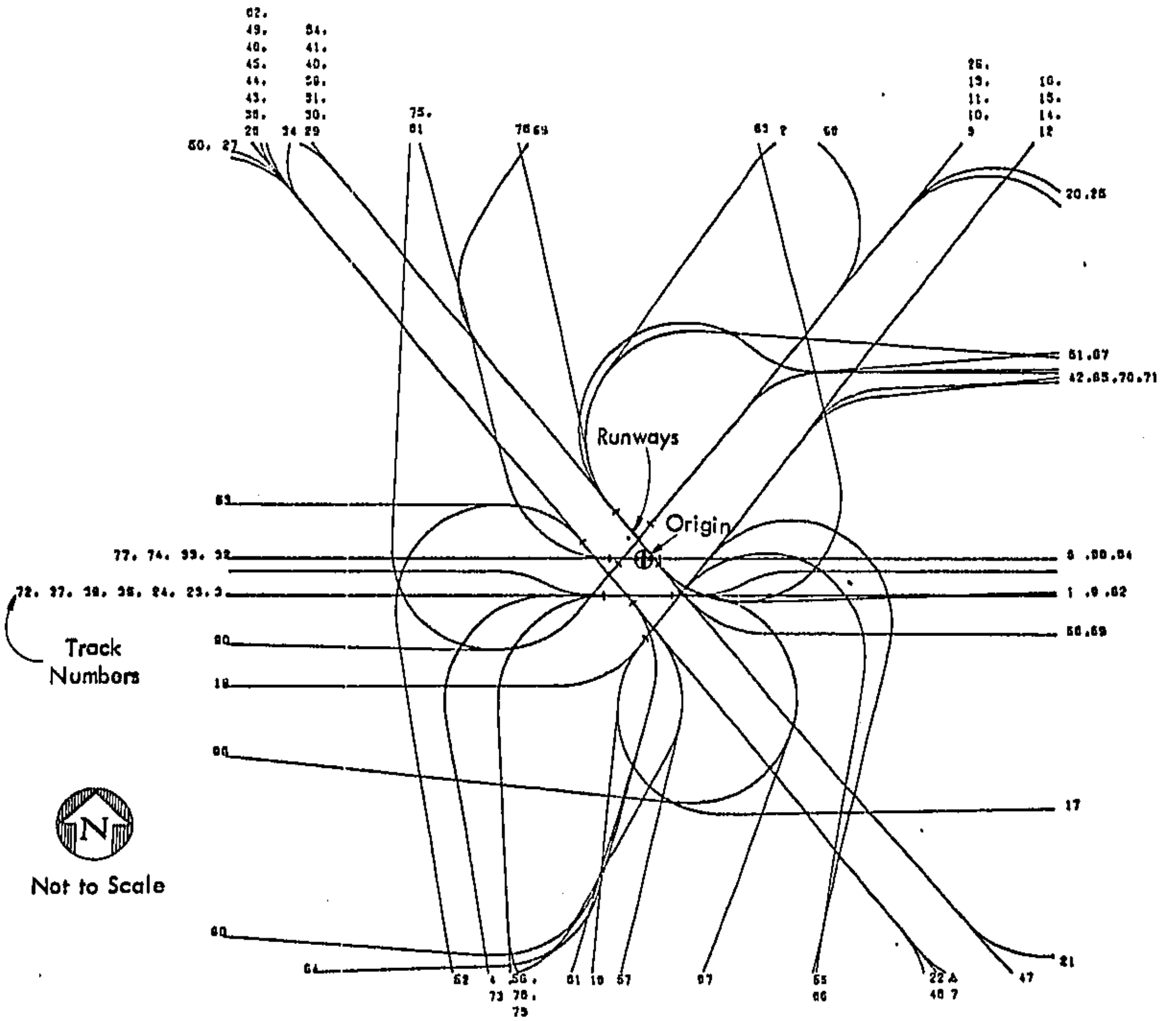

Figure 2.3-1. Ground Tracks for Chicago - O'Hare (ORD)

assignment. Additionally, departures must be further broken down into trip length categories. The trip length categories are indicative of the takeoff gross weight of the aircraft and are used to determine which takeoff altitude profile definition will be assigned to the flight.

In addition to the "airport specific" definitions, several aircraft-dependent items must be defined for the program. These items are as follows:

- <u>Noise Data</u>

  The noise values produced versus the slant distance from the aircraft for several thrust levels must be defined for each type of aircraft to be considered.

- <u>Takeoff Profiles</u>

  A takeoff profile for each defined trip length for each defined aircraft must be provided. The takeoff profile consists of defining the aircraft altitude, thrust setting and velocity as a function of the distance from brake release. These profiles are standard at all airports unless takeoff restrictions are defined. Airport elevation corrections are applied to the profiles where applicable.

2.3.3 Aircraft Noise and Operational Characteristics

Noise versus slant range characteristics for most of the existing aircraft with or without proposed noise reduction alternatives were obtained from the manufacturers. The detailed reference sources of data for each of these aircraft are summarized in Appendix B. Noise versus slant range characteristics of future aircraft were defined on the basis of data supplied by government, manufacturers or by engineering estimates by Wyle Research. Generally accepted correction factors to account for air-to-ground propagation losses, engine shielding losses, and noise level versus thrust were adopted for the study. Procedures recommended in SAE ARP-866[25] and proposed ARP-1114[26] were utilized for extrapolating or estimating aircraft noise versus slant range curves which were not otherwise available.

Particular attention was paid, in this study, to estimating nominal aircraft flight profile characteristics. In practice, these flight procedures vary widely with aircraft type, pilot, airline, runway, and weather. However, practical limitations require approximation of the operational spectrum by "typical" operating characteristics. The characteristics assumed for the purpose of the Noise Reduction Forecast Program are detailed in the following paragraphs. Specific performance parameters used for individual aircraft, based on manufacturer-supplied data, are also included.

Takeoff

The takeoff profiles were calculated assuming a windless, sea level, 59-degree F day and the ATA standard procedure for all departures.[27] Briefly, this procedure calls for takeoff at maximum power with a speed of V_2*+ 10 ktas and a constant flap setting until reaching 1500 feet above ground level. At this point, power is reduced to maximum climb power or that thrust needed to maintain a 1000 fpm rate of climb, whichever is greater. At 3000 feet, the airplane decreases the climb angle and accelerates at a rate of 1 kt/sec. Flaps are retracted as speed permits. At a speed of 250 ktas, climb is resumed in a clean configuration. Figure 2.3-2 shows this profile schematically.

Approach

Over each individual approach track, it was assumed that all aircraft, regardless of type, follow the same path, i.e., all aircraft fly at the same pattern altitudes and make altitude transition at the same places. Unlike takeoff profiles, a unique approach profile is required for each ground track at each airport. Figure 2.3-3 shows a typical profile. No weight variations were considered on approach. Aircraft of the same type were considered to be at one typical weight (see Table 2.3-1).

*Speed necessary to maintain minimum climb gradient as defined in Reference 28.

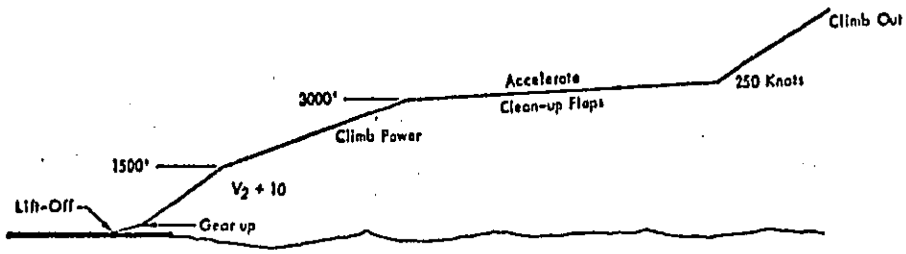

Figure 2.3-2. Typical Takeoff Profile

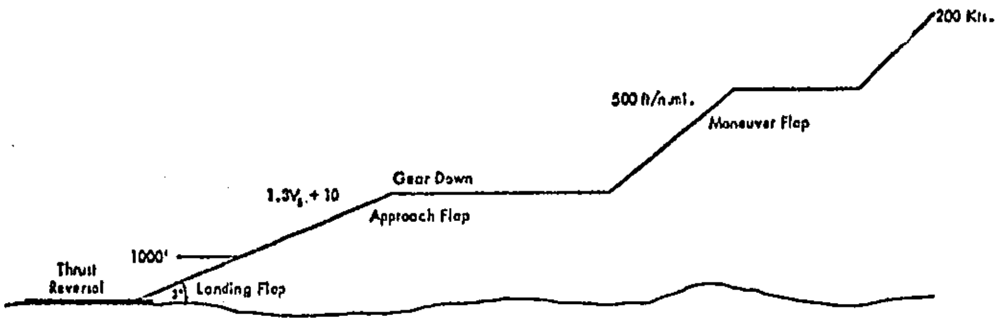

Figure 2.3-3. Typical 3° Approach Profile

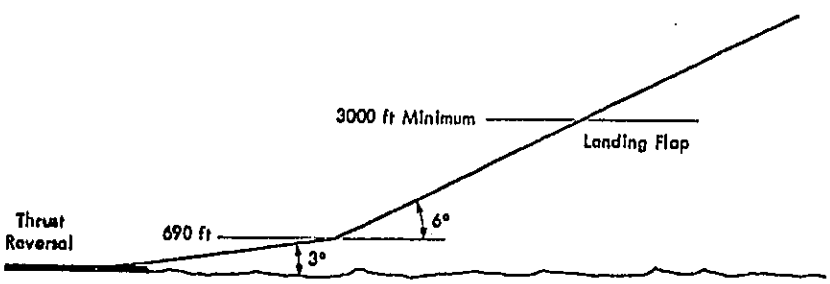

Figure 2.3-4. Typical 6°/3° Approach Profile

Table 2.3-1

Values Used for Modeling Landings for Several Aircraft

Aircraft Type	Landing Weight ~lbs.	Length Landing Roll ~ft.	Landing Speed ~kts.	Landing Power Setting (F_n*) ~lbs/eng							
				Descent with Landing Flap		Descent with Approach Flap		Descent with Maneuver Flap		Flight Idle	Thrust Reversal
				3°	6°	0°	3°	0°	500 ft/n.mi.**		
DC-8-33, 720, 707-120/320, CV-880, VC-10	180,000	4100	146	4400	2045	5150	2790	4700	1000	500	8500
DC-8-55, -61	197,500	3000	140	5450	3120	5750	3200	4600	1000	700	8500
DC-9, BAC-111	65,000	2910	122	4000	2285	3665	1975	2875	450	450	8000
DC-10, L-1011	300,000	3945	138	8535	3265	11000	5760	9800	1800	1800	20000
707-320B/C, 720B 707-120B, CV-990	190,000	4100	135	3885	1380	4790	2365	3980	700	700	8500
727	138,200	2800	132	6000	3550	5000	2590	3130	500	500	8000
737	88,000	2750	133	4825	2400	4930	2640	4820	1220	500	8000
747	500,000	4000	146	11800	5230	14950	8400	11380	2790	2790	20000

*F_n = Uncorrected net thrust.

**Gradient of pattern altitude transition.

The profile begins in the handoff area with aircraft at 200 ktas and a maneuver flap setting. Transitions between a maximum of three pattern altitudes are made at a 500 foot/n.mi. gradient. On reaching final pattern altitude or on receipt of clearance to land, flaps are changed to an approach setting. Landing gear is extended at glide slope intercept. All final approaches (including VFR) are made along a 3° glide slope. In accordance with ATA procedures, transitions from approach to landing flap settings are made at an altitude of 1000 feet. A landing speed of $1.3\,V_s^* + 10$ ktas is assumed while aircraft are on the glide slope. After touchdown, thrust is increased to simulate the noise due to thrust reversal. Approach parameters used for specific aircraft models are presented in Table 2.3-1.

6°/3° Glide Slope

The 6°/3° operational alternative consisted of a descent along a 6° glide slope from an applicable pattern altitude (never less than 3000 feet) until reaching a height of 690 feet above ground. At this point, a transition to a 3° glide slope was made and landing was treated as before. Flaps were assumed to be in a landing setting after the initial transition to the 6° segment. The transition from the 6° segment to the 3° segment was assumed to take place on the final leg for all tracks. When normal approach patterns involved a pattern altitude less than 3000 feet for any ground track, approach patterns on all tracks were elevated uniformly until the lowest pattern was at 3000 feet. This maintained the same relative pattern separation (see Figure 2.3-4).

Flap Schedules

Decisions about typical flap management schedules were made after consultation with airline operations officials (see References B-12 through B-16 in Appendix B). Results of these conversations are summarized in Table 2.3-2. For both landing and takeoff, flap settings were chosen to be representative of operations from or onto long runways. These flap settings, along with aircraft weights and approach or takeoff profile angles, formed the basis for selecting consistent thrust settings for each type of aircraft from available manufacturers' performance data.

*Stall speed as specified in Reference 28.

Table 2.3-2

Typical Flap Settings for Takeoff and Arrival for Several Aircraft*

Model	Takeoff Flaps,** Degrees	Arrival Flaps, Degrees		
		Maneuver	Approach	Landing
707-320	30	30	30	40
707-320B	14	25	30	30
720B	30	30	40	50
727	15	5	25	40
737	5	5	25	40
747	10	10	25	30
DC-8-33	25	30	35	50
DC-8-61	15	25	35	50
DC-9-15	20	15	20	50
DC-9-32	15	15	20	50
DC-10	15	5	18	35
L-1011	10	4	22	33

*Based on survey of airline operations officials cited in References B-12 to B-16. Due to the lack of complete manufacturer's data, the above values may not be wholly consistent with the flap assumptions actually used.

**Takeoff flap setting may vary with weight.

2.3.4 Noise Impact Parameters

The noise impact was computed in terms of the number of people residing within the NEF 30 and NEF 40 contours and the net impacted area (excluding airport property and water) within those same contours.

The population data used for this study were developed from population centroid information contained in the U.S. Bureau of Census tapes for the 1970 census. A population centroid, in this context, defines a weighted central location of a population distribution in an area. The location of the centroid is determined by the variation of population density in the general area of concern and represents the center of population rather than the geographic center of the area. In addition to the location of the centroid, the number of people represented was also defined. If a centroid was found to fall within one of the NEF contours, the number of people represented by the centroid was considered impacted. Figure 2.3-5 exemplifies a graphic representation of the centroid definitions around Los Angeles International Airport. Population was assumed to remain constant for the future years used in this study.

The definitions of the property boundaries for the airports were obtained from airport planning maps, provided by the airport operator or planning commission, or from FAA-provided Forms 5010 and 29-A. The locations of major bodies of water were obtained from U.S. Coast and Geodetic Geological Survey maps and from census maps. Figure 2.3-6 is a graphic example of the definitions of airport property and major bodies of water for Miami International Airport. Impacted land, then, is defined as the land area inside an NEF contour, excluding airport property. No attempt was made to assess compatibility on the basis of actual land use or of ultimate habitability.

By now, the basic procedures for evaluation of the noise from aircraft have been defined. It remains to define the methods for evaluating the airport and aviation system parameters in order that the integrated noise impact and cost of noise reduction alternatives can be defined. The last section in this chapter briefly reviews the method for relating the two parameters – cost and effectiveness.

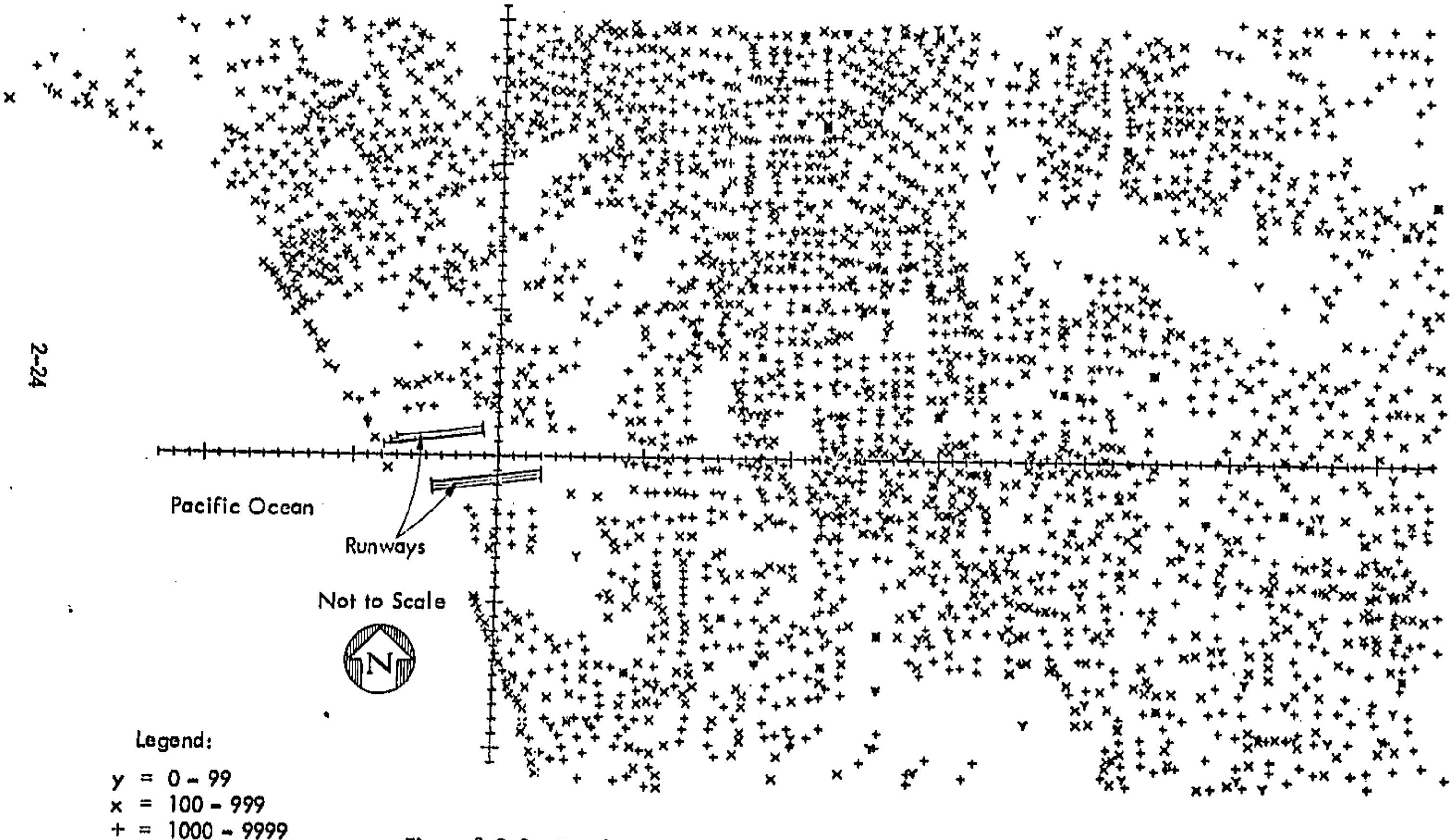

Figure 2.3-5. Population Centroid Definitions Near Los Angeles International Airport

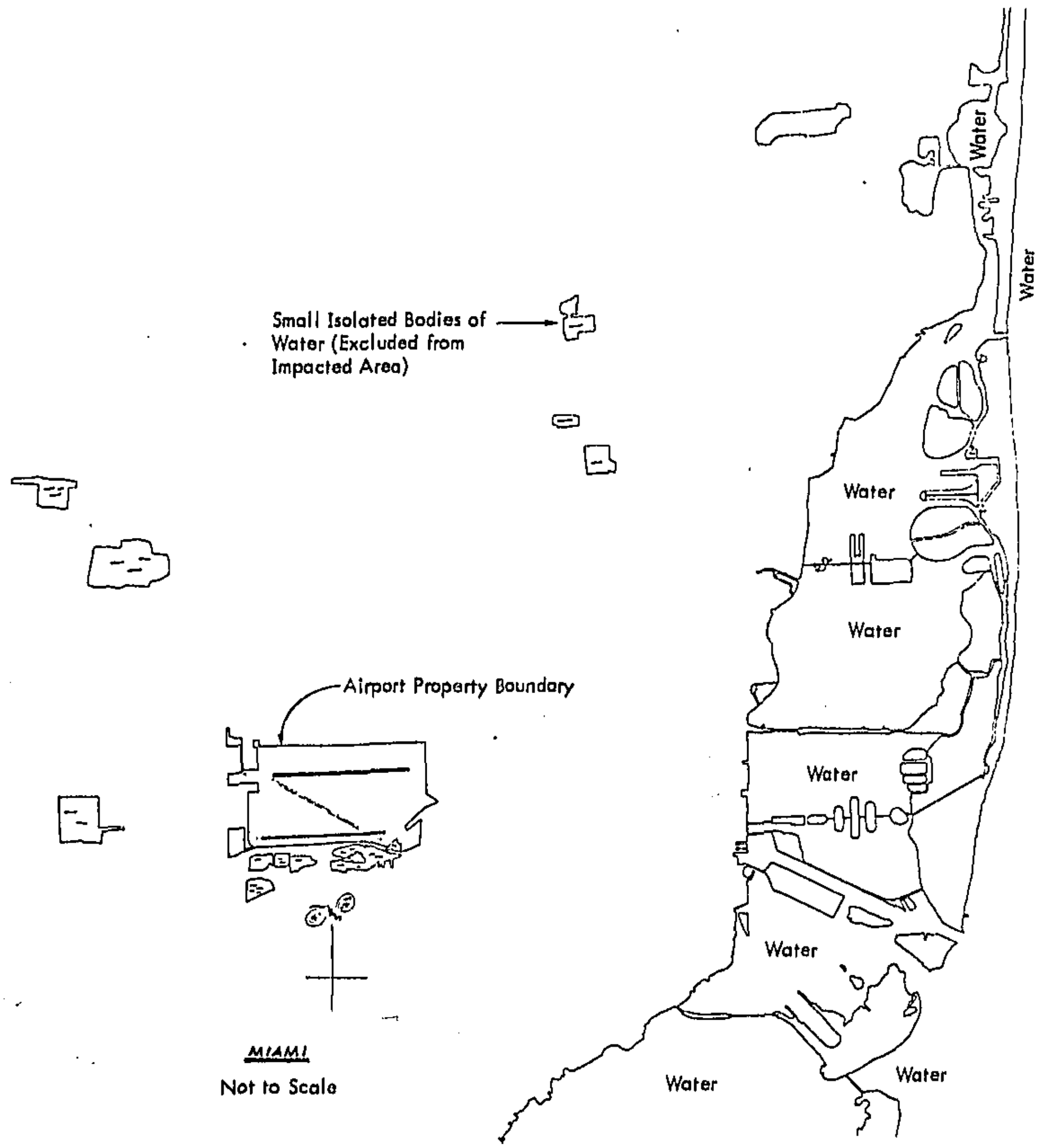

Figure 2.3-6. Definitions of Airport Property Boundaries and Water Boundaries for Miami International Airport

2.4 Airport Attributes and Aircraft Operations

The assessment of noise impact at each of the 23 airports selected for this study is based on an analysis of each existing airport and its mode and level of utilization. Forecasts are made of airport development and of evolution of the types and mix of aircraft expected to utilize each airport in the future years selected for the study.

2.4.1 Airport Attributes

The analysis for each airport includes the establishment of present airport attributes, including land area and identification of boundaries, the heading, length and layout of all usable runways, a summary of operational facilities significant to the airport's operation and effective capacity including NAVAIDS and taxiways, and an exploration of existing plans and prospects for airport development and/or expansion.

2.4.2 Airport Capacity

Consideration was given to the existing practical annual capacity of each airport, and to probable airport development and the potential for technological improvements to runway capacity. When a forecast of demand for all classes of aircraft movements for a given airport, including general aviation, exceeded the estimated airport capacity, the number of movements was limited to that number which was compatible with the estimated capacity of the airport. In this case, part of the increased passenger demand forecasted was accommodated in larger aircraft without increasing the number of operations. Any remaining demand for aircraft movements which was in excess of the airport capacity was assumed to be diverted to other airports. This excess capacity problem occurred at only Washington-National and Chicago-O'Hare airports. The resulting excess activity was assumed to be environmentally compatible and, therefore, not contributory to the noise impact analyzed in this study.

2.4.3 Airport Activity by Candidate Aircraft

The airports studied were chosen to represent a majority of the total U. S. population impacted by aircraft noise. The summation for all 23 airports of total noise impact determined in this study therefore represents a majority of the total impact of aircraft noise on populations in the vicinity of all air carrier airports throughout the United States. Noise reductions obtained on the population sample included in this study by each selected noise reduction alternative are, therefore, representative of the noise reduction potential of that alternative for the entire United States.

2.4.4 Development of Operational Data

Data were developed for each of the 23 selected study airports within the framework of the following general categories:

- 1972/1978/1981/1987 average daily demand in terms of:
  - aircraft
  - day/night distribution
  - flight track assignment
  - runway utilization
  - departure stage lengths
- Flight track geometry
- Airport (runway system) geometry

The NEF computer program defines average daily demand as annual demand divided by 365. A control total for the demand was established using the calendar year 1972 air carrier operations recorded by the FAA airport traffic control tower. Distribution with respect to aircraft type was developed through an analysis of data contained within the following documents:

- Official Airline Guide, Domestic Edition
- Official Airline Guide, International Edition
- Official Air Cargo Guide

In sorting out data from these documents, Thursday, October 12, 1972 was used as an average day. The analysis produced a distribution of traffic by aircraft types in terms of the categories of aircraft differentiated within the documents, the day/night distribution, and stage length of departures by each aircraft type. Stage length as developed was based on city-pair statistics. City-pair data were also used in a later analysis of flight track assignment where specific arrival and departure fixes were used as a function of flight origin and destination.

Flight track details were developed after undertaking a survey at each study airport. This survey involved detailed discussions with FAA air traffic control personnel to ascertain the following data:

- Runway use patterns
- Conditions influencing runway use (noise abatement, ATC rules and regulations, meteorological parameters, etc.)
- Arrival-departure fixes and inbound and outbound typical flight paths associated therewith
- Runway limitation (aircraft type, displaced thresholds, etc.)
- Flight track vertical profile limitations.

A detailed computer analysis was made of 5 years of weather tape statistical records obtained from the U.S. Weather Records Center in Asheville, North Carolina, for each of the study airports. These analyses assisted in the development of percent-use of the various runway combinations applicable to each airport.

Details associated with airport runway layouts (existing and proposed) were defined by review of available airport plans, U.S. Coast and Geodetic OC Charts, and discussions with airport management personnel.

The development of estimated fleet mixes for each of the study airports involved three primary steps. The first step estimated passenger traffic and total operations at each airport. The second step required that the projected distribution of the U.S. fleet be converted into a distribution of operations. The third step developed airport mixes based on a comparison of their present air carrier operations mix versus mix for total U.S. operations, and extrapolated a general relationship into the forecast years. The average aircraft size estimate for forecast years was utilized in this step as a general controlling number. Details of each of the forecast steps follow.

Step 1
Airport Total Passenger and Operations Forecast

This first step involved development of forecasts for each airport of passengers enplaned and the level of total air carrier operations. The basic method involved a top-down approach requiring a trend analysis and forecast of each airport's share of total U.S. domestic originations, the connecting traffic expected, and the anticipated growth of international traffic at those airports where this is a factor. The estimated share of the total U.S. domestic traffic was applied to the national forecast and connecting and international traffic added for total enplanements.

Enplanements were connected to movements by analysis and projection of the enplaning load factor and an approximate average aircraft size. The enplaning load factor is defined as that percentage of departing seats which are filled by enplaning passengers. The enplaning load factor differs from the total air carrier operating load factor, which encompasses all passengers, including through passengers. Each airport has a slightly different historical record for this variable, and the historical variation was taken into account in developing the projection. The projected industry load factor is expected to increase gradually in the future, as are the forecasts of enplaning load factor at each airport, in reaction to changes in regulatory philosophy and gradual trends toward industry improvement in utilization of available capacity.

Average aircraft size is an abstraction which is useful in order to analyze the loading characteristics at each airport, and is forecast by a combination of trend extrapolation, adjusted by judgmental considerations of expected equipment decisions of the air carriers. By relating the average aircraft size to expected enplaning load factors, the average enplanements per departure are developed. The forecast of enplanements for each airport is divided by the enplanements per departure forecast, giving required scheduled departures. This is then expanded to take into account arrivals and air carrier operations not related to scheduled passenger service, giving total air carrier operations.

Step 2

Distribution of Total U. S. Operations by Type

The primary step to determine an estimated future distribution of operations by aircraft type, having forecast the future fleet by type, involves estimating operations per aircraft year for each type. This was done by estimating operations per aircraft year for future years, by analogy to the present fleet types operating on the route patterns and in the class of service for which the new aircraft will become replacements. In other words, new fleet types are expected to generate operations in a relationship similar to present activity of the aircraft types they will replace. Present operations per aircraft year for established types of aircraft are expected to continue at approximately the level established for the base period 1971-1972.

Step 3

Airport Fleet Distribution

The distribution of operations by equipment type for individual airports was developed by the integration of several steps. First, an analysis was made of each airport's historic fleet distribution and compared to the distribution of total U.S. carrier operations. In general, this step shows that the larger the airport, the higher the frequency of use by the carriers of their larger aircraft types. This relationship is one which is extended into the future.

Another step involved the definition of the character of the airport's mission, particularly the importance of international traffic and the number of high volume markets that exist or are anticipated. Again, the larger the air traffic volumes and the more important the international traffic complexes, the higher the frequency of carrier use of larger aircraft types.

A third major factor involved consideration of the air carriers serving the subject airports, any limitations that are placed on carriers by the airport operators, and any constraints as to the level of operations at individual airports where these must temper unconstrained forecasts of demand.

Taking these major considerations into account, a first estimate of aircraft distribution was developed by applying a higher-than-average distribution of larger aircraft types for larger airports, with a corresponding lower-than-average distribution for smaller aircraft. For example, if in the total of U.S. activity we expect approximately 20 percent of operations in 1978 to be DC-9's, at a large airport like O'Hare or Kennedy, we assigned a lower percentage in the first distribution based on the present relationship of DC-9's at the subject airport to DC-9's in the U.S. Similarly, DC-8's represent a greater percentage at the airport now than the U.S. total; this higher distribution of larger aircraft is projected to apply in the future.

Refinements to this first distribution were made on the basis of several factors. The airport forecast of average aircraft size, for example, was utilized as a control number to alter the distribution as necessary. Also, the specific carriers serving each point were analyzed in view of their actual equipment and projected plans for refinements to the forecast. For example, if major operators of L-1011's dominate a particular station, the DC-10 forecast was decreased, with the amount of decrease added to the L-1011 forecast.

2.5 U.S. Aircraft Fleet

There are approximately 2000 aircraft currently in operation by the principal U.S. carriers which do not meet the present FAR Part 36 noise certification standards for subsonic turbojet airplanes. Several contracts have been awarded to aircraft and engine manufacturers to develop feasible noise reduction retrofit hardware for turbofan-powered airplanes equipped with JT8D or JT3D engines, which comprise most of the air carrier fleet not in compliance with the FAR noise limits. These contract efforts have developed the acoustic and performance data, the aircraft weight and operating cost increments, and engine-nacelle production requirements associated with each retrofit design. This section forecasts the aircraft fleet, the extent of airport operations and operating costs that would result if the airlines install the proposed retrofit hardware on these aircraft.

The total fleet of the principal U.S. carriers, operating aircraft of the types which are candidates for retrofit, has been identified.

The cost impact of the two proposed retrofit programs that correspond to the aeronautical alternatives considered in this study has been developed based on a forecast of the number of aircraft that will be retrofitted by each airline. The best current estimates of the unit costs of each of the proposed retrofit programs have been used to establish the magnitude of each airline's capital requirement for retrofit.

2.5.1 Airline Traffic and Capacity Forecasts

A forecast of the future air traffic demand and related capacity that will be provided by the principal U.S. carriers has been developed for this study. The forecast has been accomplished in four separate demand segments: (See Figure 2.5-1.)

1. Scheduled domestic passengers
2. Scheduled international passengers
3. All nonscheduled passenger services
4. Cargo services for all carrier groups

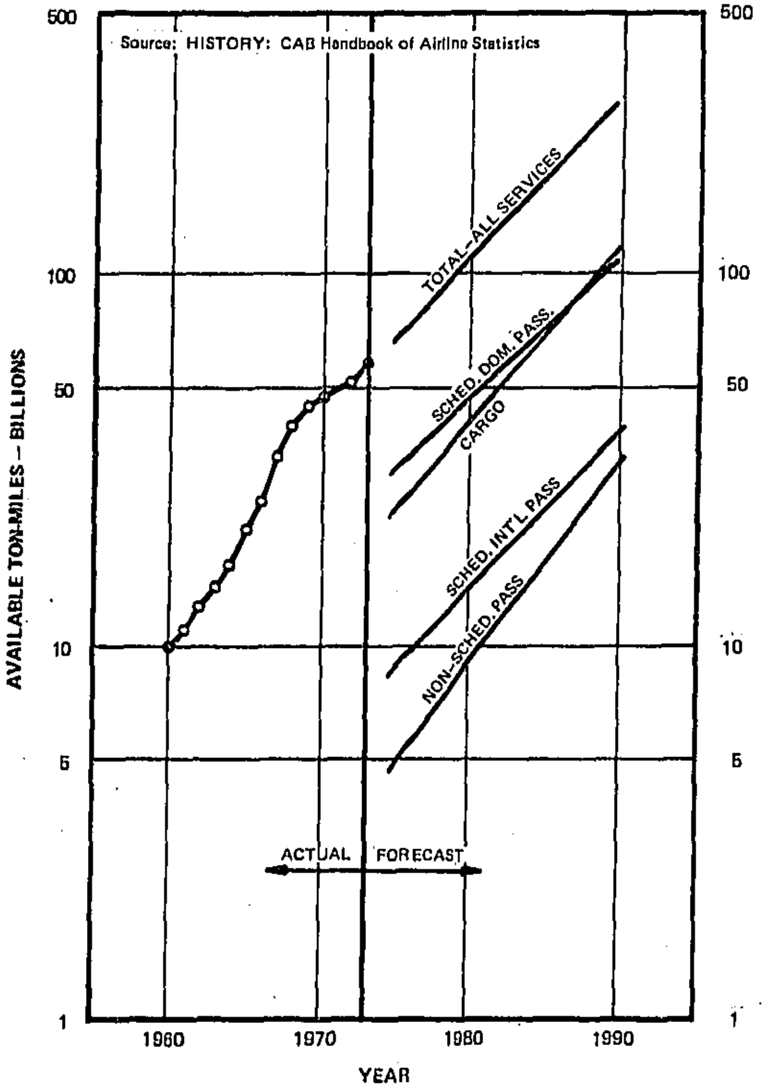

Figure 2.5-1. Airline Capacity - Total Available Ton-Miles Principal U.S. Carriers

These forecasts define the level of required aircraft productivity in annual available ton miles (ATM's). They provide the basis for derivation of the future fleet forecast, the future airline total investment requirement and the number of aircraft to be retrofitted.

The forecast of scheduled domestic passengers was developed using a top-down method based on projections of U.S. population, per capita personal consumption expenditures, airline revenues and average yield.

The airline capacity requirements for the domestic carriers were developed on the basis of industry average load factors increasing to 60 percent by the end of the forecast period. Some variance in load factor was recognized among individual carriers and carrier groups as considered appropriate.

The scheduled international passenger forecasts were developed via a similar top-down method. The U. S. carriers participating in this traffic were forecast to share proportionately in world traffic demand (excluding U.S. domestic) estimated to grow at an average annual rate of 12.9 percent.

The forecast of nonscheduled passenger operations was based on projections derived from an analysis of the service histories, for the 10-year period 1960-1970, of each carrier group participating in this type of service. The projected growth rate in nonscheduled services is forecast to be highest for the Alaskan and Supplemental Carriers.

Cargo services for all carrier groups are forecast to grow at an annual rate of 11.8 percent. This forecast recognized a difference in the growth rate expectation among carrier groups, and the increasing use of belly compartments on large passenger aircraft. The cargo demand for each carrier group was forecast in total and no attempt was made to separately identify the extent to which all cargo services would be providec by the carrier groups which at present are primarily passenger carriers.

2.5.2 The Present and Future Fleet

The eventual benefit to be derived from a retrofit or other noise reduction program, and the eventual cost of any selected program, will be largely dependent on the number of aircraft affected. This study effort has established and forecast the size and composition of the present and future U.S. civil air carrier fleet. The forecasting gave consideration to all identifiable airline fleet development plans and to the additional capacity required in the fleet to accommodate forecast future air transportation demand.

The U.S. air carrier fleet under consideration includes all U.S. operators of aircraft which may be candidates for modification in any of the presently identified noise reduction programs, i.e., all JT3D- or JT8D-powered aircraft. Table 2.5-1 summarizes the airlines considered in the analysis. Table 2.5-2 summarizes the aircraft by types which were active in the study base year 1972.

The airlines' decisions regarding aircraft retirement will no doubt be influenced by the public policy adopted relative to the methods for financing noise reduction alternatives. The forecasts of the number of candidate aircraft of each type to be retrofitted and the related number of aircraft to be retired were made on the basis of a "neutral" economic impact on aircraft operators. This implies no financial penalties to the aircraft operator associated with a forced retrofit which are not compensated by some sort of "subsidy." It also implies no financial benefits to the airline operator, such as an extended life or improved performance aircraft, which are not offset by a commensurate increase in cost.

2.5.3 Foreign Aircraft Operating in the U.S.

The U.S. aircraft and aviation industries have historically established the operating patterns for world aviation and can be expected to do so in the future. Concern for environmental externalities is not limited to the U.S.; it is to be expected, therefore, that foreign nations will exhibit the same concern for noise abatement. For

Table 2.5-1

Summary of Principal U.S. Carriers Considered in This Analysis

	TRUNKS
UAL	UNITED AIR LINES
AAL	AMERICAN AIRLINES
TWA	TRANS WORLD AIRLINES
EAL	EASTERN AIRLINES
BNF	BRANIFF AIRWAYS
CAL	CONTINENTAL AIR LINES
DAL	DELTA AIR LINES
NAL	NATIONAL AIRLINES
-	NORTHEAST AIRLINES(1)
NWA	NORTHWEST AIR LINES
WAL	WESTERN AIRLINES
PAA	PAN AMERICAN WORLD AIRWAYS
	REGIONAL
AW	HUGHES AIRWEST
AL	ALLEGHENY AIRLINES
-	CARIBBEAN ATLANTIC AIRLINES(2)
FL	FRONTIER AIRLINES
-	MOHAWK AIRLINES(3)
NC	NORTH CENTRAL AIRLINES
OZ	OZARK AIR LINES
PI	PIEDMONT AVIATION
SO	SOUTHERN AIRWAYS
TT	TEXAS INTERNATIONAL AIRLINES
-	TRANS CARIBBEAN AIRWAYS(4)
	ALASKA/HAWAII
ASA	ALASKA AIRLINES
TSA	ALOHA AIRLINES
HAL	HAWAIIAN AIRLINES
WCA	WIEN CONSOLIDATED AIRLINES
-	REEVE ALEUTIAN AIRWAYS(6)
	ALL CARGO
RDL	AIRLIFT INTERNATIONAL
FTL	FLYING TIGER LINE
SBW	SEABOARD WORLD AIRLINES
	SUPPLEMENTAL
CAP	CAPITAL INTERNATIONAL
-	JOHNSON FLYING SERVICE(6)
MIA	MCCULLOCH INTERNATIONAL AIRLINES
MDN	MODERN AIR TRANSPORT
ONA	OVERSEAS NATIONAL AIRWAYS
-	PURDUE AERONAUTICS
SAT	SATURN AIRWAYS
SOU	SOUTHERN AIR TRANSPORT
TIA	TRANS INTERNATIONAL AIRLINES
-	UNIVERSAL AIRLINES(5)
WOR	WORLD AIRWAYS
	INTRASTATE
-	AIR CALIFORNIA
-	PACIFIC SOUTHWEST AIRLINES
-	SOUTHWEST AIRLINES

Key to Disposition of Airlines no Longer in Existence
(1) Included with Delta (4) Included with American
(2) Included with Eastern (5) Included with ONA and TIA
(3) Included with Allegheny (6) Not operating large jet aircraft

Table 2.5-2

Summary of Aircraft Types Included in U.S. Airline Industry

Noisy		
Old Jets	Number of Aircraft (1)	
BAC-111	58	
B707-300	12	
B720	37	
CV-880	41	
CV-990	8	
DC-8-20	40	
DC-8-30	24	220
JT-8D (Retrofit Candidates)		
B727-100	299	
B727-100C	122	
B727-200	262	683
B737-200	150	
B737-200C	5	155
DC-9-10	72	
DC-9-10F	19	
DC-9-30	235	
DC-9-30F	7	333
JT-3D (Retrofit Candidates)		
B707-100B	96	
B707-300B	111	
B707-300C	119	
B720B	48	374
DC-8-50	44	
DC-8-50F	28	
DC-8-61	55	
DC-8-61F	9	
DC-8-62	16	
DC-8-62F	1	
DC-8-63	4	
DC-8-63F	45	202
Total - Noisy		1,967

Quiet		
Quiet Fan Jets	Number of Aircraft (1)	
B727-200Q (2)	4	
B747 (3)	106	
DC-10-10	60	
DC-10-10F	-	
DC-10-40	2	
DC-10-30	-	
DC-10-30F	-	
L-1011	18	190
Turbo Props		
CV-580/600	132	
F-27/227	59	
L-188	46	
L-382	18	
YS-11	21	
Other	17	293
Piston Aircraft	140	140
Total - Quiet		623
Total - All Types		2,590

(1) In Operation by principal U. S. carriers as of December 31, 1972.
Source: CAB Forms 41 schedules:
B-43 Inventory of Airframes & Aircraft Engines
B-47 Lease Obligations-Flight Equipment
B-7 Airframes and Aircraft Engines Acquired
B-14 Summary of Property Obtained Under Long-Term Leases

(2) New aircraft in compliance with FAR 36 - Estimated.

(3) Requirement for retrofit of early 747's to meet FAR 36 not considered in the study cost estimates.

the purpose of this study, it is forecast that retrofitting for each type of U.S. manufactured equipment will be undertaken by all foreign as well as domestic carriers serving U.S. airports. It is also forecast that foreign aircraft will have no impact on the cost of retrofit. They will not become a cost for the U.S. industry, nor will the potential for additional retrofit kits be assumed to lower the average price per kit appropriate to the number required to modify U.S. aircraft. The assumption of retrofitted foreign aircraft can be expected to have impact on the NEF contours generated for those airports which normally accommodate a significant amount of international operations.

2.5.4 The Transition to Quiet Aircraft

Forecasts of the evolution of the future U.S. fleet give recognition to the developments which may take place during the period of this study, such as FAR Part 36 compliance after some future date.[31] It has been forecast that all aircraft to be retrofitted will have the appropriate retrofit implemented prior to the time of the future year analysis. No analyses were made of any time period when any aircraft model to be retrofitted is in both the before and after stage. The forecasts also reflect our estimate that the older aircraft such as B-707, 720, DC-8, BAC 111, Convair 880 and 990 equipped with other than JT3D engines will be retired prior to the completion of any proposed noise reduction program for those fleets.

The composition of the U.S. air carrier fleet of fixed wing aircraft as it is forecast to evolve throughout the period of the study is shown in Figure 2.5-2. It can be seen that a great majority of the current fleet are the "noisy" aircraft which would be candidates for some form of noise reduction retrofit if a regulation derived from the recent Notice of Proposed Rule Making became effective.[31]

The forecast of the future composition of the fleet reflects the expected retirement of many of the older "noisy" aircraft, and the introduction of many new "quiet" aircraft. The new aircraft include not only the wide body jets, but additional

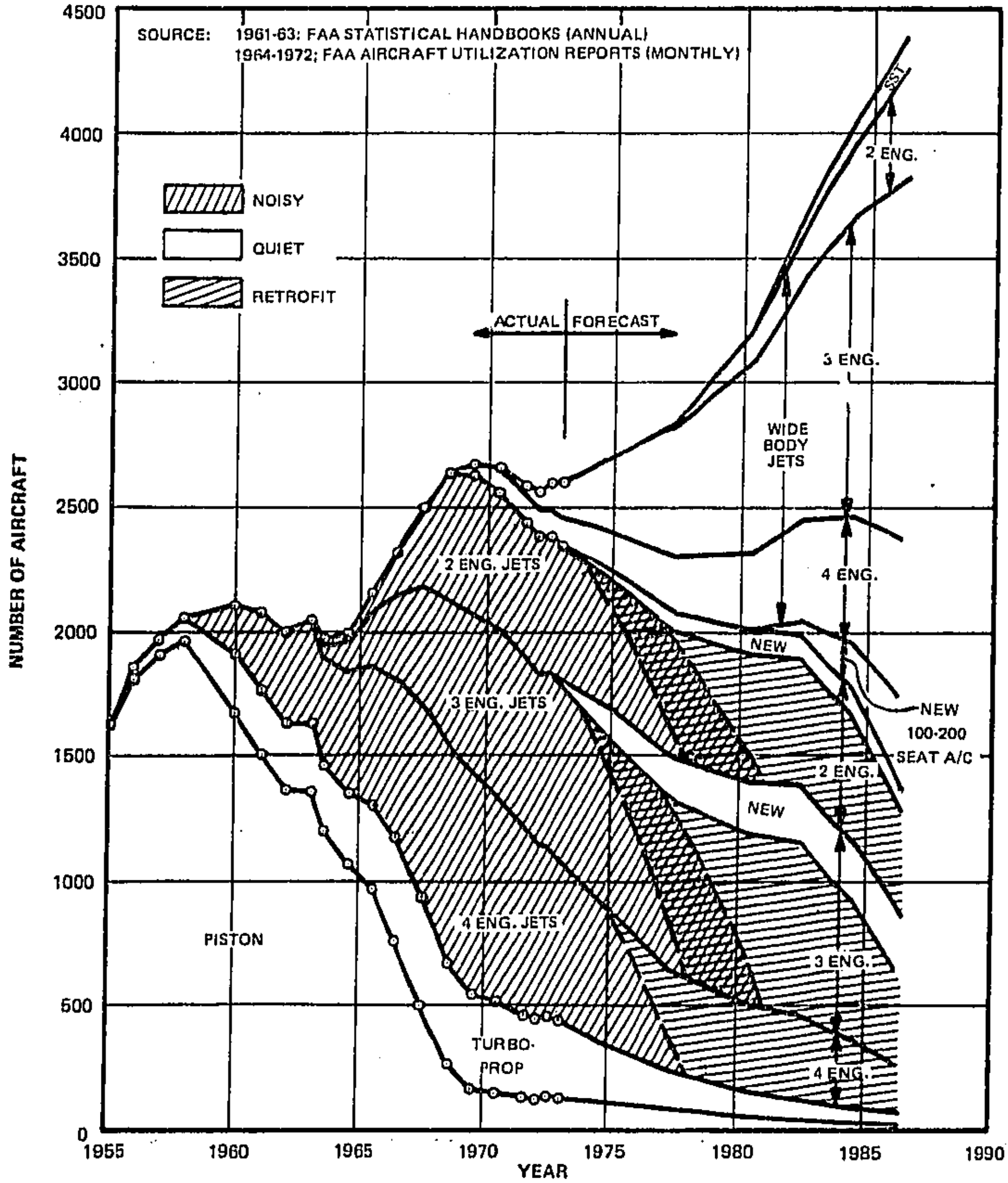

Figure 2.5-2. Composition of U.S. Air Carrier Fleet (Fixed Wing Aircraft)

aircraft of the older types delivered in compliance with existing noise regulations. In the later years of the forecast, the future fleet also includes several new types of aircraft not yet in active service.

2.5.5 The Future Activity of Retrofit Candidate Aircraft

The U.S. fleet composition is also shown on Figure 2.5-3 for the selected base year and future years to be analyzed in detail in this study. The JT3D and JT8D-powered aircraft which are candidates for retrofit have been highlighted to illustrate how they are forecast to decrease in number and as components of the total active fleet.

The same fleet summary and forecast have been translated into annual aircraft departures for the significant years of the study on Figure 2.5-4. A comparison of these two forecasts illustrates that the rate of growth of aircraft movements will not be as great as the rate of growth of active aircraft. This will result from the increasing capacity of new aircraft and their introduction onto routes with above average stage lengths and therefore fewer annual departures. These two forecasts also illustrate that the retrofit candidate aircraft will continue to contribute to airport operations at a rate which does not decrease as rapidly as their number in the active fleet.

Retrofit Candidates	1972	1978	1981	1987
Percent of Active Fleet	68	56	47	21
Percent of Total Departures	69	64	57	30

The forecast of total aircraft departures by percent for U.S. air carrier aircraft of all types is summarized on Figure 2.5-5. These forecasts of future U.S. fleet aircraft and operations provide a basis for the forecasts of the types and mix of aircraft expected to utilize the airports to be analyzed for noise impact in this study.

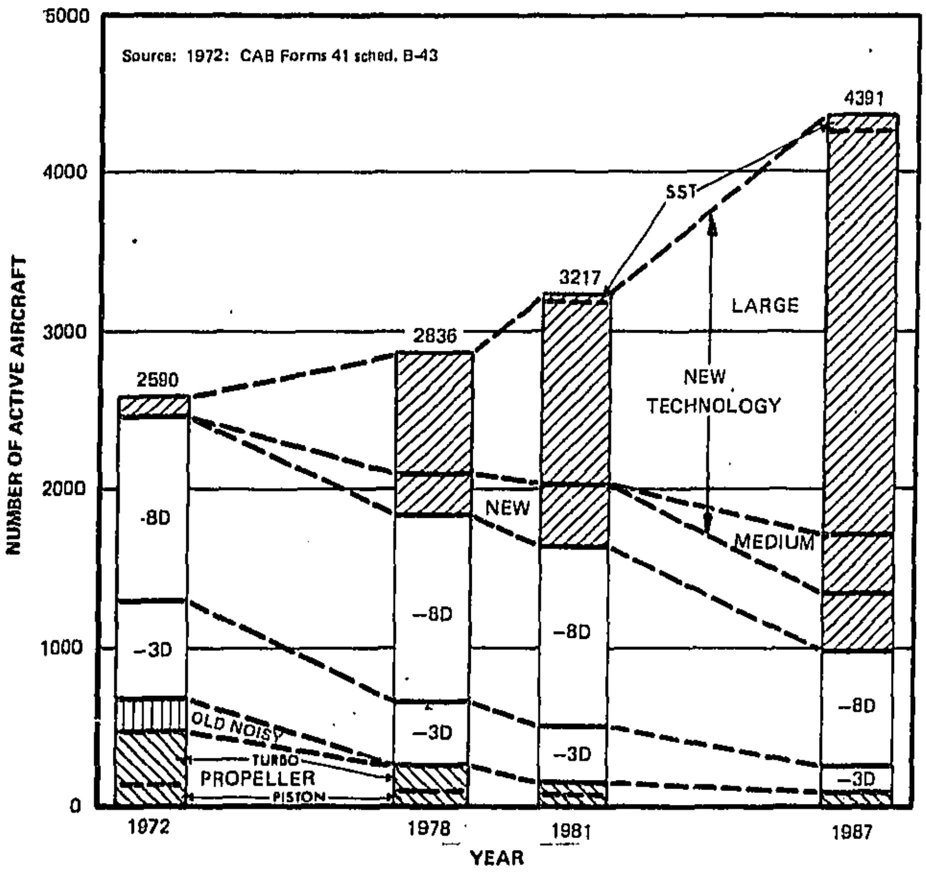

Figure 2.5-3. Active Fixed Wing Aircraft Fleet Principal U.S. Carriers

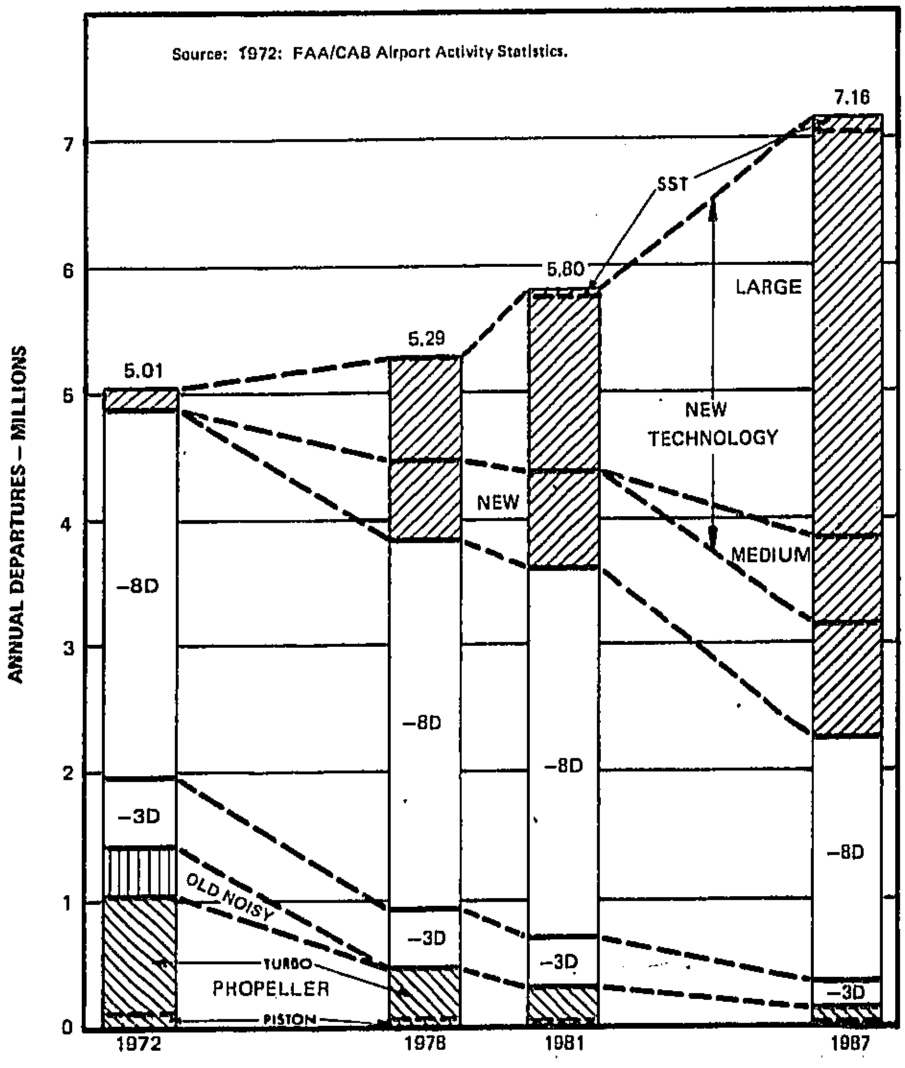

Figure 2.5-4. Total Aircraft Departures
Principal U.S. Carriers

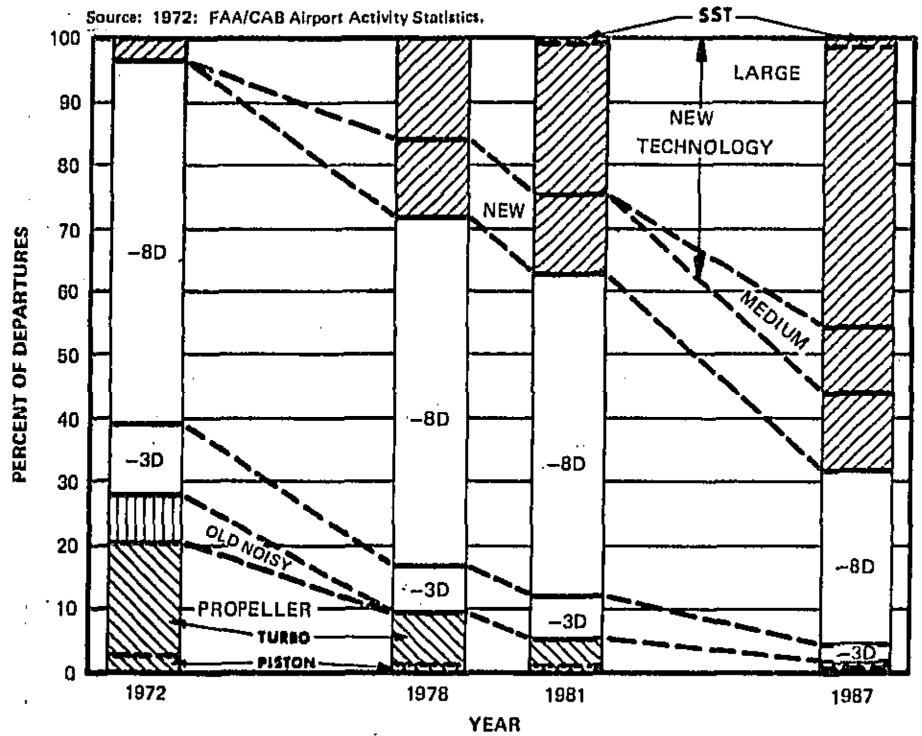

Figure 2.5-5. Aircraft Departures by Percent - All Services of Principal U.S. Carriers

2.6 Airports and Airport Fleets

The population and mix of aircraft used as the basis for noise impact analyses at each airport have been developed for each of the years analyzed in the study. Consideration has been given to the site-specific factors expected to influence the forecasts for each individual airport of the number of movements, types of aircraft, day-night distribution of activity, stage length distribution of departures, approach and departure flight paths, and percent of use of runway directions.

A summary of the considerations at each of the 23 study airports is provided in this section. A summary of the analysis for Los Angeles International Airport is presented, as an example, in Figure 2.6-1, showing the average daily movements of aircraft types used in the analysis which were categorized by general "noise" characteristics.

Tables 2.6-1 through 2.6-4 are examples (for Los Angeles) of the aircraft types and number of movements by stage lengths developed for each airport. Figure 2.6-2 illustrates the bases for conversion of stage lengths to estimated takeoff weights for each flight. The appropriate takeoff weights are utilized to establish the departure paths (profiles) for each flight in the analysis procedure.

It should be noted that the aircraft type/description are specific for 1972 and the near term forecasts. They were used as indicators of the general size and performance of aircraft that serves the various stage lengths in the more distant future, i.e., services forecast to be flown with, say, DC-9's or B-737's in 1981 and 1987, may be flown by any similar type of new 2-engine medium-range narrow bodied aircraft. In all cases, new narrow body aircraft (i.e., 707 (new) or 2-engine, medium range, narrow) were assumed to have the same noise and profile characteristics as their corresponding older SAM retrofitted versions.

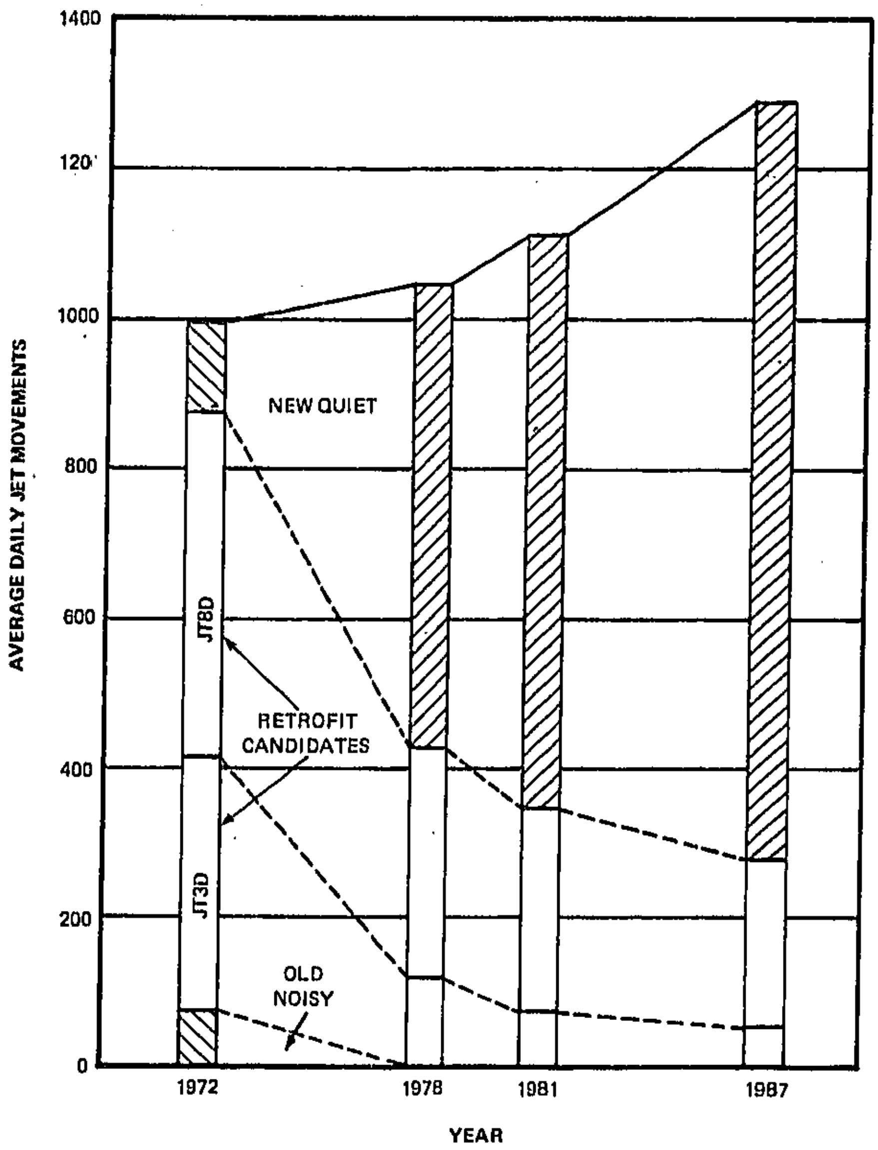

Figure 2.6-1. Forecast of Average Daily Jet Aircraft Movements
Los Angeles International Airport

Table 2.6-1

Airport Activity Forecast for NEF Analysis 1/
Los Angeles – 1972

Aircraft Type	Day/2/ Night	Arrivals	Departures by Stage Distance (Statute Miles) 0–500	500–1000	1000–1500	1500–2500	2500–3500	3500–4500	4500–5500	Over 5500
720B	D	31	9	7	5	8	2			
	N	3	1	1	0	1	0			
707-320B/C	D	16	5	1	0	8	2			
	N	3	0	0	1	0	2			
707-120B	D	39	9	1	5	22	2			
	N	11	2	0	0	9	0			
DC-8-30	D	5	0	0	2	3				
	N	1	0	0	1	0				
DC-9-15	D	10	2	8						
	N	0	0	0						
DC-8-55	D	31	12	1	1	15	2			
	N	14	5	0	0	8	1			
DC-8-61/63	D	12	4	0	1	4	0	1	0	2
	N	10	0	2	1	5	2	0	0	0
DC-9-32	D	10	9	1						
	N	1	1	0						
DC-10-10	D	16	1	3	2	9	1			
	N	2	0	1	0	1	0			
L-1011	D	2	0	0	0	2				
	N	0	0	0	0	0				
VC-10	D	1	0	0	0	1				
	N	0	0	0	0	0				
707-120/320	D	10	4	0	0	0	2	1	1	2
	N	8	1	0	0	7	0	0	0	0
727-200	D	97	68	11	15	3				
	N	7	5	1	1	0				
720	D	8	4	4						
	N	2	2	0						
727-100	D	42	15	5	6	16				
	N	13	4	2	1	6				
737-100/200	D	46	41	5						
	N	5	4	1						
747-100	D	34	3	0	2	18	9	2		
	N	6	0	0	1	2	3	0		
CV-880	D	1	0	0	0	1				
	N	0	0	0	0	0				
STOL	D	12	12							
	N	0	0							

1/ Excludes General Aviation and Military Operations

2/ "Day" - 7:00 AM - 10:00 PM (Local Time)
"Night" - 10:01 PM - 6:59 AM (Local Time)

Table 2.6-2

Airport Activity Forecast for NEF Analysis
Los Angeles – 1978

Aircraft Category	No. of Engines	Range Capability	Model 1/	Day/2/ Night	Arrivals	Departures by Stage Distance (statute miles) 0–500	500–1000	1000–1500	1500–2500	2500–3500	3500–4500	4500–5500	Over 5500
Supersonic	-	Long	Unspec.	D	-	-	-	-	-	-	-	-	-
				N	-	-	-	-	-	-	-	-	-
Wide Body	2	Short-Medium	Unspec.	D	26	11	3	3	9				
				N	7	2	2	0	3				
Wide Body	3	Medium	DC-10	D	18	1	3	2	11	1			
				N	2	0	1	0	1	0			
			L-1011	D	20	1	4	2	12	1			
				N	4	0	2	0	2	0			
			Unspec.	D	39	3	7	4	23	2			
				N	6	0	4	0	2	0			
Wide Body Stretched	3	Medium	Unspec.	D	19	1	4	2	11	1			
				N	3	0	2	0	1	0			
Wide Body	3	Long	DC-10	D	4	1	0	1	2				
				N	1	0	0	0	1				
			Unspec.	D	8	2	0	1	5				
				N	3	0	0	0	3				
Wide Body Stretched	3	Long	Unspec.	D	4	1	0	0	3				
				N	2	1	0	0	1				
Wide Body	4	Medium-Long	747	D	53	3	2	4	29	12	3		
				N	10	0	2	1	2	5	0		
Wide Body Stretched	4	Medium-Long	Unspec.	D	4	1	0	0	2	1			
				N	1	0	0	0	1	0			
Narrow Body	2	Medium	737	D	29	26	3						
				N	3	3	0						
			DC-9	D	24	5	19						
				N	2	2	0						
			Unspec.	D	15	13	2						
				N	1	1	0						
STOL	-	Short	Unspec.	D	21	18	3						
				N	1	1	0						
Narrow Body	3	Medium	727-100	D	20	7	3	2	8				
				N	6	2	1	0	3				
			727-200	D	93	65	12	16					
				N	7	5	1	1					
Narrow Body	4	Long	707	D	19	7	0	0	0	4	2	1	5
				N	16	2	0	0	14	0	0	0	0
			720	D	2	1	1						
				N	0	0	0						
			DC-8	D	18	8	0	0	9	1			
				N	4	2	0	0	2	0			
			Unspec.	D	6	1	0	0	4	1			
				N	1	0	0	0	1	0			

1/ Models indicated as "unspecified" may include current aircraft and/or new aircraft not yet in production.

2/ "Day" - 7:00 A.M. - 10:00 P.M.(local time)
"Night" - 10:01 P.M. - 6:59 A.M.(local time)

Table 2.6-3

Airport Activity Forecast for NEF Analysis
Los Angeles — 1981

Aircraft Category	No. of Engines	Range Capability	Model [1/]	Day/Night [2/]	Arrivals	Departures by Stage Distance (Statute Miles) 0–500	500–1000	1000–1500	1500–2500	2500–3500	3500–4500	4500–5500	Over 5500
Supersonic	—	Long	Unspec.	D	3	0	0	0	3				
				N	0	0	0	0	0				
Wide Body	2	Short-Medium	Unspec.	D	48	26	6	4	12				
				N	12	5	2	1	4				
Wide Body	3	Medium	DC-10	D	13	1	2	2	7	1			
				N	2	0	1	0	1	0			
			L-1011	D	17	1	3	2	10	1			
				N	3	0	2	0	1	0			
			Unspec.	D	43	11	0	5	27				
				N	7	0	0	0	7				
Wide Body Stretched	3	Medium	Unspec.	D	31	2	5	4	18	2			
				N	5	0	3	0	2	0			
Wide Body	3	Long	DC-10	D	3	1	0	1	1				
				N	1	0	0	0	1				
			Unspec.	D	9	2	0	1	5	1			
				N	4	1	0	0	3	0			
Wide Body Stretched	3	Long	Unspec.	D	7	2	0	1	4				
				N	3	1	0	0	2				
Wide Body	4	Medium-Long	747	D	58	5	3	5	30	13	2		
				N	12	0	3	1	3	5	0		
Wide Body Stretched	4	Medium-Long	Unspec.	D	7	1	0	0	4	2			
				N	1	0	0	0	0	1			
Narrow Body	2	Medium	737	D	24	21	3						
				N	3	2	1						
			DC-9	D	19	17	2						
				N	2	2	0						
			Unspec.	D	17	15	2						
				N	1	1	0						
STOL	—	Short	Unspec.	D	25	22	3						
				N	1	1	0						
Narrow Body	3	Medium	727-100	D	19	7	2	3	7				
				N	6	2	1	1	2				
			727-200	D	98	69	11	15	3				
				N	7	5	1	1	0				
Narrow Body	4	Long	707	D	11	4	0	0	0	2	1	1	3
				N	9	1	0	0	8	0	0	0	0
			DC-8	D	13	6	0	0	6	1			
				N	3	1	0	0	2	0			
			Unspec.	D	7	1	0	0	4	2			
				N	2	0	0	0	2	0			

1/ Models indicated as "unspecified" may include current aircraft and/or new aircraft not yet in production.

2/ "Day" - 7:00 A.M. - 10:00 P.M. (local time)
"Night" - 10:01 P.M. - 6:59 A.M. (local time)

Table 2.6-4

Airport Activity Forecast for NEF Analysis
Los Angeles – 1987

Aircraft Category	No. of Engines	Range Capability	Model 1/	Day/ 2/ Night	Arrivals	Departures by Stage Distance (statute miles) 0-500	500-1000	1000-1500	1500-2500	2500-3500	3500-4500	4500-5500	Over 5500
Supersonic	-	Long	Unspec.	D	5	0	0	0	5				
				N	0	0	0	0	0				
Wide Body	2	Short-Medium	Unspec.	D	89	57	9	6	17				
				N	19	8	5	1	5				
Wide Body	3	Medium	DC-10	D	15	1	3	2	8	1			
				N	2	0	1	0	1	0			
			L-1011	D	16	1	3	2	9	1			
				N	3	0	2	0	1	0			
			Unspec.	D	51	13	0	6	32				
				N	8	0	0	0	8				
Wide Body Stretched	3	Medium	Unspc.	D	43	3	8	5	24	3			
				N	7	0	5	0	2	0			
Wide Body	3	Long	DC-10	D	3	1	0	1	1				
				N	1	0	0	0	1				
			Unspec.	D	14	3	0	2	8	1			
				N	5	1	0	0	4	0			
Wide Body Stretched	3	Long	Unspec.	D	12	3	0	1	7	1			
				N	6	1	0	0	5	0			
Wide Body	4	Medium-Long	747	D	70	6	4	6	36	16	2		
				N	14	0	4	1	3	6	0		
Wide Body Stretched	4	Medium-Long	Unspec.	D	13	2	0	0	7	4			
				N	3	0	0	0	0	3			
Narrow Body	2	Medium	737	D	23	21	2						
				N	3	2	1						
			DC-9	D	19	17	2						
				N	2	2	0						
			Unspec.	D	21	18	3						
				N	1	1	0						
STOL	-	Short	Unspec.	D	35	30	5						
				N	1	1	0						
Narrow Body	3	Medium	727-100	D	10	4	1	1	4				
				N	3	1	1	0	1				
			727-200	D	81	57	9	13	2				
				N	6	4	1	1	0				
Narrow Body	4	Long	707	D	7	3	0	0	0	1	1	0	2
				N	6	1	0	0	5	0	0	0	0
			DC-8	D	11	5	0	0	6				
				N	3	1	0	0	2				
			Unspec.	D	11	2	0	0	7	2			
				N	3	0	0	0	3	0			

1/ Models indicated as "unspecified" may include current aircraft and/or new aircraft not yet in production.
2/ "Day" - 7:00 A.M. - 10:00 P.M. (local time)
"Night" - 10:01 P.M. - 6:59 A.M. (local time)

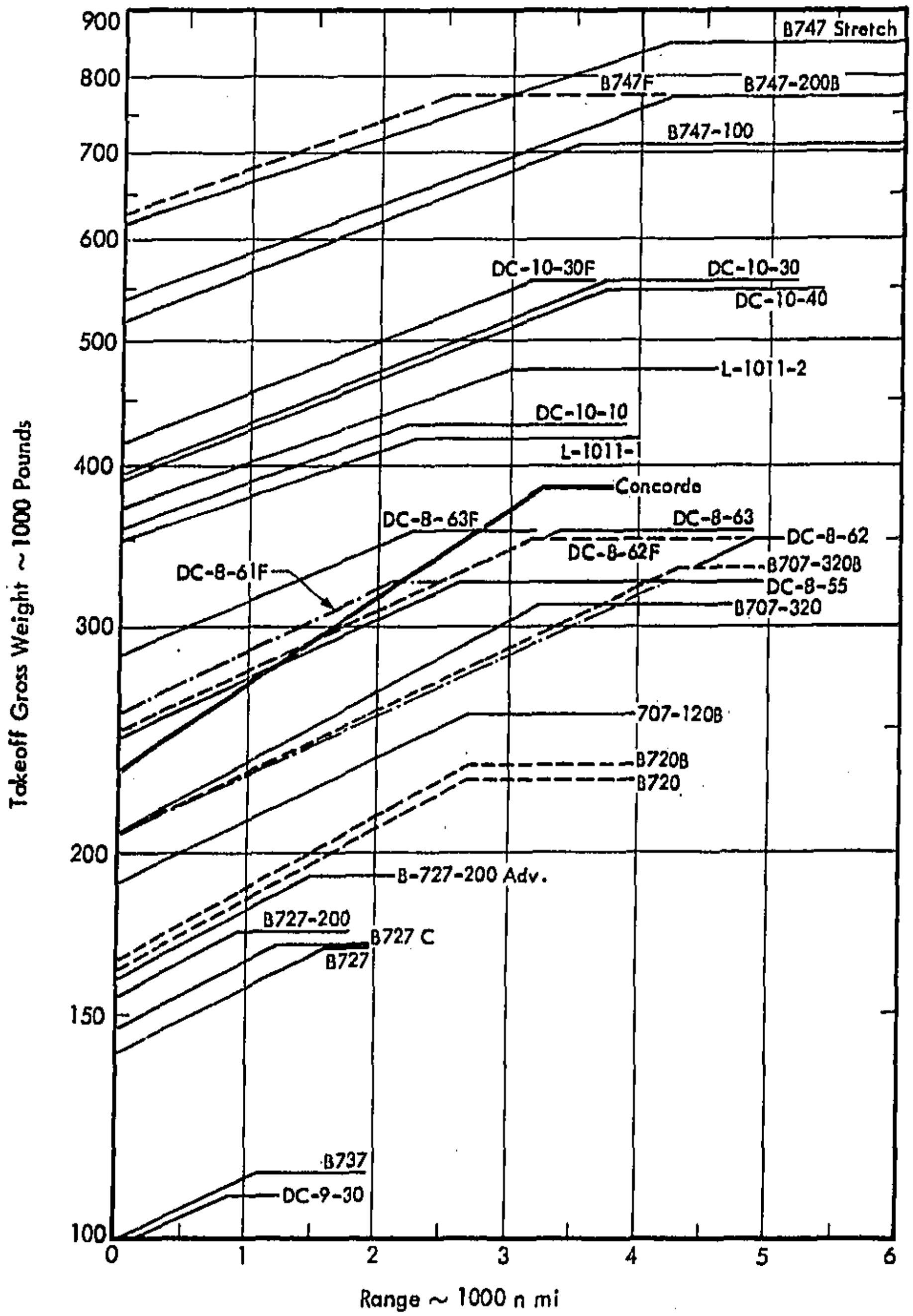

Figure 2.6-2. Takeoff Gross Weight Versus Range for Jet Transport Aircraft

2.6.1 Atlanta (ATL) - General Operating Considerations

- Extensive use of arrival aircraft path-stretching is employed.
- VFR turn-ons over the outer marker were allowed for some aircraft.
- A newly constructed parallel runway was considered in the analysis, but its operations were combined with those on the adjacent parallel runway. *
- No further new runway construction was considered to exist in the study period.
- Runway utilization was determined by the previously discussed weather tape analysis in conjunction with an Atlanta Tower Bulletin, 1 June 1972, "Runway Selection Program for Aircraft Noise Abatement," which denotes 9L/R as the preferential runways.

Table 2.6.1-1 presents the runway utilization percentages for Atlanta International.

Table 2.6.1-2 presents the average daily aircraft operations at Atlanta International.

Table 2.6.1-1

Runway Utilization Percentages for Atlanta

R/W	Arrival (%)				Departure (%)			
No.*	1972	1978	1981	1987	1972	1978	1981	1987
27R	25.3	22.0	21.8	25.3	28.0	26.8	26.5	26.5
27L	26.8	29.0	27.2	26.7	24.0	24.8	25.0	25.0
9L	21.8	20.3	20.5	21.7	24.3	24.0	23.9	23.9
9R	23.1	25.3	27.2	23.2	23.7	24.4	24.6	24.6
33	3.0	3.4	3.3	3.1				

* These runway designations were current in 1972 but have subsequently been changed following completion of the new runway to the following: 27R is now 26; 27L is now 27R; 9L is now 8; 9R is now 9L, and the new runway is 9R/27L.

Table 2.6.1-2

Average Daily Aircraft Operations for Atlanta

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720				
720B				
707-120/320				
707-120B				
707-320B/C	2	32	22	14
727-100	230	212	162	128
727-200	44	73	68	72
737-100/200	58	58	60	60
747-100	18			
DC-8-30	36			
DC-8-55	46			
DC-8-61/63	46	20	16	16
DC-10-10		74	64	56
DC-9-15	132			
DC-9-32	414	212	186	166
BAC-111				
L-1011		86	74	66
VC-10				
Cv. 880	26			
Cv. 990				
Caravelle				
707 (NEW)		6	10	16
SST (1)				
4 Eng., M.R., 747SR		18	30	54
Long Range 747/747B		54	72	98
747 Stretch				
727 (QN)		16	23	24
727 Adv.		15	23	24
2 Eng., S.R., W.B.		12	64	176
2 Eng., M.R., W.B.		76	120	190
3 Eng., M.R., W.B.		164	192	206
3 Eng., M.R., W.B., Stretch		62	102	178
3 Eng., L.R., W.B., DC-10-30		18	16	14
3 Eng., L.R., W.B.		40	52	66
3 Eng., L.R., W.B., Stretch		16	28	46
2 Eng., M.R., Narrow (2)				
2 Eng., S.R., Narrow		30	38	50
STOL, Turboprop	* 84	28	30	34
TOTAL	1136	1322	1452	1754

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows (Ref. R. Dixon Speas)

737 - 33%
DC-9 - 67%

2.6.2 Boston Logan (BOS) - General Operating Considerations

- No new runway construction within the study period.
- A detailed computer analysis was made of weather tape statistics (5 years of records) obtained from U.S. Weather records for runway utilization.
- Flight tracks and associated altitudes were determined from conversations with tower controllers and the following documents:

  Logan International Airport Control Tower Bulletin No. 71.6, Anti-Noise Procedures, 21 June 1971.

  Arrival and Departure Handling of High Performance Airplanes - Boston Metropolis, BOS TWR 7232.2, 10 May 1971.

  The Boston Center and Boston Tower Letter of Agreement.

- Flight tracks and altitudes reflected the newly installed TCA.

Table 2.6.2-1 presents the runway utilization percentages for Boston.

Table 2.6.2-2 presents the average daily aircraft operations at Boston.

Table 2.6.2-1

Runway Utilization Percentages for Boston

R/W	Arrival (%)	Departure (%)
15	6.10	6.10
22	23.38	41.60
9	-	14.22
33	19.75	19.75
27	19.48	1.47
4	31.29	16.86

Table 2.6.2-2

Average Daily Aircraft Operations for Boston

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720				
720B				
707-120/320	24			
707-120B	24			
707-320B/C	24	34	28	26
727-100	108	74	62	58
727-200	84	84	98	116
737-100/200	2	2	2	
747-100	14			
DC-8-30	2			
DC-8-55	8			
DC-8-61/63	10	12	12	14
DC-10-10	10	74	88	110
DC-9-15	16			
DC-9-32	200	166	162	174
BAC-111	36			
L-1011		68	74	82
VC-10	2			
Cv. 880	4			
Cv. 990				
Caravelle				
707 (NEW)		16	16	16
SST (1)				2
4 Eng., M.R., 747SR		32	42	68
Long Range 747/747B				
747 Stretch				
727 (QN)				
727 Adv.				
2 Eng., S.R., W.B.				
2 Eng., M.R., W.B.			36	82
3 Eng., M.R., W.B.				
3 Eng., M.R., W.B., Stretch				
3 Eng., L.R., W.B., DC-10-30				
3 Eng., L.R., W.B.		28	34	40
3 Eng., L.R., W.B., Stretch		4	8	24
2 Eng., M.R., Narrow (2)		20	10	
2 Eng., S.R., Narrow			4	8
STOL, Turboprop	20			
TOTAL	590	614	676	820

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737 - 33%
DC-9 - 67%

2.6.3 Buffalo (BUF) – General Operating Considerations

- Extended final approach applicable to inbound aircraft resulting from "keep-em-high" FAA program.
- Extended "straight-out" departure tracks (approximately 6 n.m.) from Runways 5 and 23 in interests of noise abatement.
- Preferential runway use land and departure on Runway 23.
- No new runways or runway use changes were considered during the study period.
- Transitional control procedures in accordance with Cleveland Center/Buffalo Tower Letter of Agreement dated April 15, 1971.

Table 2.6.3-1 presents the runway utilization percentages for Buffalo.

Table 2.6.3-2 presents the average daily aircraft operations at Buffalo.

Table 2.6.3-1

Runway Utilization Percentages for Buffalo

R/W	Arrival (%)	Departure (%)
23	54.0	52.0
5	38.0	38.0
31	4.0	4.0
13	4.0	6.0

Table 2.6.3-2

Average Daily Aircraft Operations for Buffalo

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720				
720B				
707-120/320				
707-120B	14			
707-320B/C	4	16	16	16
727-100	26	22	22	20
727-200	22	36	32	32
737-100/200	16	16	18	18
747-100				
DC-8-30				
DC-8-55	2			
DC-8-61/63				
DC-10-10	4			
DC-9-15				
DC-9-32	26	58	58	54
BAC-111	68			
L-1011				
VC-10				
Cv. 880				
Cv. 990				
Caravelle				
707 (NEW)				
SST (1)				
4 Eng., M.R., 747SR		2	4	6
Long Range 747/747B				
747 Stretch				
727 (QN)		8	10	11
727 Adv.		8	10	11
2 Eng., S.R., W.B.		66	74	88
2 Eng., M.R., W.B.				
3 Eng., M.R., W.B.				
3 Eng., M.R., W.B., Stretch				
3 Eng., L.R., W.B., DC-10-30				
3 Eng., L.R., W.B.				
3 Eng., L.R., W.B., Stretch				
2 Eng., M.R., Narrow (2)				
2 Eng., S.R., Narrow				
STOL, Turboprop	22	8	2	
TOTAL	204	240	246	256

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737 - 33%
DC-9 - 67%

2.6.4 Chicago-Midway (MDW) - General Operating Considerations

- No new runway construction within the study period.
- Runway utilization assigned in accordance with control tower personnel estimates.
- Flight tracks and procedures were developed as outlined in:

  Chicago O'Hare Tower and Midway Tower Letter of Agreement, 5 March 1973.

  Chicago Center and O'Hare Tower Letter of Agreement, 25 April 1973.

Table 2.6.4-1 presents the runway utilization percentages for Chicago-Midway.

Table 2.6.4-2 presents the average daily aircraft operations at Chicago-Midway.

Table 2.6.4-1

Runway Utilization Percentages for
Chicago - Midway

R/W	Arrival (%)	Departure (%)
31L	30.0	30.0
13R	10.0	10.0
22L	45.0	45.0
4R	15.0	15.0

Table 2.6.4-2

Average Daily Aircraft Operations for Chicago-Midway

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720				
720B				
707-120/320				
707-120B				
707-320B/C				
727-100	48	82	86	98
727-200	2	74	88	114
737-100/200	24	80	84	94
747-100				
DC-8-30				
DC-8-55				
DC-8-61/63				
DC-10-10				
DC-9-15	22			
DC-9-32	10	100	106	118
BAC-111				
L-1011				
VC-10				
Cv. 880				
Cv. 990				
Caravelle				
707 (NEW)				
SST (1)				
4 Eng., M.R., 747SR				
Long Range 747/747B				
747 Stretch				
727 (QN)				
727 Adv.				
2 Eng., S.R., W.B.		22	30	48
2 Eng., M.R., W.B.				
3 Eng., M.R., W.B.				
3 Eng., M.R., W.B., Stretch				
3 Eng., L.R., W.B., DC-10-30				
3 Eng., L.R., W.B.				
3 Eng., L.R., W.B., Stretch				
2 Eng., M.R., Narrow (2)				
2 Eng., S.R., Narrow				
STOL, Turboprop	8			
TOTAL	114	358	394	472

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737 - 33%

DC-9 - 67%

2.6.5 Chicago-O'Hare (ORD) - General Operating Considerations

- No new runways were considered to be constructed during the study period.
- In the existing time frame, B-747 aircraft cannot utilize Runways 4L/22R and 9L/27R due to a lack of stabilized shoulders. In the future time frame, the shoulders were considered stabilized to allow unrestricted runway use.
- Departures are held to 5000 feet for extensive periods due to operating procedures.
- Radar vectoring patterns are utilized in the handling of both arrivals and departures.
- Eighteen different runway-use combinations were analyzed. Calm winds were assigned to arrivals on Runways 27R and 32L with departures on Runways 27L and 32R.
- Noise abatement procedures (including arrival runway preferences from 11 PM to 7 AM) as outlined in O'Hare Air Traffic Control Tower Order 7110.13 were in effect.
- o Special procedures for tower enroute service between Milwaukee and O'Hare were included in the flight tracks.

Table 2.6.5-1 presents the runway utilization percentages for Chicago - O'Hare. Table 2.6.5-2 presents the average daily aircraft operations at Chicago - O'Hare.

Table 2.6.5-1

Runway Utilization Percentages for Chicago - O'Hare

R/W No.	Arrival (%)				Departure (%)			
	1972	1978	1981	1987	1972	1978	1981	1972
4L	0	0	0	0	7.0	3.9	4.3	4.3
4R	0	0	0	0	2.6	4.8	5.5	5.5
9L	3.0	3.4	3.4	3.4	3.7	3.4	3.9	3.9
9R	9.0	9.5	9.5	9.5	4.2	4.6	4.2	4.2
14L	5.0	5.0	4.9	4.9	10.0	9.1	9.8	9.8
14R	13.0	14.0	14.0	14.0	4.2	4.6	4.1	4.1
22L	1.3	1.2	1.2	1.2	1.4	1.1	1.3	1.3
22R	17.2	10.4	10.5	10.5	0.7	0.9	0.9	0.9
27L	1.7	1.6	1.6	1.6	33.0	37.0	33.9	33.9
27R	12.5	16.0	16.0	16.0	2.0	0.1	0.1	0.1
32L	33.3	34.2	34.2	34.2	3.7	4.1	3.8	3.8
32R	4.0	4.7	4.7	4.7	27.4	26.4	28.1	28.1

Table 2.6.5-2

Average Daily Aircraft Operations for Chicago-O'Hare

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720	2			
720B	30	16		
707-120/320	18			
707-120B				
707-320B/C	174	94	90	86
727-100	318	116	82	34
727-200	200	175	143	124
737-100/200	108	106	68	42
747-100				
DC-8-30	14			
DC-8-55				
DC-8-61/63	174	84	82	80
DC-10-10	40	66	50	48
DC-9-15	54			
DC-9-32	182	206	174	122
BAC-111	4			
L-1011	2	78	68	56
VC-10	2			
Cv. 880	60			
Cv. 990				
Caravelle				
707 (NEW)		16	22	26
SST (1)				
4 Eng., M.R., 747SR		32	48	70
Long Range 747/747B	66	98	102	106
747 Stretch		10	20	34
727 (QN)		38	48	41
727 Adv.		37	47	41
2 Eng., S.R., W.B.		14	60	138
2 Eng., M.R., W.B.		94	112	126
3 Eng., M.R., W.B.		150	160	164
3 Eng., M.R., W.B., Stretch		56	78	104
3 Eng., L.R., W.B., DC-10-30		16	14	12
3 Eng., L.R., W.B.		36	46	54
3 Eng., L.R., W.B., Stretch		14	26	38
2 Eng., M.R., Narrow (2)				
2 Eng., S.R., Narrow		52	60	64
STOL, Turboprop	144	72	88	100
TOTAL	1592	1676	1688	1710

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737 - 33%
DC-9 - 67%

2.6.6 Cleveland (CLE) - General Operating Considerations

- No new runway construction was assumed to be completed in the study period.
- All arrivals are kept high as long as possible and all departures are cleared to the highest possible altitudes in accordance with Cleveland Tower Bulletin No. 73-2.
- Runway utilization was assigned in accordance with monthly runway usage charts kept by the Cleveland Air Traffic Control Tower.
- SIDs and STARs were utilized to some extent; however, radar vectoring of arrivals and departures was also employed.

Table 2.6.6-1 presents the runway utilization percentages for Cleveland.

Table 2.6.6-2 presents the average daily aircraft operations at Cleveland.

Table 2.6.6-1

Runway Utilization Percentages for Cleveland

R/W	Arrival (%)	Departure (%)
5	29.0	29.0
23	59.0	59.0
18	3.0	3.0
36	3.0	3.0
27	6.0	6.0

Table 2.6.6-2

Average Daily Aircraft Operations for Cleveland

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720				
720B				
707-120/320				
707-120B	12			
707-320B/C	10	24	16	10
727-100	110	108	70	42
727-200	32	36	38	46
737-100/200	84	84	98	104
747-100				
DC-8-30	2			
DC-8-55	10			
DC-8-61/63	12	18	18	16
DC-10-10	8	22	38	62
DC-9-15	6			
DC-9-32	18	40	40	36
BAC-111	26			
L-1011		12	16	22
VC-10				
Cv. 880				
Cv. 990				
Caravelle				
707 (NEW)				
SST (1)				
4 Eng., M.R., 747SR			8	24
Long Range 747/747B				
747 Stretch				
727 (QN)		7	17	15
727 Adv.		7	17	15
2 Eng., S.R., W.B.		22	32	42
2 Eng., M.R., W.B.				
3 Eng., M.R., W.B.				
3 Eng., M.R., W.B., Stretch				
3 Eng., L.R., W.B., DC-10-30				
3 Eng., L.R., W.B.				
3 Eng., L.R., W.B., Stretch				
2 Eng., M.R., Narrow (2)				
2 Eng., S.R., Narrow				
STOL, Turboprop	36	4		
TOTAL	366	384	408	434

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737	-	33%
DC-9	-	67%

2.6.7 Denver (DEN) - General Operating Considerations

- No new runway construction was assumed during the study period.
- VFR turn-ons over the outer marker were allowed for some aircraft.
- Considerable radar vectoring is applied to arrival and departure aircraft.
- Preferential runway use is arrivals on Runway 26L and departures on Runway 26L.
- Runway utilization was based upon runway use estimates by Denver control tower personnel.

Table 2.6.7-1 presents the runway utilization percentages for Denver.

Table 2.6.7-2 presents the average daily aircraft operations at Denver.

Table 2.6.7-1

Runway Utilization Percentages for Denver

R/W	Arrival (%)	Departure (%)
8R	2.5	2.5
26L	85.0	85.0
17	2.5	2.5
35	10.0	10.0

Table 2.6.7-2

Average Daily Aircraft Operations for Denver

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720	6			
720B	22			
707-120/320				
707-120B	8			
707-320B/C	6	32	26	10
727-100	106	124	114	116
727-200	90	74	76	104
737-100/200	88	98	106	126
747-100				
DC-8-30				
DC-8-55	30			
DC-8-61/63		36	26	18
DC-10-10	34	44	74	116
DC-9-15	40			
DC-9-32	14	60	62	62
BAC-111				
L-1011		6	12	20
VC-10				
Cv. 880	16			
Cv. 990				
Caravelle				
707 (NEW)				
SST (1)				
4 Eng., M.R., 747SR		24	52	86
Long Range 747/747B				
747 Stretch				
727 (QN)		16	26	35
727 Adv.		16	26	35
2 Eng., S.R., W.B.		50	84	126
2 Eng., M.R., W.B.				
3 Eng., M.R., W.B.				32
3 Eng., M.R., W.B., Stretch				38
3 Eng., L.R., W.B., DC-10-30		6	26	38
3 Eng., L.R., W.B.				
3 Eng., L.R., W.B., Stretch				
2 Eng., M.R., Narrow (2)				
2 Eng., S.R., Narrow				
STOL, Turboprop	62	24		
TOTAL	522	610	710	962

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737 - 33%
DC-9 - 67%

2.6.8 Dulles (IAD) - General Operating Considerations

- No new runway construction within the study period.
- Runway utilization was assigned in accordance with air traffic control records.
- Construction of flight tracks and associated altitudes considered the following material:

  Intra-Facility Noise Abatement Procedures, Order IADZ 7110.86, 11 December 1972.

  Dulles Tower Facility Standard Operating Procedures IADZ 7210.6, 1 April 1972.

  Dulles Tower Bulletin 72-2, 15 September 1972, IFR Routes for Turbojet Aircraft.

  Dulles Tower-Dulles Airport Management Bulletin 73-1, 25 June 1973, VFR Flight Near Noise Sensitive Areas.

  Washington Center and Dulles Tower, Letter of Agreement, 12 September 1971, Terminal Area Control Service.

Table 2.6.8-1 presents the runway utilization percentages for Dulles International.

Table 2.6.8-2 presents the average daily aircraft operations at Dulles International.

Table 2.6.8-1

Runway Utilization Percentages for
Dulles International

R/W	Arrival (%)	Departure (%)
1L	12.0	22.0
1R	35.0	1.0
30	2.0	-
19L	2.0	44.0
19R	41.0	1.0
12	8.0	32.0

Table 2.6.8-2

Average Daily Aircraft Operations for Dulles International

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720				
720B	2			
707-120/320	4			
707-120B	30			
707-320B/C	14	28	28	34
727-100	38	44	50	52
727-200	8	38	40	52
737-100/200	6	8	8	8
747-100	8			
DC-8-30				
DC-8-55	20			
DC-8-61/63		10	16	28
DC-10-10	4	16	16	20
DC-9-15	22			
DC-9-32	6	38	38	46
BAC-111				
L-1011		10	12	16
VC-10	2			
Cv. 880				
Cv. 990				
Caravelle				
707 (NEW)				
SST (1)				8
4 Eng., M.R., 747SR		48	54	72
Long Range 747/747B				
747 Stretch				
727 (QN)				
727 Adv.				
2 Eng., S.R., W.B.				
2 Eng., M.R., W.B.		10	14	24
3 Eng., M.R., W.B.				
3 Eng., M.R., W.B., Stretch				
3 Eng., L.R., W.B., DC-10-30		16	16	20
3 Eng., L.R., W.B.				
3 Eng., L.R., W.B., Stretch			12	24
2 Eng., M.R., Narrow (2)				
2 Eng., S.R., Narrow				
STOL, Turboprop	4			
TOTAL	168	266	304	404

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737 - 33%
DC-9 - 67%

2.6.9 John F. Kennedy (JFK) - General Operating Considerations*

- No new runway construction was assumed during the study period.
- Extensive standard instrument arrival and departure (SIDS/STARS) procedures are used and reflected in the analysis.
- Considerable radar vectoring is applied to inbound aircraft.
- Unique "lead-in" lights are used to permit aircraft to approach Runway 13R/L in a circling path to avoid residential areas.
- Runway assignment by traffic controllers makes use of a computer program that considers weather and relative levels of noise exposure experienced by surrounding communities over a selected time period. Detailed runway use logs of history at airport were used to supplement our runway use analysis.

Table 2.6.9-1 presents the runway utilization percentages for John F. Kennedy International.

Table 2.6.9-2 presents the average daily aircraft operations at John F. Kennedy International.

Table 2.6.9-1

Runway Utilization Percentages for
John F. Kennedy International

R/W No.	Arrival (%)				Departure (%)			
	1972	1978	1981	1987	1972	1978	1981	1987
22L	20.2	4.5	3.8	3.8	1.8	0	0	0
22R	2.0	0	0	0	25.0	47.2	47.5	47.6
31L	7.3	0	0	0	37.0	35.0	34.8	34.8
31R	26.3	30.0	30.2	30.2	0.4	0	0	0
4L	2.1	0	0	0	11.4	2.1	2.1	2.0
4R	18.1	37.7	37.8	37.9	0.5	0	0	0
13L	15.2	22.0	22.3	22.3	2.7	0	0	0
13R	8.8	5.8	5.9	5.9	21.2	15.7	15.6	15.6

*See page 2-69.

Table 2.6.9-2

Average Daily Aircraft Operations for John F. Kennedy International

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720	4			
720B				
707-120/320	110			
707-120B	82			
707-320B/C	54	56	34	18
727-100	158	126	82	50
727-200	80	30	26	24
737-100/200				
747-100	122			
DC-8-30	30			
DC-8-55	66			
DC-8-61/63	58	34	26	18
DC-10-10	12	44	42	38
DC-9-15	26			
DC-9-32	24	56	48	40
BAC-111	10			
L-1011	10	52	52	46
VC-10	12			
Cv. 880	14			
Cv. 990				
Caravelle				
707 (NEW)		16	18	20
SST (1)		8	14	20
4 Eng., M.R., 747SR		232	222	196
Long Range 747/747B				
747 Stretch		22	22	20
727 (QN)		7	9	8
727 Adv.		7	9	8
2 Eng., S.R., W.B.		52	82	136
2 Eng., M.R., W.B.				
3 Eng., M.R., W.B.		98	122	140
3 Eng., M.R., W.B., Stretch		36	70	120
3 Eng., L.R., W.B., DC-10-30		10	12	10
3 Eng., L.R., W.B.		24	34	46
3 Eng., L.R., W.B., Stretch		10	18	32
2 Eng., M.R., Narrow (2)		12	12	10
2 Eng., S.R., Narrow				
STOL, Turboprop	2			
TOTAL	874	932	954	1000

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737 - 33%
DC-9 - 67%

2.6.10 LaGuardia (LGA) - General Operating Considerations *

- No new runways were considered to be constructed during the study period.
- Preferential runway use involves landings on Runway 22, departures on 13.
- Immediate turns are completed when necessary to permit departures to remain over nonresidential areas until relatively high altitudes are attained.
- Extensive use of standard instrument arrival and departure (SIDS/STARS) procedures were incorporated in the study.
- Considerable radar vectoring is applied to inbound aircraft.

Table 2.6.10-1 presents the runway utilization percentages for LaGuardia.

Table 2.6.10-2 presents the average daily aircraft operations at LaGuardia.

Table 2.6.10-1

Runway Utilization Percentages for LaGuardia

R/W	Arrival (%)				Departure (%)			
No.	1972	1978	1981	1987	1972	1978	1981	1987
4	9.3	5.5	5.5	5.5	24.3	33.6	33.6	33.5
13	14.3	9.0	9.0	9.0	36.2	35.1	35.4	35.8
22	39.4	58.6	58.4	58.7	1.7	0	0	0
31	37.0	26.9	27.1	26.8	37.8	31.3	31.0	30.7

* Runway utilization is heavily influenced by:

- Noise abatement procedures (both JFK and LGA are almost completely surrounded by high density residential areas).
- Potentially conflicting traffic patterns between the two facilities.
- Weather conditions.

Table 2.6.10-2

Average Daily Aircraft Operations for La Guardia

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720				
720B				
707-120/320				
707-120B				
707-320B/C				
727-100	294	120	110	90
727-200	172	207	175	166
737-100/200	38	30	120	24
747-100				
DC-8-30				
DC-8-55				
DC-8-61/63				
DC-10-10	28	28	28	24
DC-9-15	42			
DC-9-32	164	148	36	98
BAC-111	26			
L-1011		34	76	30
VC-10				
Cv. 880				
Cv. 990				
Caravelle				
707 (NEW)				
SST (1)				
4 Eng., M.R., 747SR				
Long Range 747/747B				
747 Stretch				
727 (QN)		45	59	[illegible]
727 Adv.		44	58	55
2 Eng., S.R., W.B.		6	30	78
2 Eng., M.R., W.B.		40	56	84
3 Eng., M.R., W.B.		64	28	90
3 Eng., M.R., W.B., Stretch				
3 Eng., L.R., W.B., DC-10-30				
3 Eng., L.R., W.B.				
3 Eng., L.R., W.B., Stretch				
2 Eng., M.R., Narrow (2)				
2 Eng., S.R., Narrow		30	18	44
STOL, Turboprop	34	52	70	64
TOTAL	798	848	864	902

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737	-	33%
DC-9	-	67%

2.6.11 Los Angeles (LAX) - General Operating Considerations

- No new runway construction within the study period.
- "45°" visual approach to Runways 24 or 25 was utilized in the flight track assignment. This is a short turn-on just east of Hollywood Park Race Track.
- No wide-body aircraft were assigned to Runway 25L/R in the present time frame because of load-bearing limitations associated with a tunnel below the runways. In the 1978 to 1987 time period, it was assumed this tunnel would be strengthened and runway limitations would not apply.
- A new night operation procedure was utilized which restricted landings to Runways 6 and 7 and departures to 24 and 25, thereby placing all operations over water at night.
- PSA two-segment (~6°/3°) VFR approaches were recognized.
- Preferential runway use is Runways 25L/R in the present time frame with mostly wide bodies on Runway 24. For the future, both sets of parallels were used equally.

Table 2.6.11-1 presents the runway utilization percentages for Los Angeles International.

Table 2.6.11-2 presents the average daily aircraft operations at Los Angeles International.

Table 2.6.11-1

Runway Utilization Percentages for Los Angeles International

R/W	Arrival (%)				Departure (%)			
No.	1972	1978	1981	1987	1972	1978	1981	1987
6	2.5	11.1	11.0	11.0	0	0	0	0
7	0	0	0	0	0	0	0	0
24	32.1	34.7	34.7	34.7	23.1	43.1	43.2	43.2
25	65.4	54.2	54.3	54.3	76.9	56.9	56.8	56.8

Table 2.6.11-2

Average Daily Aircraft Operations for Los Angeles International

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720	20			
720B	68	4		
707-120/320	36			
707-120B	100			
707-320B/C	38	70	40	26
727-100	110	52	50	26
727-200	208	140	126	104
737-100/200	102	64	54	52
747-100	80			
DC-8-30	12			
DC-8-55	90			
DC-8-61/63	44	44	32	28
DC-10-10	36	40	30	34
DC-9-15	20			
DC-9-32	22	52	42	42
BAC-111				
L-1011	4	48	40	38
VC-10	2			
Cv. 880	2			
Cv. 990				
Caravelle				
707 (NEW)		14	18	28
SST (1)		0	6	10
4 Eng., M.R., 747SR		26	38	52
Long Range 747/747B		100	102	116
747 Stretch		10	16	32
727 (QN)		30	42	35
727 Adv.		30	42	35
2 Eng., S.R., W.B.		8	36	104
2 Eng., M.R., W.B.		58	84	112
3 Eng., M.R., W.B.		90	100	118
3 Eng., M.R., W.B., Stretch		44	72	100
3 Eng., L.R., W.B., DC-10-30		10	8	8
3 Eng., L.R., W.B.		22	26	38
3 Eng., L.R., W.B., Stretch		12	20	36
2 Eng., M.R., Narrow (2)		32	36	44
2 Eng., S.R., Narrow				
STOL, Turboprop	24	44	52	72
TOTAL	1018	1044	1112	1290

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows
737 - 33%
DC-9 - 67%

2.6.12 Miami (MIA) - General Operating Considerations

- No new runway construction during the study period.
- Runway utilization assigned in accordance with control tower records.
- Extensive use of radar vectoring and path-stretching procedures.

Table 2.6.12-1 presents the runway utilization percentages for Miami.

Table 2.6.12-2 presents the average daily aircraft operations at Miami.

Table 2.6.12-1

Runway Utilization Percentages for Miami

R/W	Arrival (%)	Departure (%)
27L	17.56	9.46
27R	15.45	23.57
9L	31.36	47.85
9R	35.63	19.21

Table 2.6.12-2

Average Daily Aircraft Operations for Miami

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720	4			
720B	2			
707-120/320	24			
707-120B				
707-320B/C	4	22	16	10
727-100	198	138	112	92
727-200	108	106	86	78
737-100/200	2			
747-100	16			
DC-8-30	32			
DC-8-55	46			
DC-8-61/63	22	60	44	32
DC-10-10	10	66	80	92
DC-9-15	18			
DC-9-32	86	80	72	66
BAC-111				
L-1011	6	86	118	158
VC-10				
Cv. 880	6			
Cv. 990				
Caravelle				
707 (NEW)		38	26	0
SST (1)				
4 Eng., M.R., 747SR		46	86	96
Long Range 747/747B				
747 Stretch				
727 (QN)		23	28	26
727 Adv.		23	28	26
2 Eng., S.R., W.B.		14	58	146
2 Eng., M.R., W.B.				
3 Eng., M.R., W.B.				
3 Eng., M.R., W.B., Stretch				
3 Eng., L.R., W.B., DC-10-30		24	40	64
3 Eng., L.R., W.B.				
3 Eng., L.R., W.B., Stretch		8	20	46
2 Eng., M.R., Narrow (2)				
2 Eng., S.R., Narrow				
STOL, Turboprop	74			
TOTAL	658	734	814	932

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737 - 33%
DC-9 - 67%

2.6.13 Minneapolis (MSP) - General Operating Considerations

- No new runway construction within the study period.
- A detailed computer analysis was made of weather tape statistics (5 years of records) obtained from U.S. Weather records for runway utilization.
- Noise abatement procedures outlined in MSP ATCT 7100.2C, 15 March 1973, were employed.
- Extensive use of radar vectoring and path stretching was employed in areas designated in the Minneapolis ARTCC and Wold-Chamberlain ATCT Letter of Agreement.

Table 2.6.13-1 presents the runway utilization percentages for Minneapolis - St. Paul.

Table 2.6.13-2 presents the average daily aircraft operations at Minneapolis - St. Paul.

Table 2.6.13-1

Runway Utilization Percentages for Minneapolis - St. Paul

R/W	Arrival (%)	Departure (%)
22	16.60	26.80
4	18.80	13.80
11L	6.30	22.60
11R	6.40	19.10
29L	21.20	8.90
29R	30.70	8.80

Table 2.6.13-2

Average Daily Aircraft Operations for Minneapolis-St. Paul

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720				
720B	22			
707-120/320	2			
707-120B				
707-320B/C	26	36	32	30
727-100	70	78	80	82
727-200	92	96	104	108
737-100/200	16	18	16	16
747-100	10			
DC-8-30				
DC-8-55	2			
DC-8-61/63				
DC-10-10		32	36	42
DC-9-15	6			
DC-9-32	58	78	62	54
BAC-111				
L-1011		12	18	30
VC-10				
Cv. 880				
Cv. 990				
Caravelle				
707 (NEW)				
SST (1)				
4 Eng., M.R., 747SR		28	34	46
Long Range 747/747B				
747 Stretch				
727 (QN)				
727 Adv.				
2 Eng., S.R., W.B.				
2 Eng., M.R., W.B.		18	28	46
3 Eng., M.R., W.B.			10	18
3 Eng., M.R., W.B., Stretch				
3 Eng., L.R., W.B., DC-10-30				
3 Eng., L.R., W.B.				
3 Eng., L.R., W.B., Stretch				
2 Eng., M.R., Narrow (2)				
2 Eng., S.R., Narrow				
STOL, Turboprop	34			
TOTAL	338	396	420	472

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737	-	33%
DC-9	-	67%

2.6.14 Newark (EWR) - General Operating Considerations

- No new runway construction within the study period.
- Runway utilization was determined from statistics maintained by the Port Authority of New York and New Jersey.
- Flight tracks associated with Newark's arriving and departing aircraft were established in accordance with procedures set forth in the "Standard Operational Procedures Manual, New York CIFRR, March 1973." Validity and accuracy of drawn tracks were checked utilizing a blowup of the "Newark ARR-DEP NYCIFRR ASR-6 60 n.m. Video Map."

Table 2.6.14-1 presents the runway utilization percentages for Newark.

Table 2.6.14-2 presents the average daily aircraft operations at Newark.

Table 2.6.14-1

Runway Utilization Percentages for Newark

R/W	Arrival (%)	Departure (%)
4L	-	32.1
4R	38.1	-
22L	37.4	-
22R	-	50.3
11	1.1	7.1
29	23.4	10.5

Table 2.6.14-2

Average Daily Aircraft Operations for Newark

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720				
720B	2			
707-120/320				
707-120B	30			
707-320B/C	22	60	70	76
727-100	80	96	90	76
727-200	58	49	50	54
737-100/200	32	38	36	36
747-100				
DC-8-30	6			
DC-8-55	24			
DC-8-61/63	30	70	74	78
DC-10-10	2	38	54	78
DC-9-15	12			
DC-9-32	98	114	124	122
BAC-111	38			
L-1011		22	50	66
VC-10				
Cv. 880	16			
Cv. 990				
Caravelle				
707 (NEW)				
SST (1)				
4 Eng., M.R., 747SR		24	38	46
Long Range 747/747B				
747 Stretch				
727 (QN)		11	16	18
727 Adv.		10	16	18
2 Eng., S.R., W.B.		28	42	56
2 Eng., M.R., W.B.				
3 Eng., M.R., W.B.				
3 Eng., M.R., W.B., Stretch				
3 Eng., L.R., W.B., DC-10-30				
3 Eng., L.R., W.B.				
3 Eng., L.R., W.B., Stretch				
2 Eng., M.R., Narrow (2)				
2 Eng., S.R., Narrow				
STOL, Turboprop	28	10		
TOTAL	478	570	660	724

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737	-	33%
DC-9	-	67%

2.6.15 New Orleans (MSY) - General Operating Considerations

- No new runway construction within the study period.
- Runway utilization was assigned employing a 15 knot crosswind criteria with the windrose contained on the January 1972 airport layout plan for New Orleans International Airport.
- Calm Wind Runway Use was arrivals on Runway 10 and departures on Runway 19.
- Noise abatement procedures contained in Pilot Bulletin 70-3 and Pilot Bulletin 72-2, Moisant ATC Tower, were considered in flight track construction.
- Extensive radar vectoring was employed within the arrival/departure gate areas as outlined in the Letter of Agreement between Houston Center and Moisant Tower, 1 March 1973.

Table 2.6.15-1 presents the runway utilization percentages for New Orleans.

Table 2.6.15-2 presents the average daily aircraft operations at New Orleans.

Table 2.6.15-1

Runway Utilization Percentages for New Orleans

R/W	Arrival (%)	Departure (%)
1	22.0	24.0
19	18.0	41.0
10	58.0	2.0
28	2.0	33.0

Table 2.6.15-2

Average Daily Aircraft Operations for New Orleans

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720				
720B				
707-120/320				
707-120B				
707-320B/C		4		
727-100	40	46	46	54
727-200	48	62	62	84
737-100/200	2	10	8	18
747-100				
DC-8-30	20			
DC-8-55	28			
DC-8-61/63	16	32	30	36
DC-10-10	4	38	46	18
DC-9-15	44			
DC-9-32	54	78	84	6
BAC-111				
L-1011		36	46	62
VC-10				
Cv. 880	12			
Cv. 990				
Caravelle				
707 (NEW)				
SST (1)				
4 Eng., M.R., 747SR		4	8	24
Long Range 747/747B				
747 Stretch				
727 (QN)		13	20	28
727 Adv.		13	20	28
2 Eng., S.R., W.B.		6	18	60
2 Eng., M.R., W.B.				
3 Eng., M.R., W.B.				34
3 Eng., M.R., W.B., Stretch				
3 Eng., L.R., W.B., DC-10-30		10	14	12
3 Eng., L.R., W.B.				
3 Eng., L.R., W.B., Stretch				
2 Eng., M.R., Narrow (2)			22	110
2 Eng., S.R., Narrow				
STOL, Turboprop	32	2		
TOTAL	300	354	424	574

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737 - 33%
DC-9 - 67%

2.6.16 Philadelphia (PHL) - General Operating Considerations

- Study reflected use of new east-west parallel.
- Arrival-departure tracks are in accordance with agreements with New York and Washington centers and adjacent tower facilities.
- Arrival altitudes are governed by FAA "keep-em-high" philosophy and local noise abatement procedures.

Table 2.6.16-1 presents the runway utilization percentages for Philadelphia.

Table 2.6.16-2 presents the average daily aircraft operations at Philadelphia..

Table 2.6.16-1

Runway Utilization Percentages for Philadelphia

R/W	Arrival (%)	Departure (%)
9L	-	36.0
9R	36.0	-
27L	-	64.0
27R	64.0	-
17	-	-
35	-	-

Table 2.6.16-2

Average Daily Aircraft Operations for Philadelphia

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720				
720B				
707-120/320	12			
707-120B	20			
707-320B/C	26	32	30	32
727-100	80	86	78	78
727-200	46	72	74	94
737-100/200	8	18	20	24
747-100	28			
DC-8-30	12			
DC-8-55	22			
DC-8-61/63	12	14	14	16
DC-10-10	2	46	58	78
DC-9-15	30			
DC-9-32	124	170	162	172
BAC-111				
L-1011	2	28	40	64
VC-10	2			
Cv. 880	20			
Cv. 990				
Caravelle				
707 (NEW)				
SST (1)				
4 Eng., M.R., 747SR		34	40	46
Long Range 747/747B				
747 Stretch				
727 (QN)		16	25	31
727 Adv.		16	25	31
2 Eng., S.R., W.B.		34	74	120
2 Eng., M.R., W.B.				
3 Eng., M.R., W.B.				
3 Eng., M.R., W.B., Stretch				
3 Eng., L.R., W.B., DC-10-30				
3 Eng., L.R., W.B.				
3 Eng., L.R., W.B., Stretch				
2 Eng., M.R., Narrow (2)				
2 Eng., S.R., Narrow				
STOL, Turboprop	30	12		
TOTAL	476	578	640	786

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737 - 33%

DC-9 - 67%

2.6.17 Phoenix-Sky Harbor (PHX) - General Operating Considerations

- No new runway construction during the study period.
- Runway utilization was determined by control tower personnel estimates.
- Noise abatement procedures outlined in Phoenix TRACON/Tower Pilot Bulletin dated 14 January 1972 were followed.
- Sky Harbor Airport, Luke AFB, William's AFB Terminal Area Graphic Notice, 15 September 1972, was reviewed and incorporated in the flight tracks.
- SIDs and STARs were used. Also VFR approach tracks were shown because of their frequent use.

Table 2.6.17-1 presents the runway utilization percentages for Phoenix.

Table 2.6.17-2 presents the average daily aircraft operations at Phoenix.

Table 2.6.17-1

Runway Utilization Percentages for Phoenix

R/W No.	Arrival (%)				Departure (%)			
	1972	1978	1981	1987	1972	1978	1981	1987
8L	0	22.0	22.0	22.0	0	20.0	20.0	20.0
8R	50.0	28.0	28.0	28.0	50.0	30.0	30.0	30.0
26L	50.0	28.0	28.0	28.0	50.0	30.0	30.0	30.0
26R	0	22.0	22.0	22.0	0	20.0	20.0	20.0

Table 2.6.17-2

Average Daily Aircraft Operations for Phoenix

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720				
720B	10			
707-120/320				
707-120B	36			
707-320B/C	4	32	32	38
727-100	14	6	6	8
727-200	46	44	48	62
737-100/200	16	18	20	24
747-100	2			
DC-8-30				
DC-8-55	2			
DC-8-61/63				
DC-10-10	6	18	22	28
DC-9-15	10			
DC-9-32	34	58	70	86
BAC-111				
L-1011	6	16	20	24
VC-10				
Cv. 880	4			
Cv. 990				
Caravelle				
707 (NEW)				
SST (1)				
4 Eng., M.R., 747SR		12	16	26
Long Range 747/747B				
747 Stretch				
727 (QN)		10	16	21
727 Adv.		10	16	21
2 Eng., S.R., W.B.		18	26	46
2 Eng., M.R., W.B.				
3 Eng., M.R., W.B.		8	10	16
3 Eng., M.R., W.B., Stretch				
3 Eng., L.R., W.B., DC-10-30		6	6	8
3 Eng., L.R., W.B.				
3 Eng., L.R., W.B., Stretch				
2 Eng., M.R., Narrow (2)				
2 Eng., S.R., Narrow				
STOL, Turboprop	22			
TOTAL	212	256	308	408

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737 - 33%
DC-9 - 67%

2.6.18 Portland (PDX) - General Operating Considerations

- No new runway construction was assumed during the study period.
- Radar vectoring procedures are utilized in the handling of both arrivals and departures.
- Preferential runway use is arrivals on Runway 10R and departures on Runway 10L.
- Runway utilization was based upon runway use estimates by Portland control tower personnel.
- Altitude restrictions for departing aircraft as outlined in Letter of Agreement, April 16, 1973, between Seattle Air Route Traffic Control Center and Portland Tower were applied to flight tracks.

Table 2.6.18-1 presents the runway utilization percentages for Portland.

Table 2.6.18-2 presents the average daily aircraft operations at Portland.

Table 2.6.18-1

Runway Utilization Percentages for Portland

R/W	Arrival (%)	Departure (%)
10L	14.0	63.0
10R	56.0	7.0
28L	7.0	14.0
28R	22.0	14.0
20	1.0	2.0

Table 2.6.18-2

Average Daily Aircraft Operations for Portland

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720				
720B	14			
707-120/320	8			
707-120B				
707-320B/C	6	6	4	2
727-100	62	54	60	78
727-200	36	46	50	64
737-100/200	30	40	50	70
747-100				
DC-8-30				
DC-8-55	10			
DC-8-61/63	6	12	10	10
DC-10-10	2	24	30	42
DC-9-15	2			
DC-9-32	32	38	44	60
BAC-111				
L-1011				
VC-10				
Cv. 880				
Cv. 990				
Caravelle				
707 (NEW)				
SST (1)				
4 Eng., M.R., 747SR		4	6	10
Long Range 747/747B				
747 Stretch				
727 (QN)		10	16	22
727 Adv.		10	16	22
2 Eng., S.R., W.B.		20	34	58
2 Eng., M.R., W.B.				
3 Eng., M.R., W.B.				
3 Eng., M.R., W.B., Stretch				
3 Eng., L.R., W.B., DC-10-30		4	6	8
3 Eng., L.R., W.B.				
3 Eng., L.R., W.B., Stretch				
2 Eng., M.R., Narrow (2)				
2 Eng., S.R., Narrow				
STOL, Turboprop	14	6		
TOTAL	222	274	326	446

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737 - 33%
DC-9 - 67%

2.6.19 San Diego (SAN) - General Operating Considerations

- No new runway construction within the study period.
- Runway utilization was assigned based upon estimates by control tower personnel.
- VFR procedures were extensively utilized along with standard IFR approach procedures.
- San Diego Terminal Area Graphic Notice and the Los Angeles Center/Miramar RATCC Letter of Agreement, 15 February 1973, were used in the construction and altitude assignment for the flight tracks.

Table 2.6.19-1 presents the runway utilization percentages for San Diego.

Table 2.6.19-2 presents the average daily aircraft operations at San Diego.

Table 2.6.19-1

Runway Utilization Percentages for San Diego

R/W	Arrival (%)	Departure (%)
9	10.0	10.0
27	90.0	90.0

Table 2.6.19-2

Average Daily Aircraft Operations for San Diego

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720				
720B	14			
707-120/320				
707-120B	24			
707-320B/C	10	34	40	52
727-100	24	24	26	32
727-200	56	68	64	82
737-100/200	46	38	40	48
747-100				
DC-8-30	2			
DC-8-55	20			
DC-8-61/63	4	24	26	34
DC-10-10	2	8	10	16
DC-9-15				
DC-9-32	6	14	14	14
BAC-111				
L-1011		6	8	10
VC-10				
Cv. 880				
Cv. 990				
Caravelle				
707 (NEW)				
SST (1)				
4 Eng., M.R., 747SR		2	4	12
Long Range 747/747B				
747 Stretch				
727 (QN)		14	22	28
727 Adv.		14	22	28
2 Eng., S.R., W.B.			8	24
2 Eng., M.R., W.B.				
3 Eng., M.R., W.B.				
3 Eng., M.R., W.B., Stretch				
3 Eng., L.R., W.B., DC-10-30		6	8	12
3 Eng., L.R., W.B.				
3 Eng., L.R., W.B., Stretch				
2 Eng., M.R., Narrow (2)				
2 Eng., S.R., Narrow				
STOL, Turboprop				
TOTAL	208	252	292	392

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737 - 33%
DC-9 - 67%

2.6.20 San Francisco (SFO) - General Operating Considerations

- No new runway construction was assumed to be completed in the study period.
- Extensive use of standard instrument departures (SIDS) and standard arrival routes (STARS) are employed due to the complex airspace environment of the Bay Area. These SIDS and STARS delineate specific courses and altitudes for aircraft to fly and are assigned aircraft based upon their origin/destination and airline routing preferences.
- Non-SID/STAR radar vectoring and VFR operations were also used. Two high-use VFR operations are the Visual Bridge Approach to Runway 28R and the GAP Departure off Runway 28L/R.
- Preferential runway use is arrivals on Runway 28 and departures on Runway 1.
- Runway utilization was based upon the Weather Bureau tape analysis and runway use surveys conducted by San Francisco control tower personnel.
- A 600 foot takeoff displacement for Runway 1R was considered in the analysis. Although listed on a test basis, it was assumed that it will be permanently adopted.
- Six degree VFR approach procedure used by PSA was recognized.

Table 2.6.20-1 presents the runway utilization percentages for San Francisco International.

Table 2.6.20-2 presents the average daily aircraft operations at San Francisco International.

Table 2.6.20-1

Runway Utilization Percentages for
San Francisco International

R/W	Arrival (%)				Departure (%)			
No.	1972	1978	1981	1987	1972	1978	1981	1987
28	92.3	92.3	92.3	92.3	34.1	34.4	33.7	33.7
10	0.3	0.3	0.3	0.3	5.5	4.7	4.7	4.7
1	0.9	0.9	0.9	0.9	53.8	59.3	60.0	60.0
19	6.5	6.5	6.5	6.5	1.6	1.6	1.6	1.6

Table 2.6.20-2

Average Daily Aircraft Operations for San Francisco International

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720	16			
720B	34			
707-120/320	34			
707-120B	56			
707-320B/C	18	44	46	46
727-100	82	50	40	40
727-200	108	78	73	79
737-100/200	160	122	122	104
747-100	48			
DC-8-30	10			
DC-8-55	64			
DC-8-61/63	60	88	44	22
DC-10-10	16	38	38	40
DC-9-15				
DC-9-32	26	100	98	76
BAC-111				
L-1011		46	44	46
VC-10				
Cv. 880	8			
Cv. 990				
Caravelle				
707 (NEW)		26	22	22
SST (1)			8	14
4 Eng., M.R., 747SR		18	40	56
Long Range 747/747B		56	70	102
747 Stretch		6	12	28
727 (QN)		17	25	27
727 Adv.		17	24	26
2 Eng., S.R., W.B.		4	46	82
2 Eng., M.R., W.B.		26	36	62
3 Eng., M.R., W.B.		74	94	142
3 Eng., M.R., W.B., Stretch		32	56	122
3 Eng., L.R., W.B., DC-10-30		10	8	10
3 Eng., L.R., W.B.		20	28	46
3 Eng., L.R., W.B., Stretch		8	10	32
2 Eng., M.R., Narrow (2)				
2 Eng., S.R., Narrow		20	24	36
STOL, Turboprop	40	24	34	56
TOTAL	780	924	1042	1316

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows:

737 - 33%
DC-9 - 67%

2.6.21 Seattle (SEA) - General Operating Considerations

- No new runways were considered to be constructed during the study period.
- Preferential runway use is arrivals on Runway 16R and departures on Runway 16L.
- Runway utilization was based upon runway use estimates by Seattle control tower personnel.
- Considerable radar vectoring is applied to arrival and departure aircraft.
- The Visual Bay Approach to Runway 16 as outlined in Noise Abatement Procedures, Seattle Air Traffic Control Tower Order 7110.071B, was included in the flight tracks.

Table 2.6.21-1 presents the runway utilization percentages for Seattle.

Table 2.6.21-2 presents the average daily aircraft operations at Seattle.

Table 2.6.21-1

Runway Utilization Percentages for Seattle

R/W	Arrival (%)	Departure (%)
16L	3.0	48.0
16R	57.0	12.0
34L	2.0	38.0
34R	38.0	2.0

Table 2.6.21-2

Average Daily Aircraft Operations for Seattle

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720				
720B	38			
707-120/320	12			
707-120B				
707-320B/C	28	26	20	16
727-100	62	70	74	78
727-200	46	72	74	82
737-100/200	10	12	14	14
747-100	10			
DC-8-30				
DC-8-55	22			
DC-8-61/63	26	38	30	26
DC-10-10	4	16	18	20
DC-9-15				
DC-9-32	22	18	18	20
BAC-111				
L-1011		8	10	10
VC-10				
Cv. 880				
Cv. 990				
Caravelle				
707 (NEW)				
SST (1)				
4 Eng., M.R., 747SR		32	48	74
Long Range 747/747B				
747 Stretch				
727 (QN)		15	24	27
727 Adv.		15	24	27
2 Eng., S.R., W.B.		14	16	24
2 Eng., M.R., W.B.				
3 Eng., M.R., W.B.				38
3 Eng., M.R., W.B., Stretch				
3 Eng., L.R., W.B., DC-10-30		24	30	36
3 Eng., L.R., W.B.				
3 Eng., L.R., W.B., Stretch				
2 Eng., M.R., Narrow (2)				
2 Eng., S.R., Narrow				
STOL, Turboprop	20			
TOTAL	300	360	400	492

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737	-	33%
DC-9	-	67%

2.6.22 St. Louis (STL) - General Operating Considerations

- No new runway construction within the study period.
- A detailed computer analysis was made of weather tape statistics (5 years of records) obtained from the U.S. Weather records for runway utilization at St. Louis Airport.
- Arrival and departure flight tracks were based upon radar vectoring in assigned areas in accordance with the Kansas City ARTCC and St. Louis Airport ATCT, Letter of Agreement, 21 April 1971.
- Special procedures regarding the arrival handling of turbine-powered aircraft as outlined in St. Louis ATCT Order 7110.14C was followed.

Table 2.6.22-1 presents the runway utilization percentages for St. Louis.

Table 2.6.22-2 presents the average daily aircraft operations at St. Louis.

Table 2.6.22-1

Runway Utilization Percentages for St. Louis

R/W No.	Arrival (%)				Departure (%)			
	1972	1978	1981	1987	1972	1978	1981	1987
6	3.9	2.1	2.1	2.1	0.4	0.4	0.4	0.4
12	54.2	54.2	54.2	54.2	57.5	57.5	57.5	57.5
24	3.4	3.4	3.4	3.4	1.9	1.9	1.9	1.9
30	38.5	40.3	40.3	40.3	40.2	40.2	40.2	40.2

Table 2.6.22-2

Average Daily Aircraft Operations for St. Louis

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720				
720B				
707-120/320	6			
707-120B	34			
707-320B/C	8	36	26	
727-100	102	38	40	44
727-200	62	72	67	80
737-100/200	8	6	6	8
747-100				
DC-8-30				
DC-8-55				
DC-8-61/63				
DC-10-10		38	60	100
DC-9-15	70			
DC-9-32	122	190	208	248
BAC-111	10			
L-1011	2	40	60	100
VC-10				
Cv. 880	14			
Cv. 990				
Caravelle				
707 (NEW)				
SST (1)				
4 Eng., M.R., 747SR		48	76	138
Long Range 747/747B				
747 Stretch				
727 (QN)		16	22	26
727 Adv.		16	22	26
2 Eng., S.R., W.B.				
2 Eng., M.R., W.B.		8	26	76
3 Eng., M.R., W.B.				
3 Eng., M.R., W.B., Stretch				
3 Eng., L.R., W.B., DC-10-30				
3 Eng., L.R., W.B.		8	14	24
3 Eng., L.R., W.B., Stretch				
2 Eng., M.R., Narrow (2)				
2 Eng., S.R., Narrow				
STOL, Turboprop	66	28		
TOTAL	504	544	627	870

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737 - 33%
DC-9 - 67%

2.6.23 Washington National (DCA) - General Operating Considerations

- No new runway construction within the study period.
- Runway utilization was assigned employing a 15-knot crosswind criterion on a U.S. Weather Bureau windrose with a period of record spanning January 1, 1954 to December 31, 1963.
- Washington National Airport noise abatement procedures as contained in the Airmen's Information Manual were used in flight track construction.
- Procedures contained in the Washington Center and Washington Approach Control Letter of Agreement, 12 September 1971, were followed.
- Radar vectoring techniques and routings were utilized.

Table 2.6.23-1 presents the runway utilization percentages for Washington National.

Table 2.6.23-2 presents the average daily aircraft operations at Washington National.

Table 2.6.23-1

Runway Utilization Percentages for Washington National

R/W	Arrival (%)	Departure (%)
15	5.0	11.0
18	39.0	33.0
36	42.0	50.0
33	14.0	6.0
21	-	-
3	-	-

Table 2.6.23-2

Average Daily Aircraft Operations for Washington National

Aircraft Type/Description	Average Daily Operations			
	1972	1978	1981	1987
720				
720B				
707-120/320				
707-120B				
707-320B/C				
727-100	136	76	64	50
727-200	122	100	80	65
737-100/200	62	62	46	32
747-100				
DC-8-30				
DC-8-55				
DC-8-61/63				
DC-10-10		48	60	64
DC-9-15	6			
DC-9-32	144	158	154	126
BAC-111	32			
L-1011		68	86	94
VC-10				
Cv. 880				
Cv. 990				
Caravelle				
707 (NEW)				
SST (1)				
4 Eng., M.R., 747SR				
Long Range 747/747B				
747 Stretch				
727 (QN)		21	26	22
727 Adv.		21	26	21
2 Eng., S.R., W.B.		30	82	156
2 Eng., M.R., W.B.				
3 Eng., M.R., W.B.				
3 Eng., M.R., W.B., Stretch				
3 Eng., L.R., W.B., DC-10-30				
3 Eng., L.R., W.B.				
3 Eng., L.R., W.B., Stretch				
2 Eng., M.R., Narrow (2)				
2 Eng., S.R., Narrow				
STOL, Turboprop	98	38		
TOTAL	600	622	624	630

(1) For the purpose of the DOT 23 Airport Study, aircraft in this class are considered to be of the 707 (New) variety.

(2) Split category as follows

737 - 33%
DC-9 - 67%

2.7 Cost of Noise Reduction Alternatives

This section includes a summary of the data and methods used to compute the total marginal costs associated with the various noise retrofit alternatives considered within the scope of this study.

The alternative programs for noise reduction have been evaluated in terms of total costs of the investment required to develop, certificate, and install the selected modifications on all candidate aircraft, plus the marginal operating costs associated with the modification over the time period, and for the varying number of candidate aircraft, subject to the program.

The total cost of each retrofit program has been constructed from the sum of four marginal cost elements attributable to each program:

Implementation Costs:

- Investment - initial costs for the modifications required for each aircraft, plus appropriate spares.
- Lost Time - value of loss of aircraft productivity while out of service during retrofit.

Added Operating Costs:

- Changes in Cash Direct Operating Cost - for the modified aircraft resulting from changes in weight, fuel consumption, and performance caused by the retrofit.
- Lost Productivity - of the modified aircraft resulting from loss of payload and range capability caused by the retrofit weight and fuel consumption changes.

The Implementation Costs represent one-time costs as the direct result of the aircraft modifications. The added Operating Costs represent recurring costs, also directly attributable to the modifications, and extend through the remaining life of each aircraft that is retrofitted.

Evaluation of the costs of proposed noise reduction programs is based on certain specific data derived from retrofit R&D studies currently being conducted under contracts for FAA and NASA. The estimates for retrofit kit costs, installation costs, installation time requirements, weight and fuel consumption changes and other factors identified as contributing to the investment are marginal operating costs of modified airplanes and are derived from the latest information available from these sources.

2.7.1 The Formulation of Present Value

Each of the cost elements of a given program will increase (in current dollars) over the period of time that the total fleet is being retrofitted and returned to service. The change in cash direct operating cost and the lost productivity will continue over the life of each aircraft and gradually decline in total as the modified aircraft in each fleet are retired or disposed of by their present operators (see Figure 2.7-1).

Since each retrofit program entails a particular stream of expenditures over separate periods of time, the various programs are evaluated for comparisons on the basis of a computed "present value" of the total cash flow required over the life cycle of each program. The net cash flow for each program has been developed for both the implementation costs required to produce and install the modifications and the added operating costs which will accumulate during the span of time when the modifications are extant on aircraft in the U.S. fleet. The cumulative net cash flow in current dollars for each program has been converted to present value using a discount rate of 10 percent.

It is important to recognize that in present value formulations, costs (or benefits) are computed on the basis of net cash flow realized, not profits. Thus, for example, depreciation charges need not be computed as an element of recurrent cost. Furthermore, if an expenditure for a capital investment is recognized at the beginning of the project, allowing for depreciation charges would result in double accounting for the same expenditure.

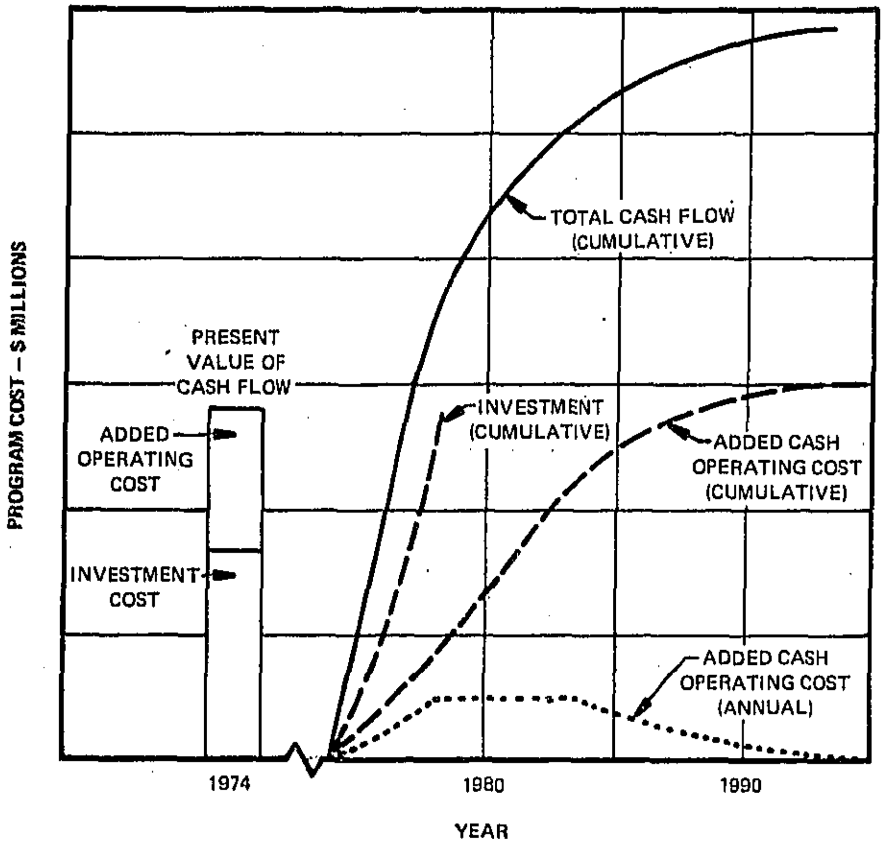

Figure 2.7-1. Noise Retrofit Program Cost Evaluation Method to Define Present Value of Cash Flow

It should be noted that only marginal costs are considered in computation of retrofit program costs for comparison between alternative programs. The comparisons can thus be reviewed separately from any consideration of the method by which noise reduction programs may eventually be financed.

The discount rate of 10 percent has been selected as appropriate considering the rate of return achieved by regulated monopolies, and the target return established by the Civil Aeronautics Board (CAB) for certain classes of airlines. The sensitivity of program cost calculations to choice of discount rate is illustrated in the summary data.

2.7.2 Retrofit Implementation Schedule

The cost computations for all retrofit programs are based on the implementation schedules shown in Figure 2.7-2. These schedules reflect estimates of the time required to develop, demonstrate, certificate, tool-up, produce and install the modifications on all of the candidate aircraft then active in the U.S. fleet.

At this time, the SAM (quiet nacelle) development is essentially complete, with flight-certifiable modifications demonstrated on both JT3D- and JT8D-powered aircraft. The regulatory procedure to require this modification to U.S. carrier fleets has begun with the publication of the associated Notice of Proposed Rule Making on March 27, 1974.[31] The proposed date for total fleet compliance with the modification program is July 1, 1978, allowing for the necessary industry tooling-up period and individual aircraft modifications. For purposes of this study, it was assumed that all civil air carrier aircraft operating from U.S. airports could be modified with SAM (quiet nacelles) by the end of 1978.

The REFAN development program is still underway, with the initial results of ground tests of a 727 and flight tests of a DC-9 due in mid-1975. No development effort is currently underway for the 737 aircraft, which is also powered by the JT8D engine. Assuming this modification program were to be implemented, it was assumed for purposes of this study that all JT8D-powered civil air carrier aircraft operating from U.S. airports could be modified with refanned engines by the end of 1981.

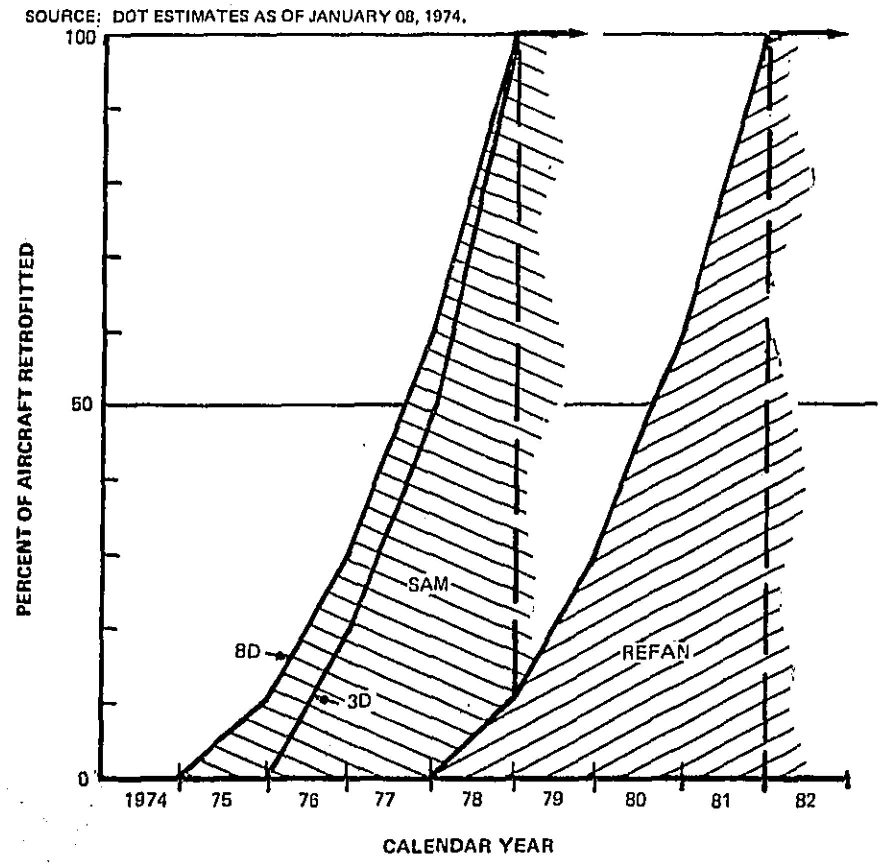

Figure 2.7-2. Noise Retrofit Schedule - Percent of Fleet Completed

Actual modifications were assumed to take place generally over a 4-year period for each program, that is, during the period 1975-78 for the SAM modifications, and 1978-81 for the REFAN modifications. For costing purposes, modifications to the JT8D-powered aircraft were assumed to be completed on a 10, 20, 30 and 40 percent annual completion basis during the 4-year period for both the SAM and REFAN modifications. Because of the fewer numbers of JT3D-powered aircraft and the somewhat longer time which will be required for tooling, the SAM modification of these aircraft was assumed to take place during 1976-78 on a 20, 30 and 50 percent annual completion schedule. These assumptions were used in constructing Figure 2.7-2.

2.7.3 The Retrofitted Fleet

The number of retrofitted aircraft in operation after each program is initiated has been forecast for each type of candidate aircraft. These forecasts have been prepared giving consideration to the known and anticipated plans of the individual carriers operating the candidate aircraft in the U.S. fleet. The rate of retirement or disposition of various aircraft types has been estimated and the number of aircraft forecast to be remaining at the end of each retrofit program, for the five types of aircraft which are candidates for retrofit, has been established.

Figure 2.7-3 shows the history and status of the number of Boeing 707 and 720 aircraft active in the fleets operated by the principal U.S. carriers. It can be seen that this fleet reached a peak in 1969 and has been decreasing since then. The "non-fan" B-707's have decreased most rapidly and are forecast to be completely eliminated from the U.S. fleet prior to the end of the SAM retrofit program. The JT3D-powered B-707's are also forecast to continue decreasing in number through 1978 such that 217 aircraft will survive the retrofit program and be equipped with the SAM modifications. The fleet is forecast to remain stable for 5 years after retrofit, then begin to decrease again until all are eliminated from active service prior to exceeding a 20-year useful life. The dashed line in the figure represents the maximum number of retrofit candidate aircraft that could be in operation assuming a 20-year useful life which is not borne out by historical data.

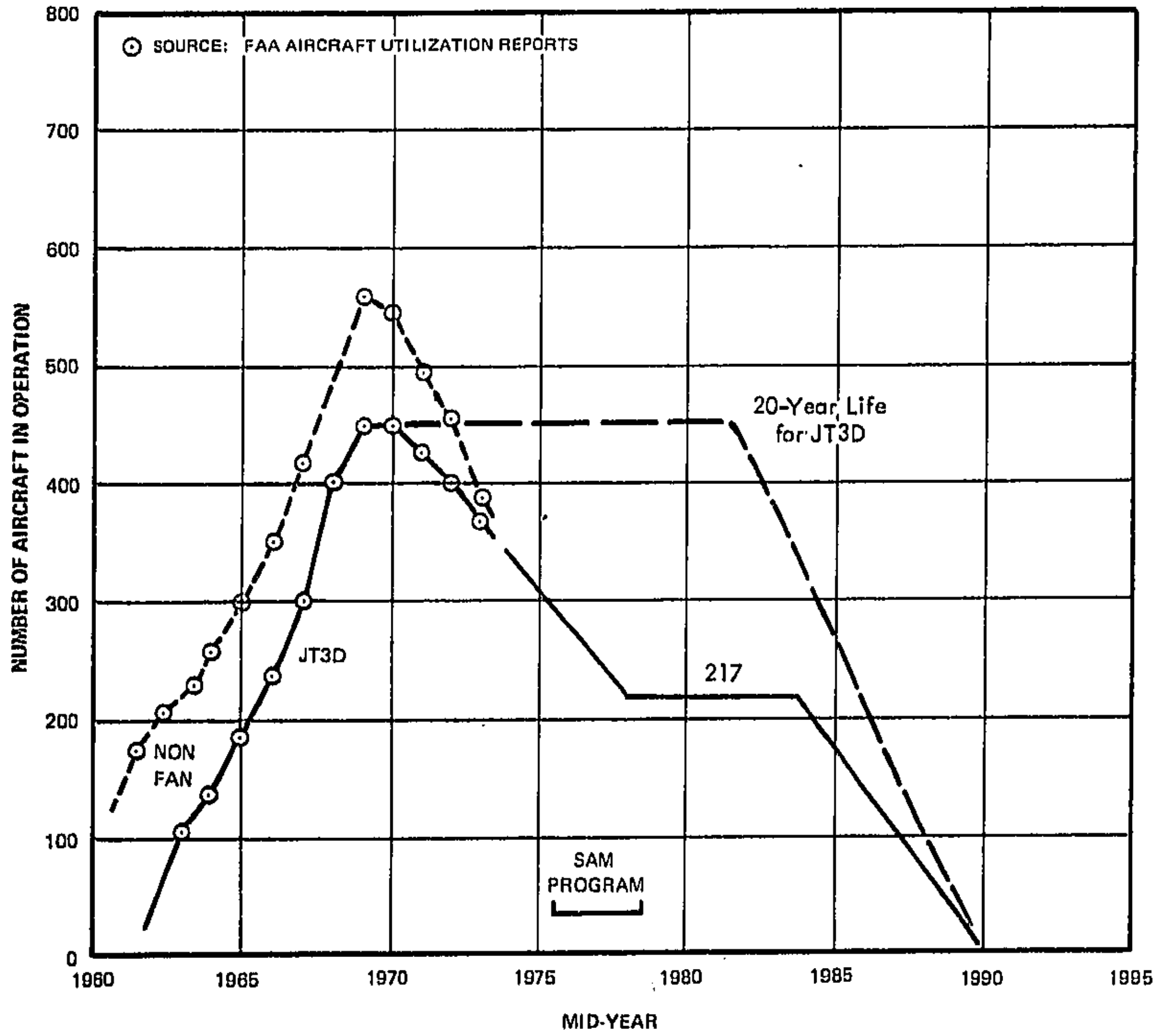

Figure 2.7-3. U.S. Airline Fleet Trends
Boeing 707 and 720

Similar forecasts are shown for the DC-8 fleet in Figure 2.7-4, the B-737 fleet in Figure 2.7-5, the DC-9 fleet in Figure 2.7-6, and the B-727 in Figure 2.7-7. For the B-727 it will be noted that additional aircraft are forecast to be added to this fleet. Those added after 1972 are estimated to have SAM treatment installed when delivered. There will, therefore, be more retrofit candidates for REFAN than for SAM in 1978 since, for purposes of this study, all aircraft of a type are REFAN candidates whether or not they have previously had SAM treatment installed. Despite this, there are fewer REFAN retrofits forecast because the investment per aircraft is 10 times greater and only those aircraft that were less than 15 years old were considered to be worthy candidates.

The number of aircraft of each type forecast to be retrofitted with either SAM or REFAN in each of the years of the established implementation schedule are shown in Table 2.7-1. The number of aircraft of each type and the total of all types forecast for retrofit in any year of the 3- or 4-year programs appear to be reasonably within the manufacturers' production rate capability (barring delays in go-ahead or material lead time).

The number of retrofitted aircraft in operation after each program is initiated is shown for each type of candidate aircraft in Table 2.7-2 for SAM and in Table 2.7-3 for REFAN. These forecasts indicate that 1,530 aircraft would actually receive the SAM retrofits, of which 346 use JT3D engines, and 1,184 use JT8D engines. There would be 1,048 aircraft receiving the REFAN retrofit, of which all use JT8D engines. However, at the end of 1972 (study base year) there were 1,747 potential candidate aircraft, of which 576 used JT3D engines, and 1,171 used JT8D engines.

2.7.4 Retrofit Cost Per Aircraft

The costs to retrofit each of the types of candidate aircraft for quieter operation are summarized in Table 2.7-4. These 1973 costs are the current best estimates from work done by the FAA and NASA R&D contractors. They are weighted averages

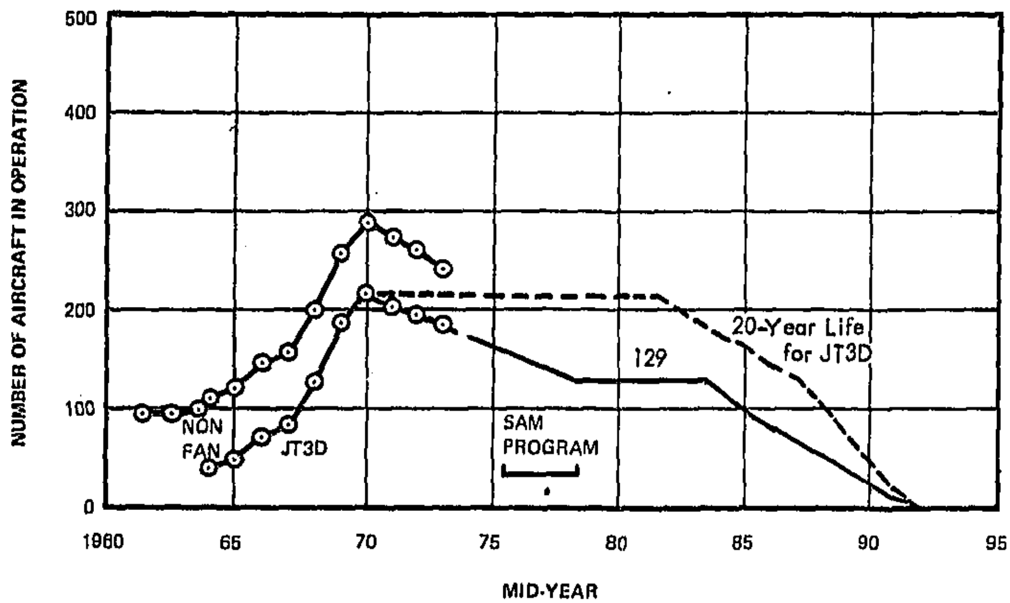

Figure 2.7-4. U.S. Airline Fleet Trends – DC-8

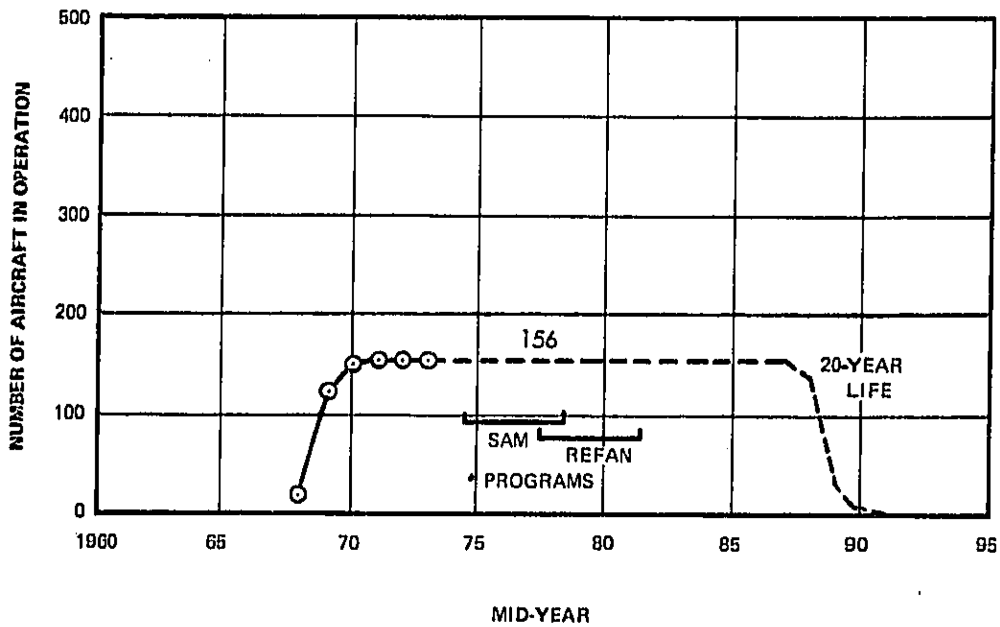

Figure 2.7-5. U.S. Airline Fleet Trends – B-737

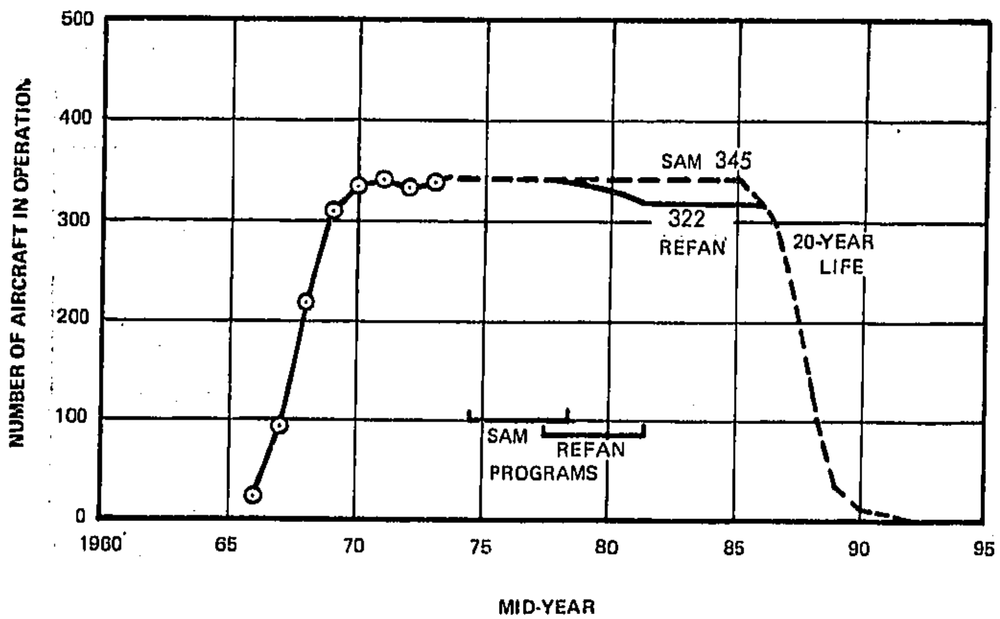

Figure 2.7-6. U.S. Airline Fleet Trends – DC-9

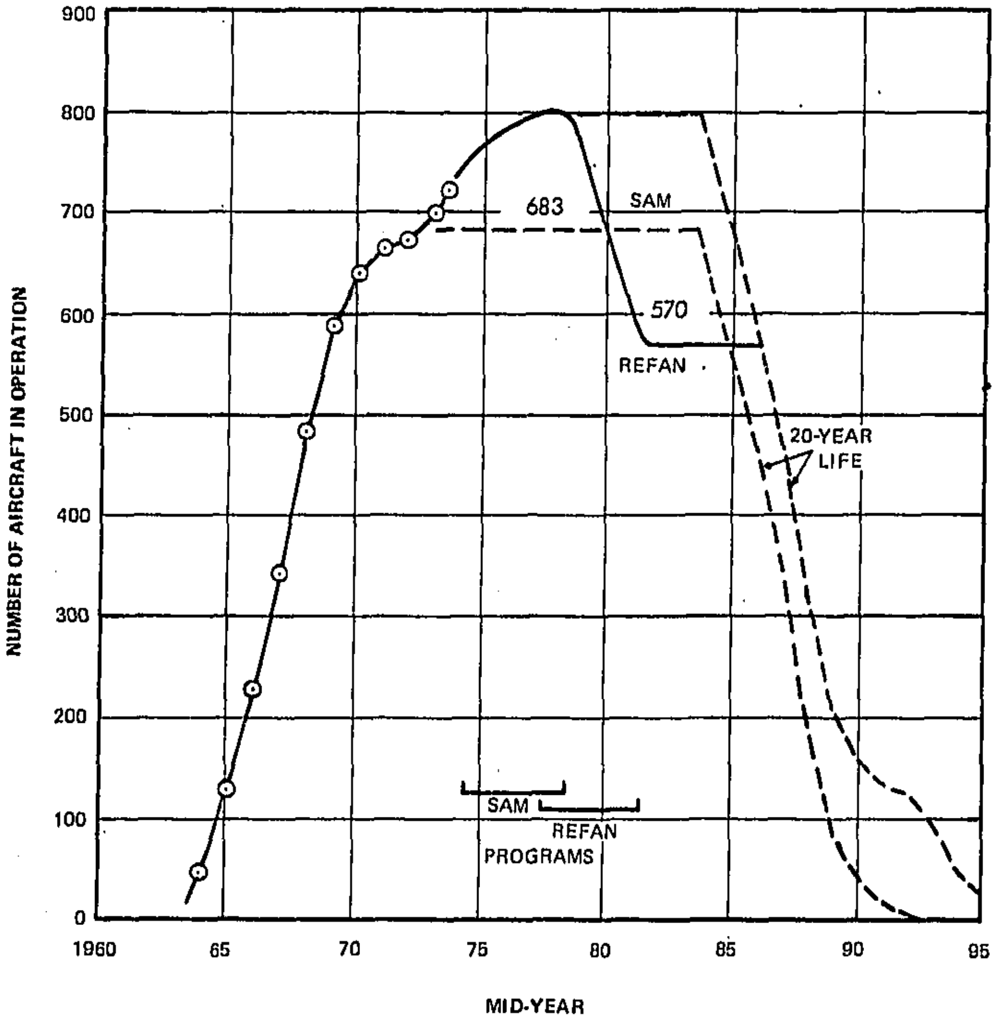

Figure 2.7-7. U.S. Airline Fleet Trends – B-727

Table 2.7-1

Noise Retrofit Schedule - Number of Aircraft Retrofitted

Program	Calendar Year 1975	1976	1977	1978	1979	1980	1981	Totals
SAM:								
B-707	-	43	65	109				217
DC-8	-	26	39	64				129
B-727	68	137	205	273				683
B-737	16	31	47	62				156
DC-9	35	69	103	138				345
TOTALS	119	306	459	646				1,530
REFAN:								
B-727				57	114	171	228	570
B-737				16	31	47	62	156
DC-9				32	64	97	129	322
TOTALS				105	209	315	419	1,048

Source: Schedule - DOT estimate as of January 8, 1974.

Table 2.7-2

Number of Aircraft in Operation with SAM Retrofit

Year	B737	DC-9	B727	B707	DC-8	Totals
1975	8	15	32	-	-	
1976	30	67	135	20	10	
1977	70	155	300	75	45	
1978	120	275	540	160	100	
1979	156	345	683	217	129	1,530
1980	156	345	683	217	129	
1981	156	345	683	217	129	1,530
1982	156	345	683	217	129	
1983	156	345	683	217	129	
1984	156	345	637	200	120	
1985	156	345	553	170	100	
1986	156	322	454	135	85	
1987	156	251	341	105	65	918
1988	138	126	198	70	50	
1989	33	34	94	35	30	
1990	6	10	43	10	15	
1991	1	7	16	0	5	
1992	0	5	10	0	0	
1993	0	0	0	0	0	

Table 2.7-3

Number of Aircraft in Operation
With REFAN Retrofit

Year	B737	DC-9	B727	B707	DC-8	Totals
1978	8	15	27			
1979	30	60	110			
1980	70	140	255			
1981	120	255	450			
1982	156	322	570			1,048
1983	156	322	570			
1984	156	322	570			
1985	156	322	570			
1986	156	322	570			
1987	156	251	458			865
1988	138	126	315			
1989	33	34	211			
1990	6	10	160			
1991	1	7	133			
1992	0	5	127			
1993	0	0	97			
1994	0	0	50			
1995	0	0	27			
1996	0	0	15			
1997	0	0	5			
1998	0	0	0			

Table 2.7-4

Noise Retrofit Investment Costs Per Aircraft-
$ Millions

	Calendar Year							
	1973*	1975	1976	1977	1978	1979	1980	1981
SAM:								
B-707	.90	-	1.10	1.18	1.26			
DC-8	.77	-	.94	1.01	1.08			
B-727	.17	.19	.21	.22	.24			
B-737	.20	.23	.24	.26	.28			
DC-9	.175	.20	.21	.23	.25			
REFAN:								
B-727	1.70				2.38	2.55	2.73	2.92
B-737	1.45				2.03	2.18	2.33	2.49
DC-9	.96				1.35	1.44	1.54	1.65

* DOT Estimate as of April 24, 1974. (1973 dollars)
Installed cost per aircraft, including spares.
Costs escalated at 7 percent per annum.

considering the many variations of aircraft models within the total fleet of each aircraft type. These costs are per aircraft and are intended to include development, production, installation, and spares provisioning. Spares costs are estimated at 6 percent for nacelles and 20 percent for engines.

These investment costs are all of the nonrecurring costs that would normally be capitalized. The investment cost to complete a retrofit installation on the established implementation schedules is forecast to increase at 7 percent per year up to the year of actual installation.

2.7.5 Fleet Investment Cost

The total investment required to accomplish either of the SAM or REFAN programs on the established schedule for all the U.S. aircraft of each type that are forecast to receive retrofit is shown in Figure 2.7-8. The data are shown both in "current dollars" (i.e., the cumulative sum of the investments during each year of the 3- or 4-year implementation schedule) and in "present value" (i.e., the investments in each year discounted from the year incurred back to 1974, at 10 percent per year).

It can be seen that for the B-727 fleet, the required investment in REFAN is about 10.2 times that for SAM when considering the totals for "current dollars" even though fewer 727 aircraft are projected for REFAN modification than for SAM modification. On a "present value" comparison, fleet investment cost for B-727 REFAN is about 7.7 times that for SAM, since the REFAN program is scheduled for 3 years farther into the future.

2.7.6 Lost Time Cost

Consideration has been given to the aircraft operators' "cost" resulting from lost productivity of aircraft during the time when they may be out of service while noise retrofit modifications are installed. The "loss" attributable to retrofit is the excess of estimated out-of-service time beyond 5 days, since it is estimated that favorable scheduling would take advantage of a normal period of refurbishment forecast to occur

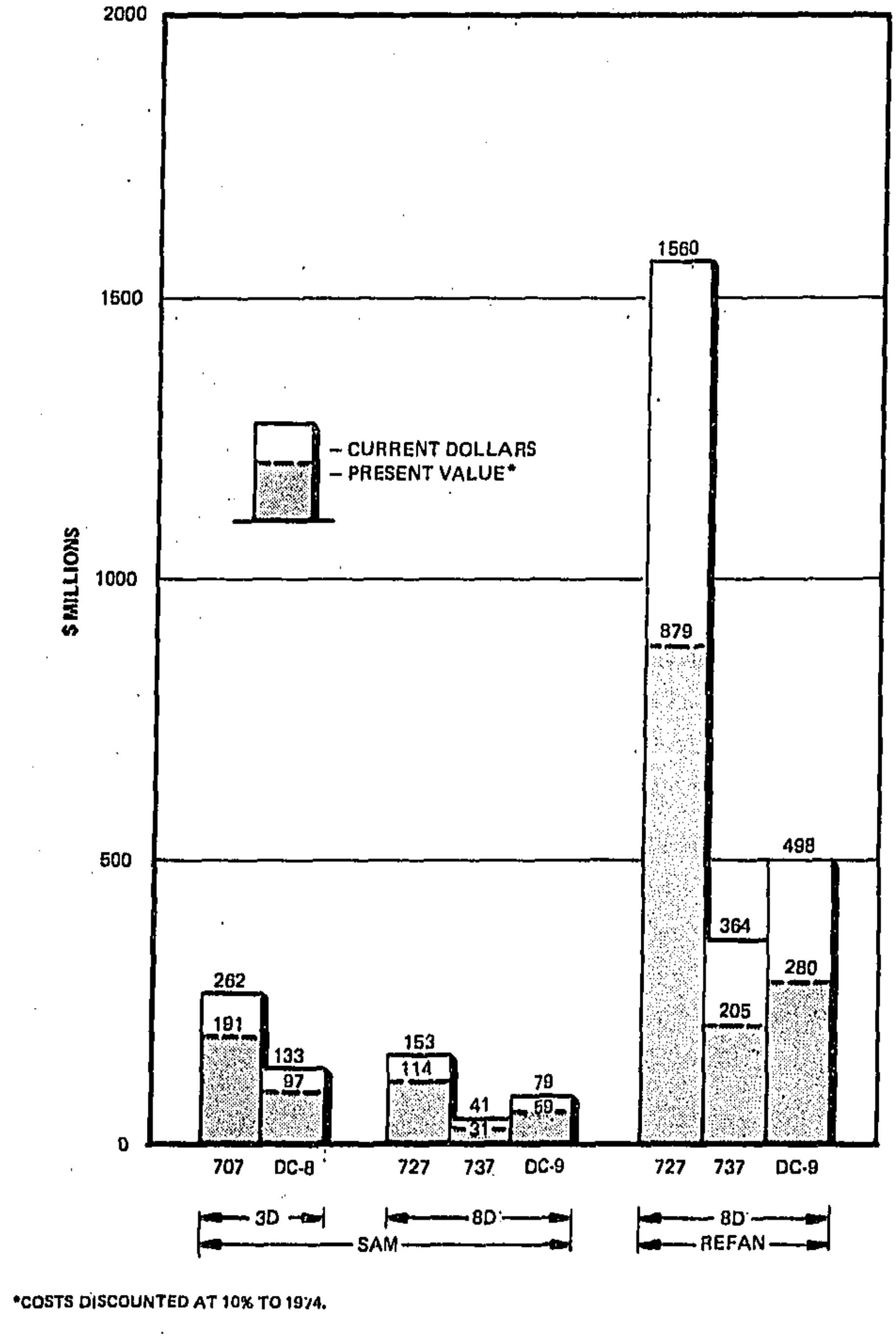

Figure 2.7-8. Noise Retrofit Fleet Investment Cost
(Kits + Installation + Spares)

at least once for each aircraft during the 3 or 4 years over which the retrofit programs would take place. Table 2.7-5 summarizes the lost time and cost estimates used for each aircraft type.

2.7.7 Changes to Cash DOC

Estimates of the change in cash aircraft direct operating costs (DOC) which would result from each type of retrofit for each type aircraft are presented in Table 2.7-6. Cash DOC includes flight crew, fuel/oil, aircraft and engine maintenance and aircraft insurance. Depreciation is not, and need not be, considered as an element of recurring cost, since retrofit programs are being compared on the basis of present value of net cash flow, with investment included as a separate category.

The estimated changes in cash DOC are applied to actual experience (pre-retrofit) hourly cash operating costs for each type aircraft. The trend of total cash DOC for the industry is shown in Figure 2.7-9. The trend of each cost element is shown in Figures 2.7-10 through 2.7-13.

An inflation rate has been applied to each element of the cash DOC to account for forecast increases. The rate applied to each cost element is shown on the respective figure. Fuel costs were also increased sharply to reflect more recent experience. The base year costs (1972) were doubled prior to application of the inflation rate for calculation of future fuel costs. The average annual utilization of each type aircraft has also been forecast to provide the basis for computing the total change in cash DOC for each type aircraft each year they continue to operate after retrofit. (See Figure 2.7-14.)

2.7.8 Lost Productivity

Lost aircraft productivity "cost" has been developed from the estimates of the increase in aircraft operating weight resulting from retrofit as shown in Table 2.7-7, and from the changes in fuel consumption rates shown in Table 2.7-8. The lost productivity cost is computed on the basis of achieving the same total productivity after retrofit

Table 2.7-5

Lost Time and Cost for Aircraft Out of Service During Noise Retrofit

Aircraft	Retrofit Installation Downtime [1/]		Normal Refurbish Downtime [2/]	Retrofit Lost Time		Aircraft Lost Time Cost $/Day [3/]
JT-3D Engines	SAM			SAM		
B-707's	13 days		5 days	8 days		$ 8,300
DC-8's	13 days		5 days	8 days		$ 9,000
JT-8D Engines	SAM	REFAN		SAM	REFAN	
B-727's	1	13 days	5 days	0	8 days	$ 6,900
B-737's	1	9 days	5 days	0	4 days	$ 3,500
DC-9's	1	9 days	5 days	0	4 days	$ 4,900

1/ D.O.T. Estimates as of April 24, 1974 (SAM and REFAN)

2/ At least once during 4-year retrofit period.

3/ Based on airline survey - Rohr Economic Model - April 1972.

Table 2.7-6

Noise Retrofit
Change in Cash Aircraft Operating Costs*
(Percent Increase)

Aircraft	S.A.M. Sound Absorption Material**	REFAN New Front Fan***
JT-3D Engines		
B707's	0.5	-
DC-8's	0.6	-
JT-8D Engines		
B727's	0.1	2.35
B737's	0.2	2.58
DC-9's	0.1	2.52

*Crew, fuel, maintenance and insurance.

Source: **DOT Estimates as of January 8, 1974.
***NASA Estimates as of October, 1973.

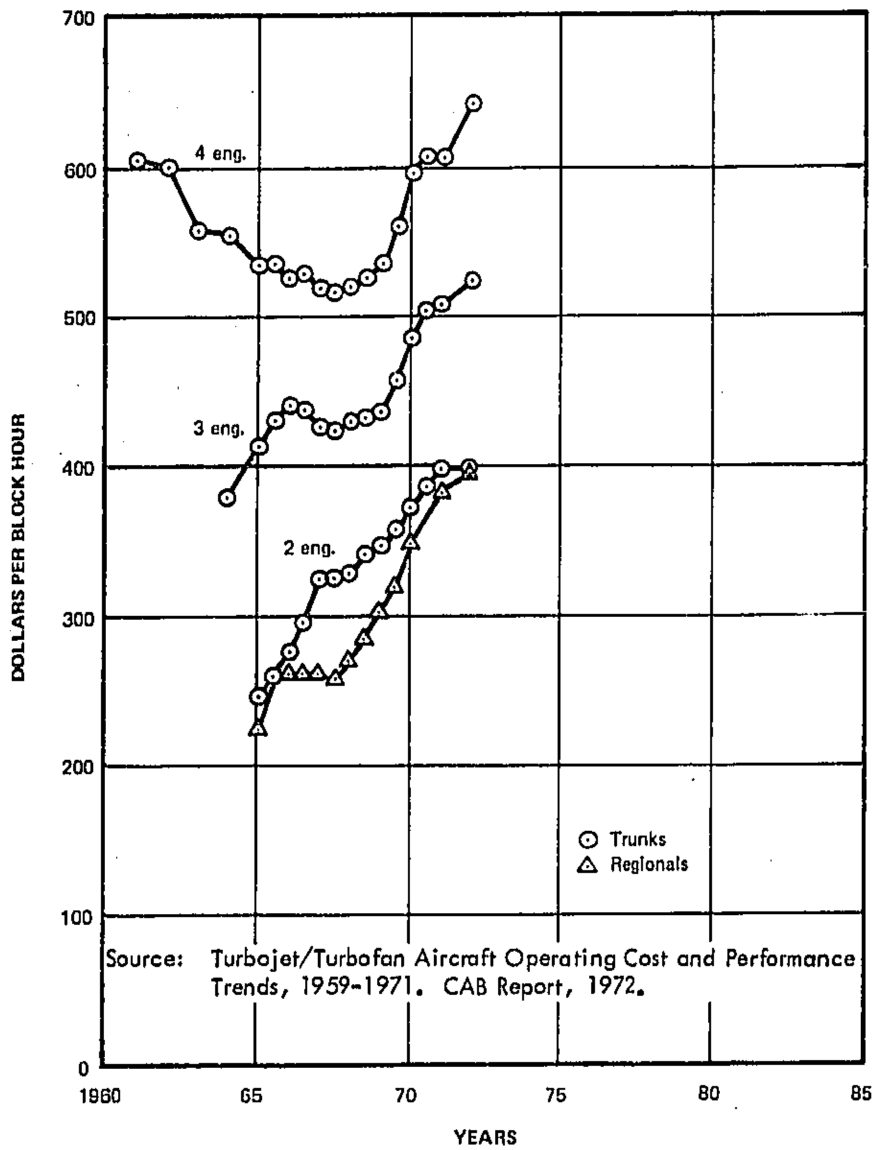

Figure 2.7-9. Aircraft Operating Costs — Cash D.O.C.
Narrow Body Turbofan Aircraft

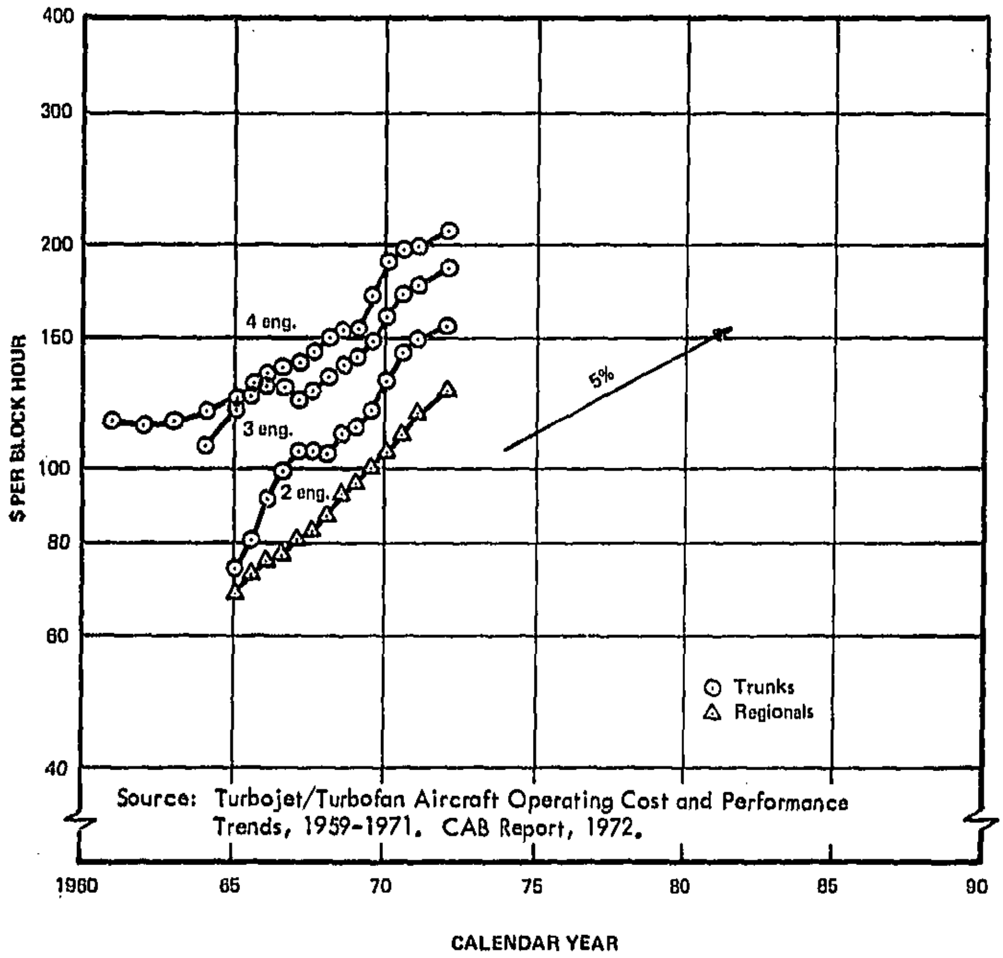

Figure 2.7-10. Flight Crew Costs – Narrow Body Turbofan Aircraft

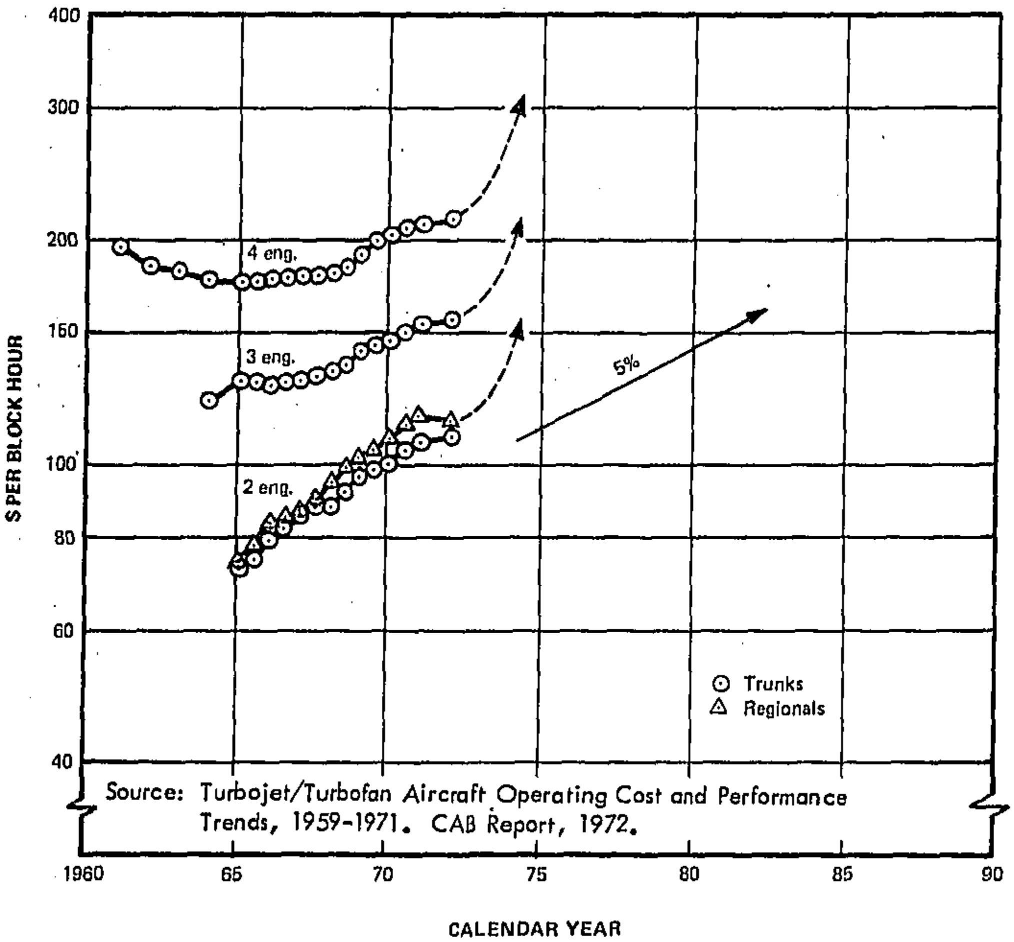

Figure 2.7-11. Fuel Costs – Narrow Body Turbofan Aircraft

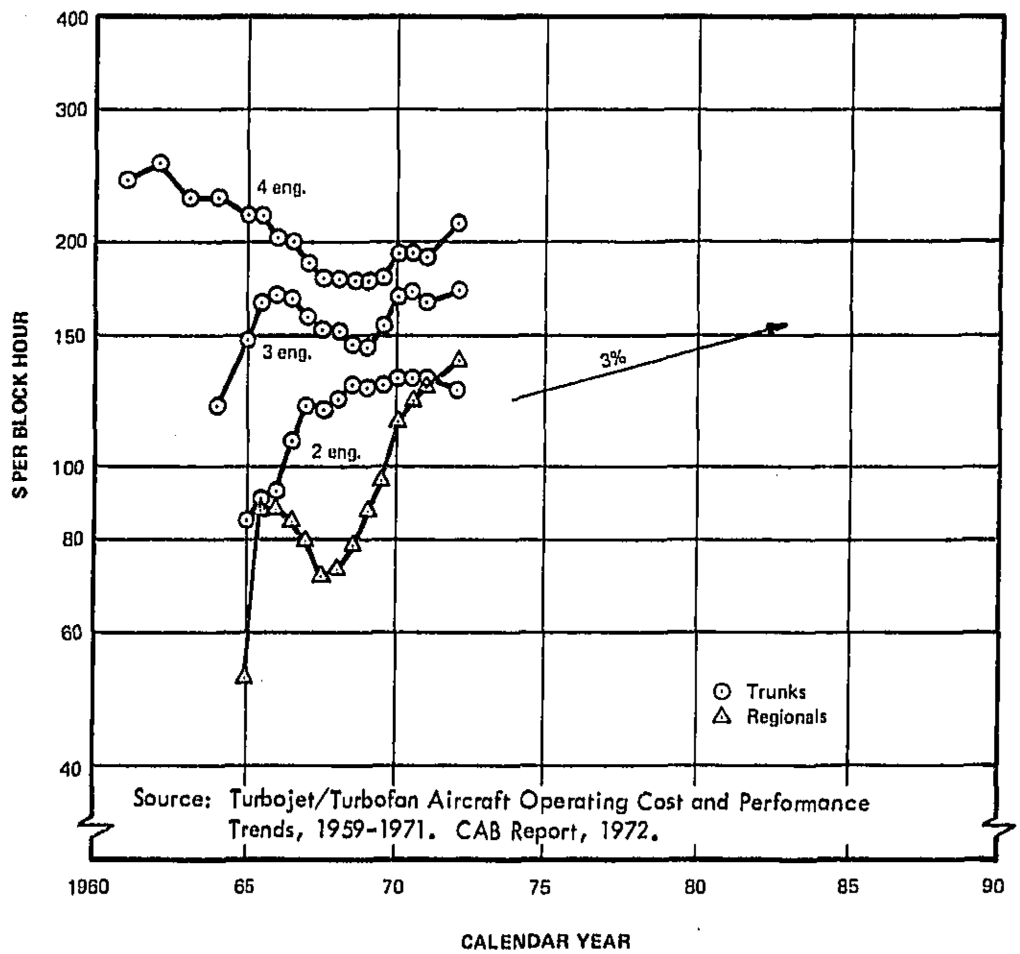

Figure 2.7-12. Maintenance Costs – Narrow Body Turbofan Aircraft

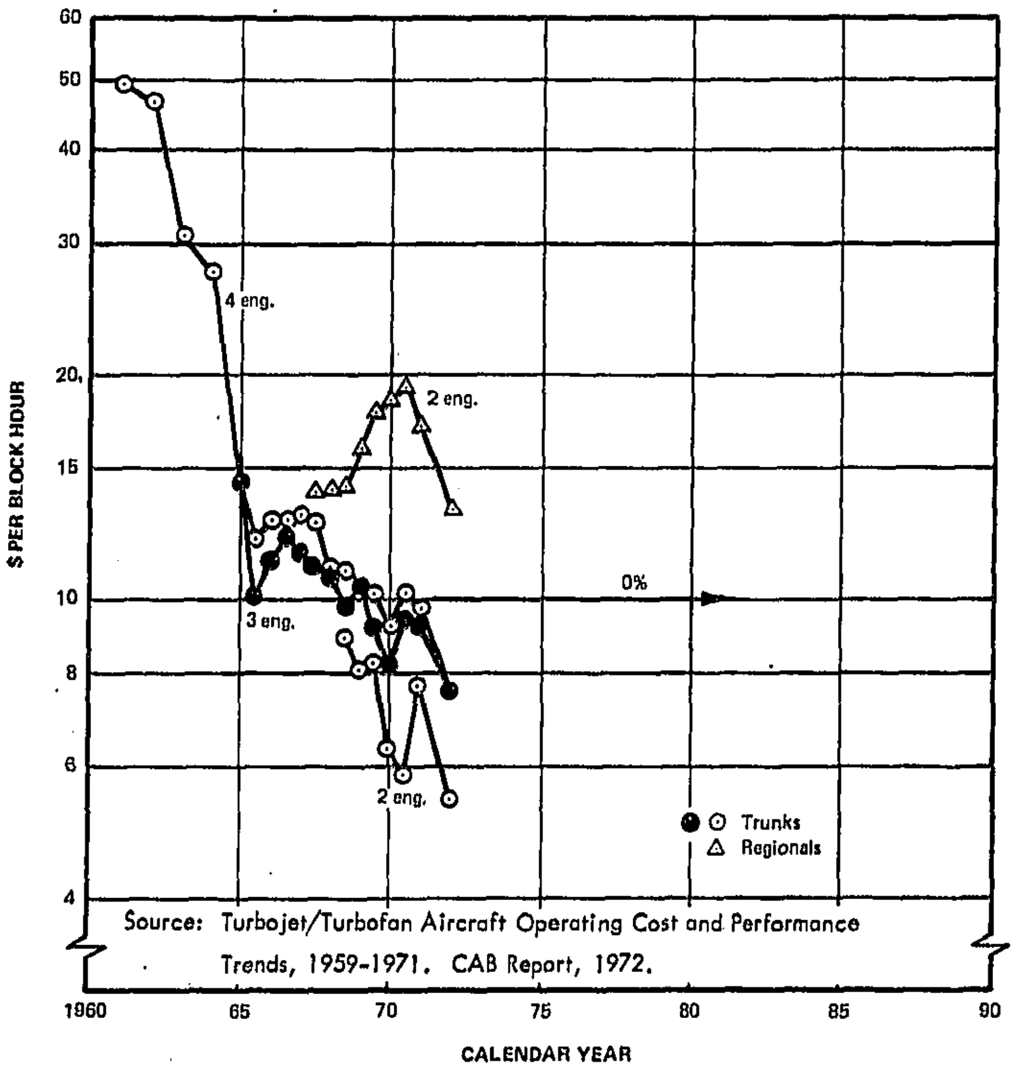

Figure 2.7-13. Insurance Costs — Narrow Body Turbofan Aircraft

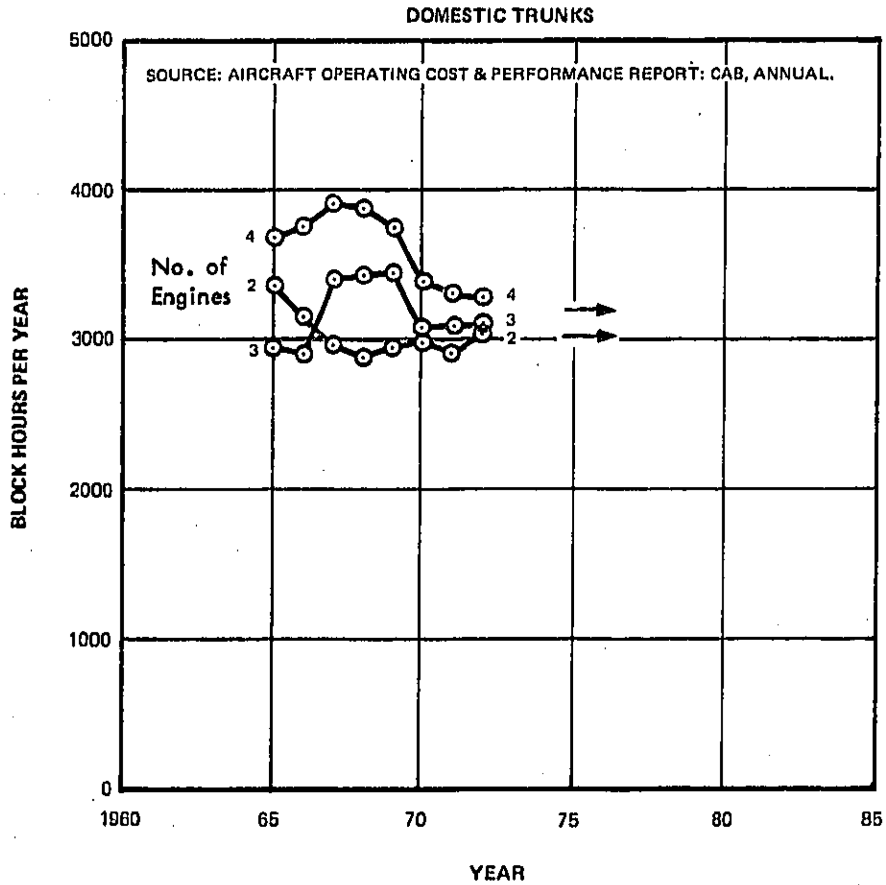

Figure 2.7-14. Annual Aircraft Utilization – Narrow Body Turbofan Aircraft

Table 2.7-7

Noise Retrofit
Change in Aircraft Operating Weight
(Pounds Increase)

Aircraft	SAM Sound Absorption Material	REFAN New Front Fan (3)
JT-3D Engines		
B-707's	3,300 (1)	-
DC-8's	3,300 (1)	-
JT-8D Engines		
B-727's	395 (1)	4,365
B-737's	200 (1)	2,780
DC-9's	200 (2)	2,482

Source: (1) Boeing Estimate as of February 26, 1974.
(2) DOT Estimate as of January 8, 1974.
(3) NASA Estimate as of October, 1973

Table 2.7-8

Noise Retrofit
Change in Aircraft Fuel Consumption
(Percent Increase)

Aircraft	SAM Sound Absorption Material (1)	REFAN New Front Fan (2)
JT-3D Engines		
B707's	0.2	-
DC-8's	0.2	-
JT-8D Engines		
B727's	0.0	2.5
B737's	0.0	2.5
DC-9's	0.0	0.5

Source: (1) DOT Estimates as of January 8, 1974
(2) Estimates based on NASA data as of January 21, 1974.

that was available from the retrofit fleet prior to retrofit. No revenue is "lost"; however, there may be an added cost when the after-retrofit DOC is applied over any added utilization of aircraft necessary to produce the before-retrofit level of fleet productivity. For example, the B-707 is estimated to suffer an operating weight empty (OWE) increase of 3300 pounds and an increase in average fuel requirement of 0.2 percent as a result of SAM retrofit. Both of these effects reduce the productivity potential of the aircraft. In order to achieve as much productivity from B-707's after retrofit, the average aircraft utilization must be increased. The extent of added flying hours required to restore fleet productivity is directly related to the utilization and useful load capacity of the aircraft type. For B-707's again, at an average annual utilization of 3200 hours and 45,000 pound capacity, the required increase would be 260 hours per year if all flights operated at their maximum potential load.

Many flights are operated below limiting weights and have some capacity to accommodate an increase in retrofit OWE or required fuel without reducing payload. The extent of such accommodation, however, has wide variation depending on aircraft type, mission fuel and payload requirements. Figure 2.7-15 has been prepared to summarize the empirical relationship developed to provide a basis for comparative evaluation of this effect. The example on this figure shows the relative lost productivity for B-707's, at the estimated OWE and mission fuel penalties from retrofit, to be 14 percent. Thus 14 percent of the 260 hours, or 36 hours per year, of added utilization will be required to offset the weight and fuel consumption penalties associated with SAM retrofit.

Lost productivity "cost" is evaluated for each type aircraft as the product of any such required increase in utilization in hours/year and the after-retrofit cash DOC in $/hour, cumulated for the number of aircraft forecast to be in operation each year during the life cycle of each program. A sample calculation is shown in Table 4.1-2 (page 4-3).

This recurring cost of added operations required to make up for the lost productivity of retrofit aircraft may not in reality be incurred through increased utilization of the retrofit fleet. Aircraft operators can be expected also to employ such alternatives

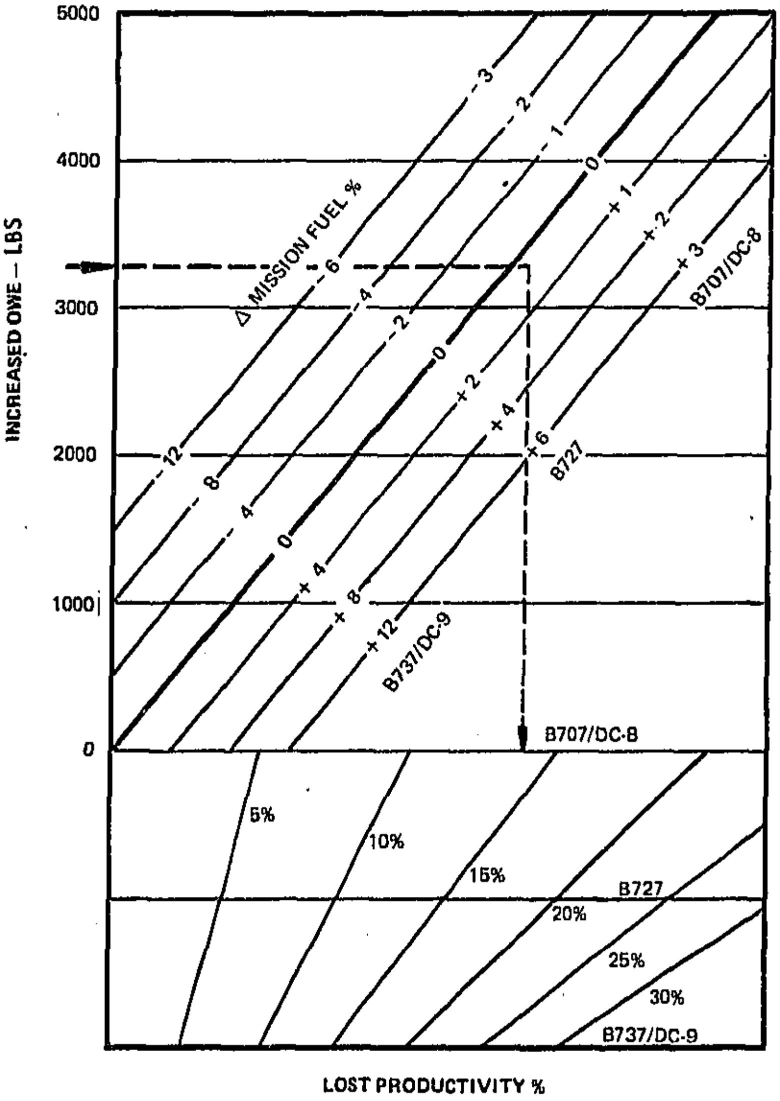

Figure 2.7-15. Lost Productivity (Accountability for Lost Payload) from Changes to OWE and Mission Fuel Due to Retrofit

as use of other additional aircraft, performance recovery programs for the retrofit aircraft, and/or revised operating procedures. In any event, the lost productivity "cost" as evaluated above is intended to be a proxy for all of these alternatives to provide a basis for relative comparisons, between aircraft types and retrofit programs, of the penalties inherent in aircraft weight and fuel consumption increases.

2.8 Cost Effectiveness

2.8.1 Relationship Between Costs and "Benefits"

One of the recurring issues in Systems Analysis is the criterion problem. Only in those rare instances in which benefits can be measured in the same units as the costs incurred can the acceptance or rejection of projects be made with tools prevalent in economic theory without requiring the exercise of judgment. In cases where costs are determinable in monetary units, while "benefits" are specified in different units (i.e., reduced noise impact), the problem is more complicated. If a threshold phenomenon exists (for example, benefits must be at least at a specified level), some relationship between costs and "benefits" are established on an a priori basis. In many instances, however, such relationships do not exist.

The airport noise reduction program seems to fall into this category. Through present value computations, costs can be ascertained for desired levels of effectiveness. However, the judgment of whether a given level of expenditures can be justified by the "benefits" expected depends on the value system of the decision maker and, as such, is beyond the scope of the system analyst.

2.8.2 Transitory Impact of Retrofit

A proper evaluation of both the reduction of noise impact and the cost of achieving it, in any selected program, requires an examination of the changes in effectiveness and cost as they accrue over the life of the program. Each program encompasses a period of implementation and a gradual decline in effectiveness as the subject aircraft are retired. As shown in this study, the baseline noise exposure decreases in future years. This slow decrease in noise impact results from the expected gradual transition to quieter aircraft as present aircraft are retired. The baseline impact reduces even though the volume of aircraft activity is forecast to increase in future years.

If various noise retrofit programs are postulated, the estimated noise impact is significantly reduced at an earlier date and in varying amounts depending on the program or programs implemented. As the modified aircraft in each program are eventually retired, their contribution to reduced noise impact will disappear as each type is phased out. It can also be seen that the later any program is implemented, the less total effect it will have.

2.8.3 Measure of Effectiveness

The selection of a proper measure for effectiveness is by itself a complex conceptual problem. A variety of possible measures (such as percentage reduction in land or people exposed to various levels of noise, or that percentage times the number of years anticipated) have been identified and explored. The measure chosen for this report is best described as the average percent reduction in impact from a baseline criterion over the period of consideration from 1972 to 1987. This measure is graphically displayed in Figure 2.8-1 and Figure 2.8-2. If the baseline criterion is defined as the integral area falling beneath the baseline curve and bounded by the time axis and the years 1972 and 1987, then the average percent reduction over that time period is the percentage of the baseline criterion area falling between the baseline curve and the alternative curve.

Finally, the choice of an appropriate baseline comparator remains. For the purposes of this report, two baseline criteria are used. First, as exemplified by Figure 2.8-1, the results of the analysis for 1972 is considered as the constant baseline value and, hence, this baseline curve is a straight line on the effectiveness graph at the 100 percent level. Second, as exemplified by Figure 2.8-2, the selection of the two-segment approach and the fleet mix changes properly introduce a time-varying baseline corresponding to the time-varying effects of the other alternatives. Results obtained from the use of both baselines are reported.

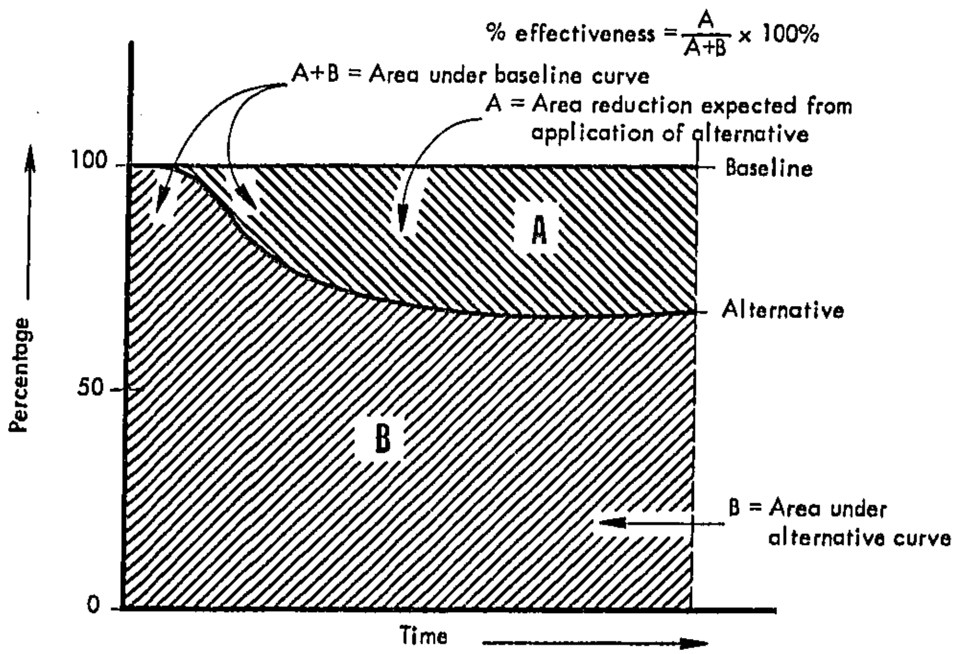

Figure 2.8-1. Example of Measure of Effectiveness with a Constant Baseline.

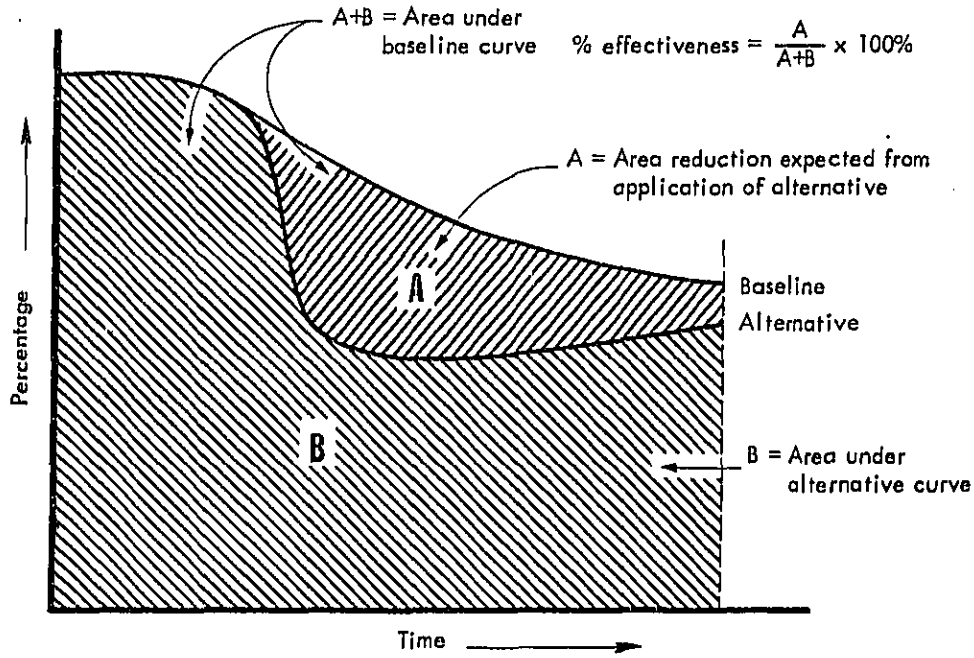

Figure 2.8-2. Example of Measure of Effectiveness with a Time Variant Baseline.

3.0 NOISE IMPACT ANALYSIS

This section presents the results of the analysis of aircraft-generated noise impact for the 23 airports. The data base for this analysis includes a large array of variables which take into consideration the peculiar conditions of each of the 23 facilities. Included are the many operating variables which characterize each airport and also their unique land area impact sensitivity and associated population densities. The various noise abatement alternatives are evaluated in terms of the resultant impact area and population involved. The effectiveness of the alternatives is then presented in terms of changes on impact with time relative to 1972 baseline and to a time-varying baseline. Finally, some general trends in the impact analysis relative to a national model are considered.

3.1 Impacted Land Area and Population

Figure 3.1-1 illustrates a set of computer-generated noise exposure isopleths or contours around an airport. The larger, or outer contour connects the locations around the airport with NEF values of 30, while the inner contour connects locations with NEF values of 40.

To determine the land area impacted for a set of contours such as in Figure 3.1-1, the contours are combined with similar, hand-generated, descriptions of the airport property boundaries and, if any, boundaries of nearby bodies of water. By a direct comparison of the definitions, the area that is within either contour, but not within the airport property boundaries and not located over a body of water, can be found and thus, a definition of the area of impacted land is determined. Figure 3.1-2 illustrates this procedure.

To determine the population residing within (i.e., impacted by) a set of contours such as Figure 3.1-1, again, the contour coordinates are combined with coordinate data on population residing in the vicinity around the airport. The population data are extracted from data tapes generated by the U.S. Bureau of Census for the 1970 census. The data are comprised of coordinate information combined with a count of people corresponding to each coordinate point. The coordinates have been transformed to coincide with the same Cartesian axes used to generate the NEF contours. Each population coordinate is examined to determine whether or not it falls within the confines of the contours. For those points falling within the contours, the corresponding population counts are summed. When all of the population coordinates have been examined, the resulting sum is considered to be the number of people impacted. Figure 3.1-3 illustrates the locations of the population coordinates with respect to the NEF contours in Figure 3.1-1. For the purposes of this study, no attempt was made to forecast population growth for the future years.

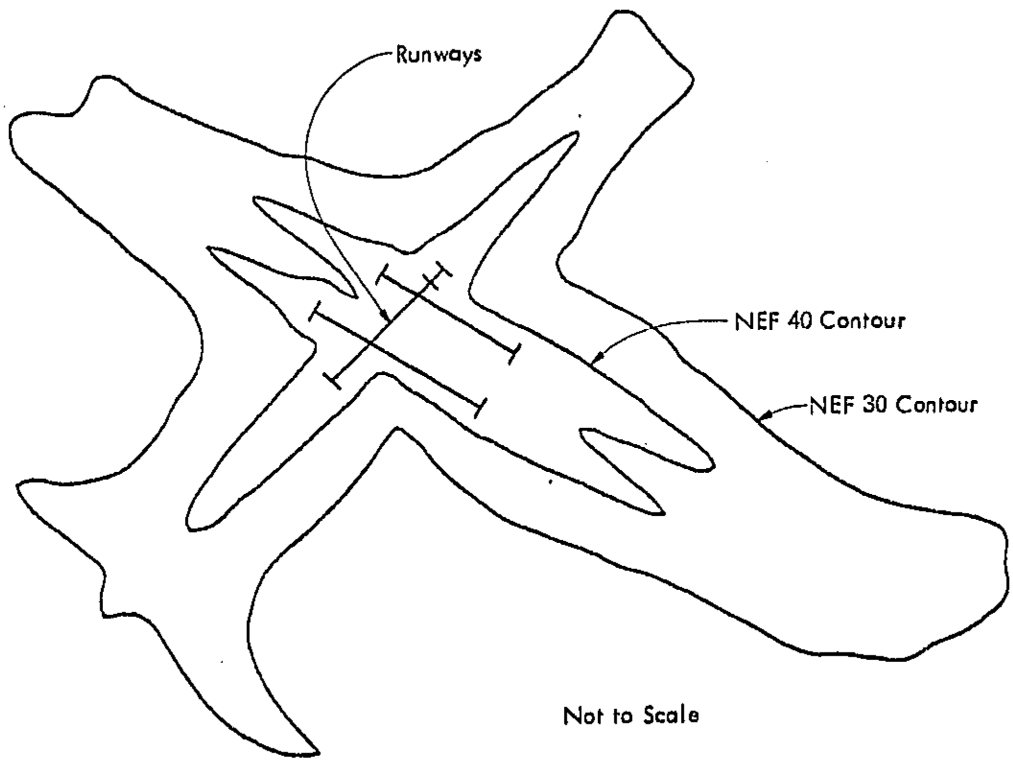

Figure 3.1-1. Example of NEF 30 and NEF 40 Contours

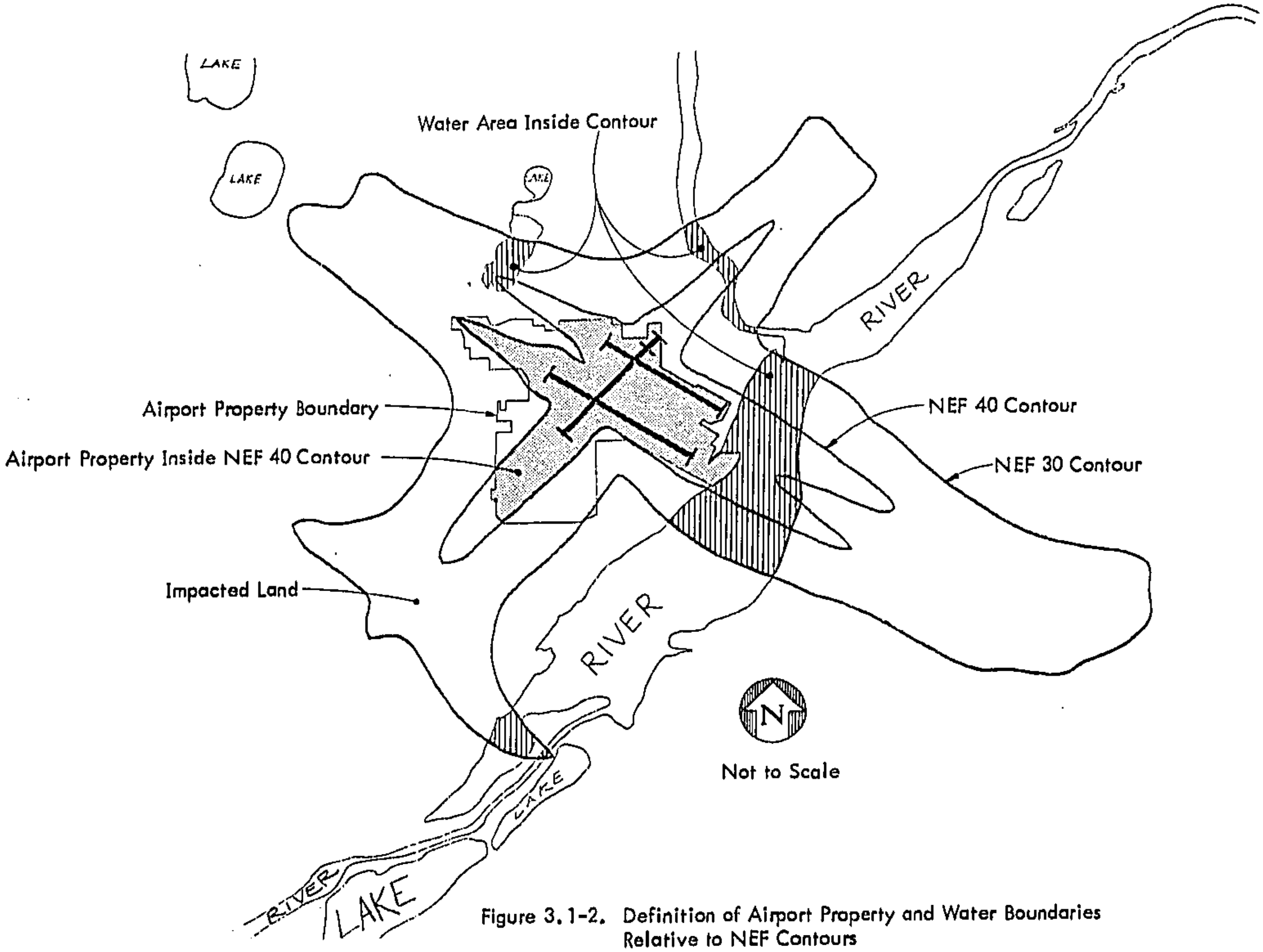

Figure 3.1-2. Definition of Airport Property and Water Boundaries Relative to NEF Contours

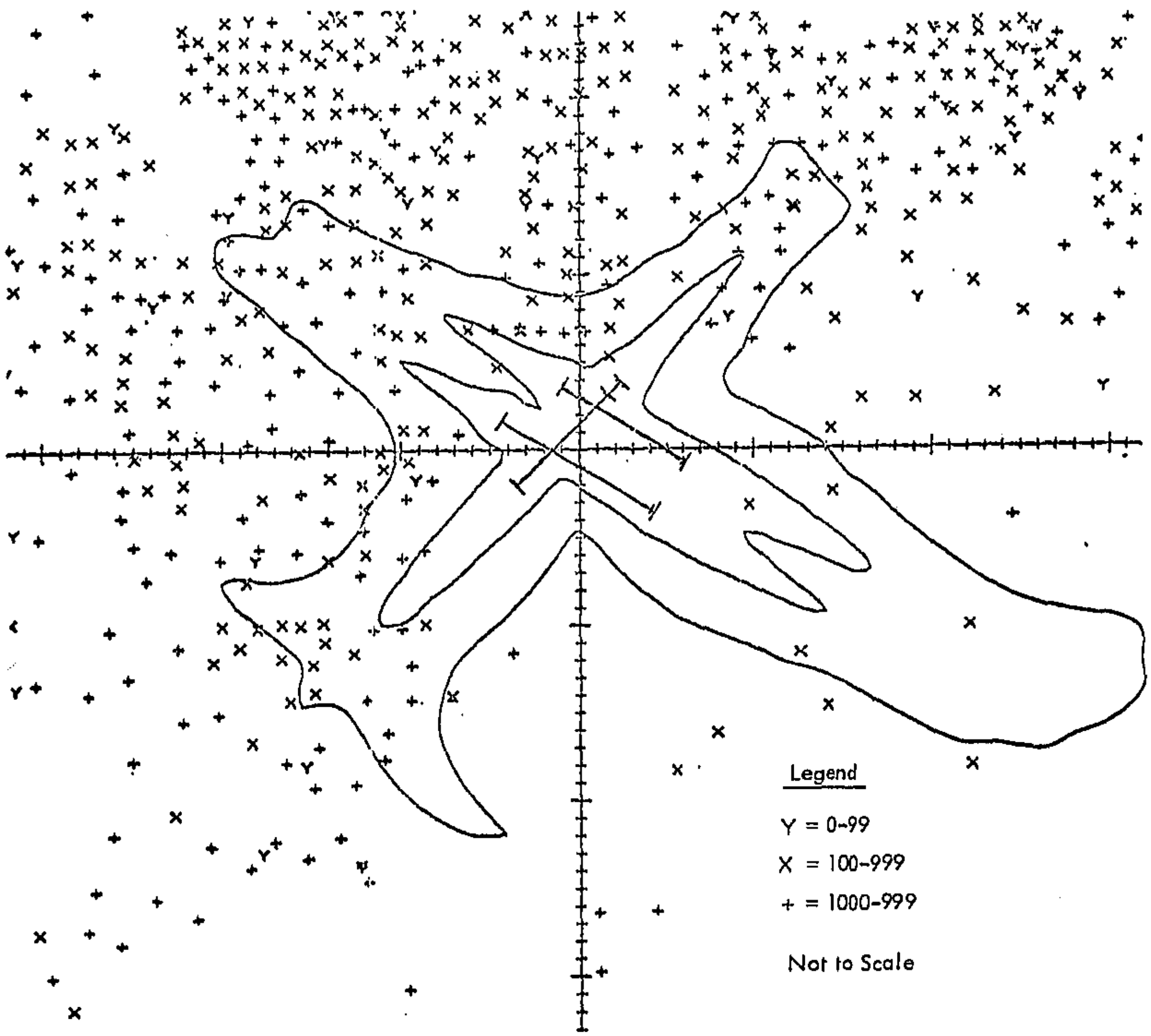

Figure 3.1-3. Definition of Population Centroids in Relation to NEF Contours

Tables 3.1-1 through 3.1-23 reflect the results of the noise impact analysis for all analysis years and alternatives at each of the 23 airports. Also included in each table, for information purposes, is the total area contained within each NEF contour examined. The combined totals for all 23 airports are given in Table 3.1-24. Population values were rounded to the nearest 100 people; land areas were rounded to the nearest whole square mile.

Table 3.1-1. Impact of NEF Contours for Atlanta

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	99.8	27.0	8.7									
6°/3° Glideslope				84.9	19.2	7.1	85.4	19.2	6.5	80.2	39.6	18.7
6°/3° Glideslope SAM 3D and 8D				76.7	15.2	0.8				74.3	33.3	18.7
6°/3° Glideslope SAM 3D, REFAN 8D							38.2	6.5	0	50.7	25.8	8.6

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	107	19	9									
6°/3° Glideslope				75	13	6	78	13	6	69	28	13
6°/3° Glideslope SAM 3D and 8D				63	11	4				60	24	11
6°/3° Glideslope SAM 3D, REFAN 8D							28	6	2	34	16	8

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	101	14	4									
6°/3° Glideslope				69	8	2	72	8	2	63	22	8
6°/3° Glideslope SAM 3D and 8D				57	6	1				54	18	6
6°/3° Glideslope SAM 3D, REFAN 8D							22	2	0	28	11	3

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-2. Impact of NEF Contours for Boston

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	431.3	32.0	5.6									
6°/3° Glideslope				159.2	16.8	3.4	148.8	16.8	2.2	167.8	61.5	18.3
6°/3° Glideslope SAM 3D and 8D				123.7	8.7	0.6				135.5	45.4	10.2
6°/3° Glideslope SAM 3D, REFAN 8D							49.4	2.9	0	59.3	18.2	3.4

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	77	11	4									
6°/3° Glideslope				41	7	3	39	7	3	43	17	8
6°/3° Glideslope SAM 3D and 8D				32	5	2				34	14	6
6°/3° Glideslope SAM 3D, REFAN 8D							14	3	1	17	8	3

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	33	2	0									
6°/3° Glideslope				15	1	1	13	1	1	16	5	2
6°/3° Glideslope SAM 3D and 8D				11	0	0				13	4	1
6°/3° Glideslope SAM 3D, REFAN 8D							3	1	0	5	2	0

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-3. Impact of NEF Contours for Buffalo

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	113.8	9.7	1.7									
6°/3° Glideslope				25.9	1.7	0.9	25.9	1.7	0.9	25.9	9.9	3.3
6°/3° Glideslope SAM 3D and 8D				17.4	0.9	0.3				17.4	8.4	0.9
6°/3° Glideslope SAM 3D, REFAN 8D							8.4	0.9	0	8.4	0.9	0.7

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	39	4	2									
6°/3° Glideslope				11	2	1	11	2	1	11	5	2
6°/3° Glideslope SAM 3D and 8D				8	1	0				8	3	1
6°/3° Glideslope SAM 3D, REFAN 8D							4	1	0	4	2	1

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	38	3	1									
6°/3° Glideslope				10	1	0	10	1	0	10	4	1
6°/3° Glideslope SAM 3D and 8D				7	0	0				7	2	0
6°/3° Glideslope SAM 3D, REFAN 8D							3	1	0	3	1	0

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-4. Impact of NEF Contours for Chicago-Midway

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	38.5	1.8	1.0									
6°/3° Glideslope				74.4	14.5	1.8	80.2	14.5	1.8	88.5	42.7	16.3
6°/3° Glideslope SAM 3D and 8D				66.6	8.6	1.8				77.9	38.8	12.0
6°/3° Glideslope SAM 3D, REFAN 8D							13.9	0.8	0	16.9	4.3	1.8

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	7	1	0									
6°/3° Glideslope				13	3	1	14	3	1	15	7	3
6°/3° Glideslope SAM 3D and 8D				11	2	1				13	6	3
6°/3° Glideslope SAM 3D, REFAN 8D							3	0	0	3	1	1

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	6	0	0									
6°/3° Glideslope				12	2	0	13	2	0	14	6	2
6°/3° Glideslope SAM 3D and 8D				10	1	0				12	5	2
6°/3° Glideslope SAM 3D, REFAN 8D							2	0	0	2	0	0

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-5. Impact of NEF Contours for Chicago-O'Hare

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	771.7	66.6	28.7									
6°/3° Glideslope				300.5	34.1	8.1	249.2	25.8	8.1	216.7	70.1	24.0
6°/3° Glideslope SAM 3D and 8D				156.6	10.3	0.5				108.7	29.8	7.1
6°/3° Glideslope SAM 3D, REFAN 8D							62.9	7.1	0.3	62.9	20.4	4.0

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	183	31	14									
6°/3° Glideslope				85	17	9	74	15	8	68	30	14
6°/3° Glideslope SAM 3D and 8D				56	11	6				46	20	10
6°/3° Glideslope SAM 3D, REFAN 8D							33	8	3	34	15	8

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	173	22	7									
6°/3° Glideslope				75	9	3	64	8	2	58	21	7
6°/3° Glideslope SAM 3D and 8D				46	4	1				36	11	3
6°/3° Glideslope SAM 3D, REFAN 8D							23	2	0	24	7	2

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-6. Impact of NEF Contours for Cleveland

ALTERNATIVE	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	128.7	11.2	4.1									
6°/3° Glideslope				59.1	9.5	2.9	57.8	9.5	2.9	57.6	14.1	9.5
6°/3° Glideslope SAM 3D and 8D				41.3	4.3	0				41.3	11.4	4.3
6°/3° Glideslope SAM 3D, REFAN 8D							12.1	0	0	11.4	6.3	2.9

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	39	5	2									
6°/3° Glideslope				22	4	2	21	4	2	21	8	4
6°/3° Glideslope SAM 3D and 8D				16	3	1				17	6	3
6°/3° Glideslope SAM 3D, REFAN 8D							6	1	0	7	3	1

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	37	3	1									
6°/3° Glideslope				20	3	1	19	3	1	19	6	3
6°/3° Glideslope SAM 3D and 8D				14	2	0				15	4	2
6°/3° Glideslope SAM 3D, REFAN 8D							4	0	0	5	2	0

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-7. Impact of NEF Contours for Denver

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	180.3	28.3	10.9									
6°/3° Glideslope				182.1	27.0	11.4	183.2	27.0	12.4	192.9	87.1	27.0
6°/3° Glideslope SAM 3D and 8D				144.9	19.5	5.4.				173.3	65.4	25.0
6°/3° Glideslope SAM 3D, REFAN 8D							59.4	8.8	1.1	72.9	25.8	12.4

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	41	7	3									
6°/3° Glideslope				35	6	3	35	6	3	37	15	6
6°/3° Glideslope SAM 3D and 8D				25	4	2				31	12	5
6°/3° Glideslope SAM 3D, REFAN 8D							11	2	1	13	6	3

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	35	5	2									
6°/3° Glideslope				30	4	2	30	4	2	32	11	3
6°/3° Glideslope SAM 3D and 8D				20	2	1				26	9	3
6°/3° Glideslope SAM 3D, REFAN 8D							7	1	0	9	.3	2

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-8. Impact of NEF Contours for Dulles International

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	3.5	0	0									
6°/3° Glideslope				3.5	0	0	4.7	0	0	4.7	0	0
6°/3° Glideslope SAM 3D and 8D				0	0	0				4.7	0	0
6°/3° Glideslope SAM 3D, REFAN 8D							0	0	0	0	0	0

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	24	5	2									
6°/3° Glideslope				22	4	2	35	6	3	43	17	7
6°/3° Glideslope SAM 3D and 8D				17	3	1				35	13	5
6°/3° Glideslope SAM 3D, REFAN 8D							9	1	1	11	5	2

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	13	0	0									
6°/3° Glideslope				10	0	0	22	1	0	30	6	0
6°/3° Glideslope SAM 3D and 8D				6	0	0				22	4	0
6°/3° Glideslope SAM 3D, REFAN 8D							2	0	0	3	0	0

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-9. Impact of NEF Contours for John F. Kennedy International

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	507.3	111.5	41.9									
6°/3° Glideslope				261.3	38.2	9.4	161.6	25.9	3.4	142.7	55.0	22.3
6°/3° Glideslope SAM 3D and 8D				210.9	24.8	3.8				106.0	35.3	7.8
6°/3° Glideslope SAM 3D, REFAN 8D							78.6	6.6	0	75.3	26.9	5.1

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	188	31	13									
6°/3° Glideslope				103	18	8	62	11	5	51	21	10
6°/3° Glideslope SAM 3D and 8D				82	14	6				41	16	7
6°/3° Glideslope SAM 3D, REFAN 8D							30	6	3	28	12	6

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	53	11	3									
6°/3° Glideslope				27	3	0	18	1	0	14	4	2
6°/3° Glideslope SAM 3D and 8D				19	2	0				11	4	0
6°/3° Glideslope SAM 3D, REFAN 8D							7	0	0	6	1	0

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-10. Impact of NEF Contours for La Guardia

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	1057.0	17.1	0									
6°/3° Glideslope				764.2	10.3	0	704.6	8.7	0	680.4	58.9	7.6
6°/3° Glideslope SAM 3D and 8D				637.4	7.6	0				578.7	43.5	7.6
6°/3° Glideslope SAM 3D, REFAN 8D							26.1	0	0	19.5	1.9	0

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	43	6	2									
6°/3° Glideslope				35	5	2	33	5	2	32	11	5
6°/3° Glideslope SAM 3D and 8D				31	4	2				28	10	4
6°/3° Glideslope SAM 3D, REFAN 8D							8	2	1	7	3	2

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	33	2	0									
6°/3° Glideslope				28	1	0	25	1	0	24	5	1
6°/3° Glideslope SAM 3D and 8D				24	1	0				20	3	1
6°/3° Glideslope SAM 3D, REFAN 8D							3	0	0	3	0	0

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-11. Impact of NEF Contours for Los Angeles

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	293.4	51.1	28.8									
6°/3° Glideslope				81.4	15.8	1.6	75.6	14.0	1.6	70.4	32.7	13.6
6°/3° Glideslope SAM 3D and 8D				59.9	7.3	0.2				56.1	17.4	3.3
6°/3° Glideslope SAM 3D, REFAN 8D							33.6	3.3	0.2	37.4	12.7	3.3

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	97	21	10									
6°/3° Glideslope				51	11	5	46	10	4	42	20	9
6°/3° Glideslope SAM 3D and 8D				37	7	3				35	16	7
6°/3° Glideslope SAM 3D, REFAN 8D							24	7	2	26	12	5

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	28	7	3									
6°/3° Glideslope				10	1	1	9	2	0	8	4	2
6°/3° Glideslope SAM 3D and 8D				7	1	0				8	3	1
6°/3° Glideslope SAM 3D, REFAN 8D							4	2	0	5	1	1

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-12. Impact of NEF Contours for Miami

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	260.0	29.7	6.4									
6°/3° Glideslope				229.9	25.4	6.4	207.6	23.3	6.4	189.1	77.5	21.6
6°/3° Glideslope SAM 3D and 8D				179.9	11.3	0.6				163.2	53.8	9.9
6°/3° Glideslope SAM 3D, REFAN 8D							79.8	5.9	0	82.6	27.2	7.1

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	69	14	6									
6°/3° Glideslope				59	12	5	54	11	5	48	21	10
6°/3° Glideslope SAM 3D and 8D				43	9	3				39	17	9
6°/3° Glideslope SAM 3D, REFAN 8D							21	5	2	22	11	5

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	52	10	2									
6°/3° Glideslope				44	8	2	41	7	2	36	16	6
6°/3° Glideslope SAM 3D and 8D				34	5	1				30	13	5
6°/3° Glideslope SAM 3D, REFAN 8D							16	1	0	17	7	2

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-13 Impact of NEF Contours for Minneapolis-St. Paul

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	96.7	8.8	0.3									
6°/3° Glideslope				69.9	0.3	0.3	75.4	3.3	0.3	82.3	22.9	5.6
6°/3° Glideslope SAM 3D and 8D				60.8	0.3	0				77.9	19.5	3.3
6°/3° Glideslope SAM 3D, REFAN 8D							32.4	0.3	0	43.5	14.3	0.3

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	31	7	3									
6°/3° Glideslope				24	5	2	26	5	2	28	13	6
6°/3° Glideslope SAM 3D and 8D				21	4	2				26	12	5
6°/3° Glideslope SAM 3D, REFAN 8D							14	3	1	17	9	4

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	24	3	1									
6°/3° Glideslope				18	1	0	20	1	0	21	7	2
6°/3° Glideslope SAM 3D and 8D				15	1	0				19	6	1
6°/3° Glideslope SAM 3D, REFAN 8D							8	1	0	11	4	1

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-14. Impact of NEF Contours for Newark

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	431.9	27.5	7.1									
6°/3° Glideslope				284.7	29.5	8.3	181.0	19.2	7.1	257.0	66.9	27.3
6°/3° Glideslope SAM 3D and 8D				139.1	6.5	0				119.0	25.7	4.6
6°/3° Glideslope SAM 3D, REFAN 8D							42.2	3.1	0	52.0	15.2	3.1

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	100	12	5									
6°/3° Glideslope				79	12	5	57	9	4	74	26	11
6°/3° Glideslope SAM 3D and 8D				42	6	3				39	14	6
6°/3° Glideslope SAM 3D, REFAN 8D							17	3	1	20	9	4

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	86	8	3									
6°/3° Glideslope				66	9	3	46	6	2	60	20	8
6°/3° Glideslope SAM 3D and 8D				33	4	1				31	10	4
6°/3° Glideslope SAM 3D, REFAN 8D							12	1	0	15	7	2

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-15. Impact of NEF Contours for New Orleans

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	32.5	8.9	6.1									
6°/3° Glideslope				28.9	7.4	2.5	30.5	8.9	2.5	32.7	18.2	8.9
6°/3° Glideslope SAM 3D and 8D				25.4	7.1	0				30.2	15.8	7.9
6°/3° Glideslope SAM 3D, REFAN 8D							15.8	2.5	0	18.2	10.5	6.1

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	34	6	3									
6°/3° Glideslope				23	5	2	28	5	2	33	11	6
6°/3° Glideslope SAM 3D and 8D				17	4	1				25	9	5
6°/3° Glideslope SAM 3D, REFAN 8D							10	2	1	12	6	3

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	26	3	1									
6°/3° Glideslope				16	3	1	21	3	1	25	8	4
6°/3° Glideslope SAM 3D and 8D				13	2	0				19	6	3
6°/3° Glideslope SAM 3D, REFAN 8D							7	0	0	9	3	1

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-16. Impact of NEF Contours for Philadelphia

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	76.9	0.3	0									
6°/3° Glideslope				68.9	0.3	0	71.1	0.3	0	81.1	18.1	0.3
6°/3° Glideslope SAM 3D and 8D				52.3	0	0				64.1	8.9	0
6°/3° Glideslope SAM 3D, REFAN 8D							5.6	0	0	9.6	0.3	0

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	36	8	4									
6°/3° Glideslope				34	6	3	35	6	3	39	17	7
6°/3° Glideslope SAM 3D and 8D				28	5	2				34	14	6
6°/3° Glideslope SAM 3D, REFAN 8D							13	3	1	14	6	3

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	18	2	1									
6°/3° Glideslope				17	2	0	17	1	0	21	6	2
6°/3° Glideslope SAM 3D and 8D				13	2	0				17	4	2
6°/3° Glideslope SAM 3D, REFAN 8D							4	0	0	4	1	0

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-17. Impact of NEF Contours for Phoenix

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	20.5	6.2	1.4									
6°/3° Glideslope				21.1	2.2	0	25.3	3.6	0	28.5	14.1	3.6
6°/3° Glideslope SAM 3D and 8D				15.0	0	0				21.3	11.2	0.5
6°/3° Glideslope SAM 3D, REFAN 8D							11.2	0	0	14.1	0.5	0

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	13	3	1									
6°/3° Glideslope				11	2	1	14	3	1	15	7	3
6°/3° Glideslope SAM 3D and 8D				9	1	1				12	6	2
6°/3° Glideslope SAM 3D, REFAN 8D							5	1	0	6	2	0

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	10	2	0									
6°/3° Glideslope				8	0	0	11	1	0	12	4	1
6°/3° Glideslope SAM 3D and 8D				6	0	0				9	3	0
6°/3° Glideslope SAM 3D, REFAN 8D							2	0	0	3	0	0

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-18. Impact of NEF Contours for Portland

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	1.2	0.3	0									
6°/3° Glideslope				0.9	0	0	0.9	0	0	0.9	0.3	0
6°/3° Glideslope SAM 3D and 8D				0.3	0	0				0.9	0.3	0
6°/3° Glideslope SAM 3D, REFAN 8D							0	0	0	0.3	0	0

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	20	4	1									
6°/3° Glideslope				12	2	0	12	2	1	15	7	3
6°/3° Glideslope SAM 3D and 8D				9	1	0				13	6	2
6°/3° Glideslope SAM 3D, REFAN 8D							3	1	0	4	2	1

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	11	1	0									
6°/3° Glideslope				6	1	0	6	0	0	8	2	0
6°/3° Glideslope SAM 3D and 8D				3	0	0				7	2	0
6°/3° Glideslope SAM 3D, REFAN 8D							0	0	0	1	1	0

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-19. Impact of NEF Contours for San Diego

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	77.3	24.0	3.3									
6°/3° Glideslope				63.6	5.3	0.7	76.6	26.7	3.9	79.1	49.2	30.4
6°/3° Glideslope SAM 3D and 8D				55.0	3.0	0				64.0	39.1	21.0
6°/3° Glideslope SAM 3D, REFAN 8D							40.9	0.7	0	42.5	21.0	0.7

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	18	3	1									
6°/3° Glideslope				13	2	1	20	3	2	23	9	4
6°/3° Glideslope SAM 3D and 8D				10	1	0				16	6	2
6°/3° Glideslope SAM 3D, REFAN 8D							5	1	0	6	3	1

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	12	2	1									
6°/3° Glideslope				8	1	1	13	2	2	11	6	3
6°/3° Glideslope SAM 3D and 8D				7	1	0				9	5	1
6°/3° Glideslope SAM 3D, REFAN 8D							3	1	0	4	2	1

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-20. Impact of NEF Contours for San Francisco

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	124.4	11.4	2.3									
6°/3° Glideslope				90.7	11.4	2.3	70.4	11.4	2.3	62.2	15.7	8.1
6°/3° Glideslope SAM 3D and 8D				48.6	3.3	1.4				41.6	14.3	3.3
6°/3° Glideslope SAM 3D, REFAN 8D							25.3	2.3	0	23.1	9.2	2.3

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	76	13	6									
6°/3° Glideslope				56	10	5	45	9	4	41	17	8
6°/3° Glideslope SAM 3D and 8D				32	6	2				31	12	5
6°/3° Glideslope SAM 3D, REFAN 8D							21	4	2	21	9	4

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	22	1	1									
6°/3° Glideslope				21	2	1	15	1	0	12	4	2
6°/3° Glideslope SAM 3D and 8D				8	1	0				7	2	0
6°/3° Glideslope SAM 3D, REFAN 8D							5	0	0	5	1	0

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-21. Impact of NEF Contours for Seattle

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	123.2	17.3	3.4									
6°/3° Glideslope				79.0	8.3	1.3	79.6	7.5	1.3	79.6	28.1	7.5
6°/3° Glideslope SAM 3D and 8D				65.6	1.3	0.2				68.7	16.7	2.7
6°/3° Glideslope SAM 3D, REFAN 8D							19.9	1.3	0.2	24.2	6.2	1.3

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	47	8	4									
6°/3° Glideslope				31	5	2	31	5	2	31	12	5
6°/3° Glideslope SAM 3D and 8D				22	3	1				24	9	4
6°/3° Glideslope SAM 3D, REFAN 8D							9	2	1	10	5	2

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	42	6	2									
6°/3° Glideslope				27	3	0	27	3	0	27	9	3
6°/3° Glideslope SAM 3D and 8D				19	1	0				21	6	2
6°/3° Glideslope SAM 3D, REFAN 8D							6	1	0	7	3	0

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-22. Impact of NEF Contours for St. Louis

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	100.0	8.5	1.7									
6°/3° Glideslope				72.3	6.4	1.7	77.0	7.6	3.0	90.0	30.0	8.5
6°/3° Glideslope SAM 3D and 8D				65.4	3.9	1.2				85.0	30.0	8.5
6°/3° Glideslope SAM 3D, REFAN 8D							36.5	7.6	1.2	54.7	15.9	6.4

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	30	5	2									
6°/3° Glideslope				22	4	2	24	5	2	29	12	5
6°/3° Glideslope SAM 3D and 8D				19	3	1				27	11	5
6°/3° Glideslope SAM 3D, REFAN 8D							13	3	2	17	7	3

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	28	3	1									
6°/3° Glideslope				20	2	1	22	3	1	27	10	3
6°/3° Glideslope SAM 3D and 8D				17	2	0				25	9	3
6°/3° Glideslope SAM 3D, REFAN 8D							11	2	1	15	5	2

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-23. Impact of NEF Contours for Washington National

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	24.4	0	0									
6°/3° Glideslope				15.2	0.9	0	12.8	0.9	0	8.8	0.9	0.9
6°/3° Glideslope SAM 3D and 8D				6.2	0.9	0				6.2	0.9	0.9
6°/3° Glideslope SAM 3D, REFAN 8D							0.9	0	0	0.9	0	0

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	14	2	1									
6°/3° Glideslope				11	2	1	11	2	1	9	4	2
6°/3° Glideslope SAM 3D and 8D				10	2	1				8	4	2
6°/3° Glideslope SAM 3D, REFAN 8D							4	1	0	4	2	1

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	7	0	0									
6°/3° Glideslope				5	0	0	5	0	0	3	1	0
6°/3° Glideslope SAM 3D and 8D				5	0	0				3	1	0
6°/3° Glideslope SAM 3D, REFAN 8D							1	0	0	0	0	0

(c) Impacted Land Area Inside Contour - Square Miles

Table 3.1-24. Impact of NEF Contours for 23 Airports.

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	4994.3	499.2	163.4									
6°/3° Glideslope				3021.6	284.5	70.1	2685.2	275.8	66.6	2719.1	813.5	283.3
6°/3° Glideslope SAM 3D and 8D				2249.0	144.8	16.8				2116.0	564.9	159.5
6°/3° Glideslope SAM 3D, REFAN 8D							693.1	60.6	3.0	780.4	264.1	69.5

(a) Total Population Inside Contour - Thousands of People

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	1333	226	98									
6°/3° Glideslope				868	157	71	805	147	67	817	335	151
6°/3° Glideslope SAM 3D and 8D				640	110	45				642	260	115
6°/3° Glideslope SAM 3D, REFAN 8D							305	66	25	337	154	71

(b) Total Area Inside Contour - Square Miles

ALTERNATIVE	YEAR 1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	888	110	34									
6°/3° Glideslope				562	65	19	539	60	16	551	187	65
6°/3° Glideslope SAM 3D and 8D				394	38	5				421	134	40
6°/3° Glideslope SAM 3D, REFAN 8D							155	16	1	184	62	17

(c) Impacted Land Area Inside Contour - Square Miles

3.2 Effectiveness Analysis

Analysis of the effectiveness of the alternative strategies in this study requires consideration of time-varying characteristics inherent in their application. One of these characteristics is the time required to physically perform the modification on the candidate aircraft in the fleet. The retrofit schedules for the installation of sound absorbing material (SAM) in the engine nacelles for the JT3D and JT8D engines and for the installation of refanned engines on JT8D-powered aircraft are discussed in Section 2.7.2 and graphically illustrated in Figure 2.7-2. Briefly reiterated, these schedules are: (1) for JT3D-powered aircraft, the SAM treatment is forecast to begin in calendar year 1976 and to be completed on a 20%-30%-50% annual basis encompassing 3 years (1976-78); (2) for the JT8D-powered aircraft, the SAM treatment to begin in 1975 and be completed on a 10%-20%-30%-40% annual basis encompassing 4 years (1975-78), and the REFAN treatment would begin in 1978 and follow the same percentage completion schedule as the JT8D/SAM treatment over a 4-year period (1978-81). Thus, the years chosen for analysis cover a baseline year (1972), the year that the SAM treatment, if implemented, is forecast to be completed (1978), the year that the REFAN program, if implemented, is forecast to be completed (1981), and a future year to be used to indicate trends (1987). For purposes of this study, the two-segment approach procedure, 6°/3°, is assumed to be in effect for all but the year 1972 and to be used in conjunction with any retrofit alternative considered.

The summaries of the total noise impact on land area and population for the 23 airports, combined, are contained in Tables 3.2-1 and 3.2-2 respectively. Each table is divided into three sections. Section (a) contains the summation of the individual impact values at 23 airports for the NEF 30 and NEF 40 noise levels and for each of the alternatives in each of the years considered. Section (b) reflects the percentage of the 1972 baseline values for each of the cases. Similarly, Section (c) contains the percent reduction in impact from the corresponding 1972 baseline values.

Using Section (b) of these tables, time-effectiveness graphs can be constructed as illustrated in Figures 3.2-1, -2, -3, and -4. For these figures, straight lines are

Table 3.2-1

Impacted Land Area Inside NEF Contours for 23 Airports

(a) Impacted Area Inside Contour – Square Miles

	Year							
	1972		1978		1981		1987	
	30	40	30	40	30	40	30	40
Baseline	888	110						
6°/3° Glideslope			562	65	539	60	551	65
6°/3° Glideslope SAM 3D and 8D			394	38			421	40
6°/3° Glideslope SAM 3D, REFAN 8D					155	16	184	17

(b) Percent of 1972 Baseline

	Year							
	1972		1978		1981		1987	
Alternative	30	40	30	40	30	40	30	40
Baseline	100	100						
6°/3° Glideslope			63	59	61	55	62	59
6°/3° Glideslope SAM 3D and 8D			44	35			47	36
6°/3° Glideslope SAM 3D, REFAN 8D					17	15	21	15

(c) Percent Reduction from 1972 Baseline

	Year							
	1972		1978		1981		1987	
Alternative	30	40	30	40	30	40	30	40
Baseline	0	0						
6°/3° Glideslope			37	41	39	45	38	41
6°/3° Glideslope SAM 3D and 8D			56	65			53	64
6°/3° Glideslope SAM 3D, REFAN 8D					83	85	79	85

Table 3.2-2

Population Inside NEF Contours for 23 Airports

(a) Total Population Inside Contour – Thousands of People

Alternative	Year							
	1972		1978		1981		1987	
	30	40	30	40	30	40	30	40
Baseline	4994.3	499.2						
6°/3° Glideslope			3021.6	284.5	2685.2	275.8	2719.1	283.3
6°/3° Glideslope SAM 3D and 8D			2249.0	144.8			2116.0	159.5
6°/3° Glideslope SAM 3D, REFAN 8D					693.1	60.6	780.4	69.5

(b) Percent of 1972 Baseline

Alternative	Year							
	1972		1978		1981		1987	
	30	40	30	40	30	40	30	40
Baseline	100	100						
6°/3° Glideslope			61	57	54	55	54	57
6°/3° Glideslope SAM 3D and 8D			45	29			42	32
6°/3° Glideslope SAM 3D, REFAN 8D					14	12	16	14

(c) Percent Reduction from 1972 Baseline

Alternative	Year							
	1972		1978		1981		1987	
	30	40	30	40	30	40	30	40
Baseline	0	0						
6°/3° Glideslope			39	43	46	45	46	43
6°/3° Glideslope SAM 3D and 8D			55	71			58	68
6°/3° Glideslope SAM 3D, REFAN 8D					86	88	84	86

used to connect the data points available from the study. Obviously, nature does not change abruptly, as these figures would imply, and faired curves should be drawn through the data points. The proper curvatures are subject to considerable speculation and disagreement; therefore, for purposes of this report, only straight lines are displayed to avoid unintentional biasing of the comparisons. The "curves" on these graphs demonstrate the time-varying relative effectiveness of each of the alternatives considered. It can be seen, for instance, in Figure 3.2-1, that the projected changes in fleet mix and fleet operations along with the assumed adoption of the 6°/3° approach procedure achieve a certain measure of effectiveness in the year 1978, are slightly more effective in 1981, but show a slight upward (i.e., less effective) trend by 1987. This upward trend is also reflected in the other two alternatives. Figures 3.2-2, -3, and -4, to a varying degree, demonstrate similar trends with the exception of the SAM 3D/8D option in Figure 3.2-3. This particular curve demonstrates a slight downward (i.e., more effective) trend from 1978 to 1987. In analyzing the 23 airports individually, to determine the cause of this seeming peculiarity, it was found that eight of the airports indicate an increasing trend in effectiveness for this option. Further examination reveals that if Kennedy and either of La Guardia, O'Hare, or Newark are deleted from the analysis, the curve would demonstrate the opposite trend. This analysis serves to point out that even though the data base for this study is large, the use of the results must still be tempered with caution.

The time-varying effectiveness of the alternatives, particularly the SAM 3D/8D and SAM 3D/RFN 8D options, is also demonstrated in Figures 3.2-1, -2, -3, and -4. This can be observed most readily by considering their start points. The start of the SAM 3D/8D option begins at year-end 1974, while the start of the SAM 3D/RFN 8D option begins 1 year later. The completions of the two programs are separated by 3 years due to the offset implementation schedule for "refanning" the JT8D-powered aircraft. Thus, it can be seen that the SAM 3D/8D alternative is more effective in the earlier years, while the SAM 3D/RFN 8D option becomes more effective later on. This "offset" in effectiveness tends to complicate the determination of the best alternative.

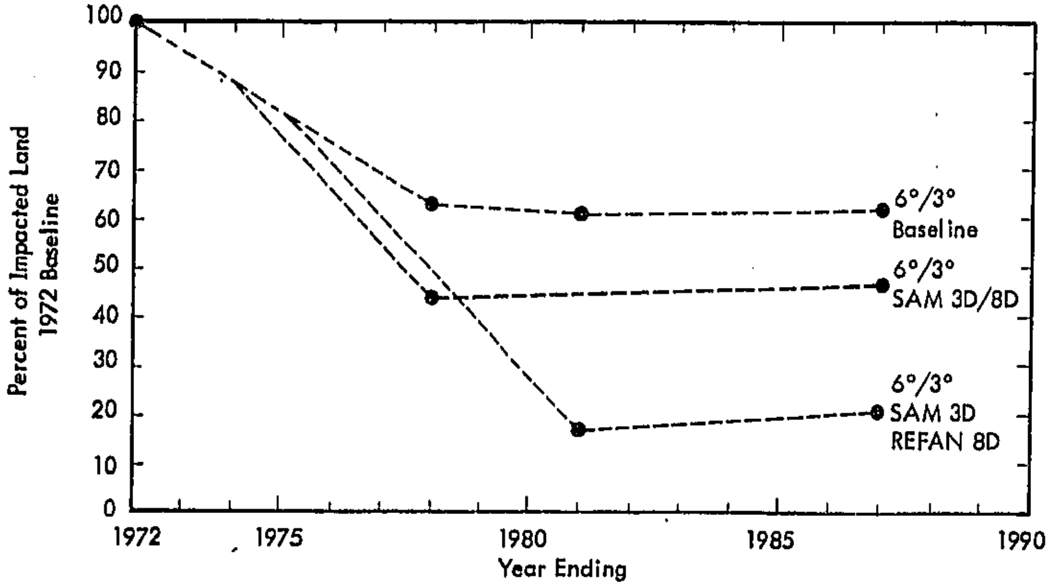

Figure 3.2-1. Cumulative Effectiveness Curves for One Baseline and Two Alternatives at 23 Airports Regarding Impacted Land Within NEF 30 Contours

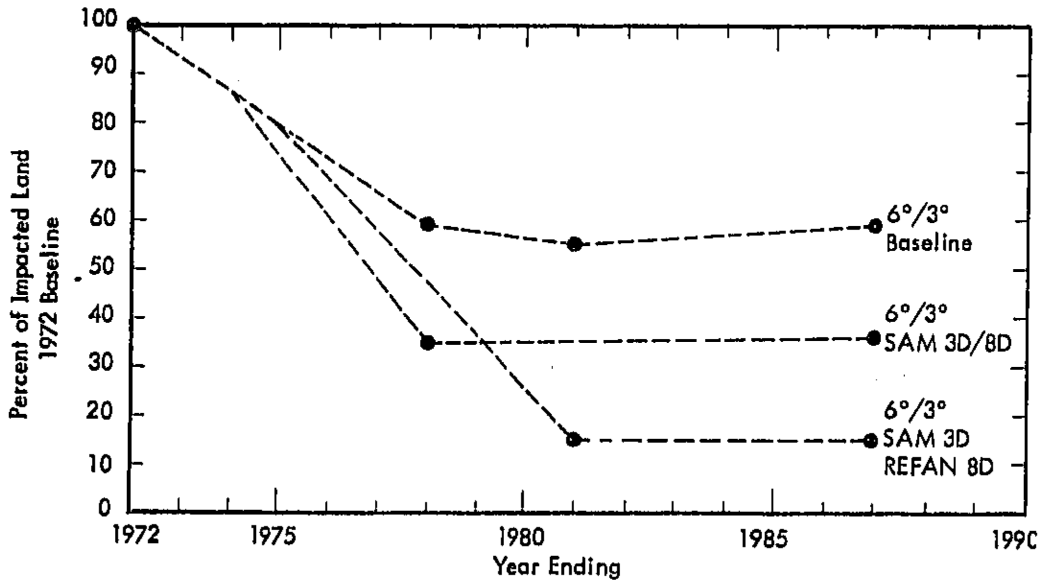

Figure 3.2-2. Cumulative Effectiveness Curves for One Baseline and Two Alternatives at 23 Airports Regarding Impacted Land Within NEF 40 Contours

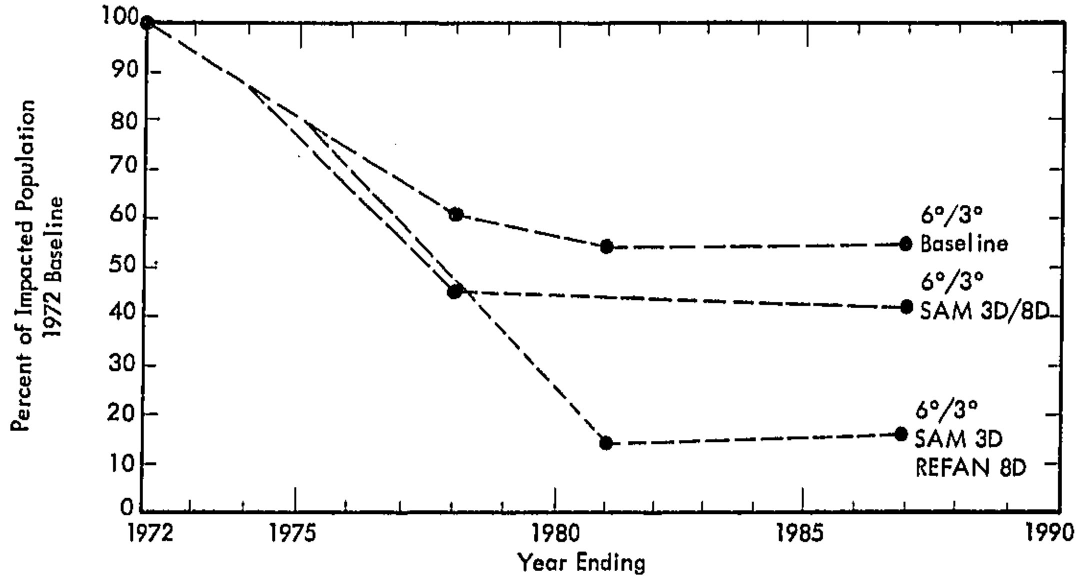

Figure 3.2-3. Cumulative Effectiveness Curves for One Baseline and Two Alternatives at 23 Airports Regarding Impacted Population within NEF 30 Contours

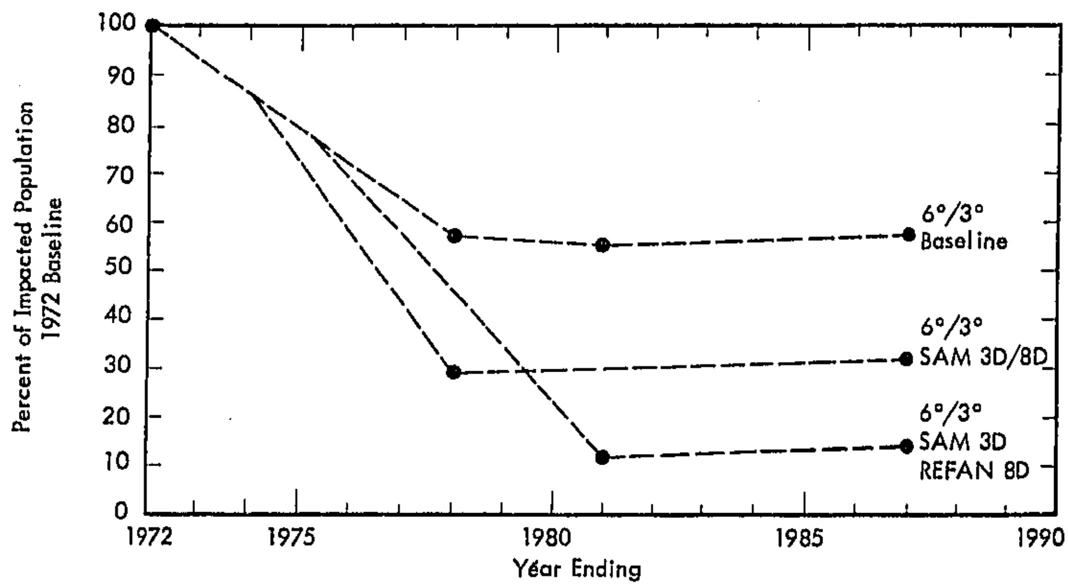

Figure 3.2-4. Cumulative Effectiveness Curves for One Baseline and Two Alternatives at 23 Airports Regarding Impacted Population within NEF 40 Contours

The measure chosen for this report to determine the overall effectiveness of an alternative is the integral area under the alternative curve bounded by the percentage-time axes and the year 1987. This measure, normalized to a baseline criterion, can be described as the average effectiveness over the 15-year period of the study. The areas under the curves shown in Figures 3.2-1, -2, -3, and -4 are given in Table 3.2-3. Since the year 1972 is to be used as one of the baseline criteria, then the baseline effectiveness curve can be represented as a straight line at the 100 percent level from 1972 to 1987.

The percent of impact reduction for each of the alternatives, using 1972 as a constant baseline and the 6°/3° altdrnative as a time-varying baseline comparator, is given in Table 3.2-4. The percentages for this table are calculated in the following manner:

$$R_e = 100\% \left(1 - \frac{A_A}{A_B}\right)$$

where:

R_e = percent of impact reduction

A_A = area under alternative curve

A_B = area under baseline curve

These percentages, in Table 3.2-4, are then the measures of effectiveness for the cost-effectiveness analysis which is discussed in Section 5.

Table 3.2-3

Area Under Effectiveness Curves

Alternative	Area Under Curves - (Percent-Years): Impacted Land NEF 30	Impacted Land NEF 40	Impacted Population NEF 30	Impacted Population NEF 40
6°/3° Glide Slope	1044	990	980	975
6°/3° SAM 3D/8D	862	748	842	762
6°/3° SAM 3D, REFAN 8D	684	645	642	615

Area Under Curve for 1972 Baseline = 1500 (Percent - Years)

Table 3.2-4

Percent Impact Reduction for Alternatives

Alternative	Impacted Land				Impacted Population			
	1972 Base*		6°/3° Base		1972 Base*		6°/3° Base	
	NEF 30	NEF 40	NEF 30	NEF 40	NEF 30	NEF 40	NEF 30	NEF 40
6°/3° Glide Slope	30	34	0	0	35	35	0	0
6°/3° SAM 3D/8D	43	50	17	24	44	49	14	22
6°/3° SAM 3D, REFAN 8D	54	57	34	35	57	59	34	37

*Numbers include the effects of the influx of newer and quieter aircraft.

3.3 Analysis of Impact

As described in Section 3.1, the total area inside a NEF contour can be comprised of three composite areas. These three areas are the area within the airport property boundary, the area encompassing water and, finally, the remaining land area which has been termed "impacted land." The relationships between total area and impacted area, airport property area and water area within the NEF contour area summations for the 23 airports are illustrated in Figure 3.3-1.

The three lines in Figure 3.3-1 represent smoothed values through the data points for each of the components of the total area. One of the significant features illustrated concerns the almost constant value of airport property within the contours over a wide range of values of the total area within the NEF contours. When the latter is greater than 400 square miles, the portion of airport property within the NEF 30 (or higher) contours seems to reach a limit of about 86 square miles. This represents approximately 80 percent of the total airport property area in the 23 airports. This indicates that approximately 20 percent (~21 square miles) of the total airport property for these 23 airports does not reside within the NEF contours examined in this study.

The line shown for impacted land is a linear regression line through the plotted points. The values for plotting the points were obtained from Table 3.1-24, the combined totals for all 23 airports. The data points used for the water area and airport property area lines were generated during the course of the study and are given in Table 3.3-1 in the form of total values for all 23 airports.

In addition to the relationship to total area, the impacted land can also be related to impacted population within the NEF contours. This relationship is illustrated in Figure 3.3-2. The solid line, labeled 23 Airports, represents a quadratic fit through the data points plotted. The equation of the line is:

$$Y = 1.2X^2 + 4567X - 19048, \quad \text{People}$$

where

Y is the number of impacted people

and X is the total area of impacted land in square miles

Two items of interest can be determined from this equation. First, if the equation is differentiated (i.e., $dY/dX = 2.4X + 4567$), the average population densities for various areas of impacted land can be evaluated to show that the average population density increases as the impacted area increases. This indicates that as the impacted land lies farther from the airport, the average number of people in a unit area becomes greater. This is reasonable and indicates the curve is sloping in the correct direction. Second, the negative constant term in the equation indicates that it is possible to have some impacted land area (~ 4 square miles) without impacting any people.

The two dashed lines in Figure 3.3-2 represent results when either Atlanta or La Guardia is deleted from the data and only 22 airports are analyzed. These two particular airports were deleted one at a time to demonstrate the sensitivity of the center curve to perturbations in area and population values. Atlanta and La Guardia were chosen for deletion since each represents the maximum excursion from the 23-airport curve in its respective direction if only one airport is deleted. The dashed lines also serve to again demonstrate that caution must be used when interpreting the data and attempting to generalize the results for a total national figure beyond the data from the 23 airports.

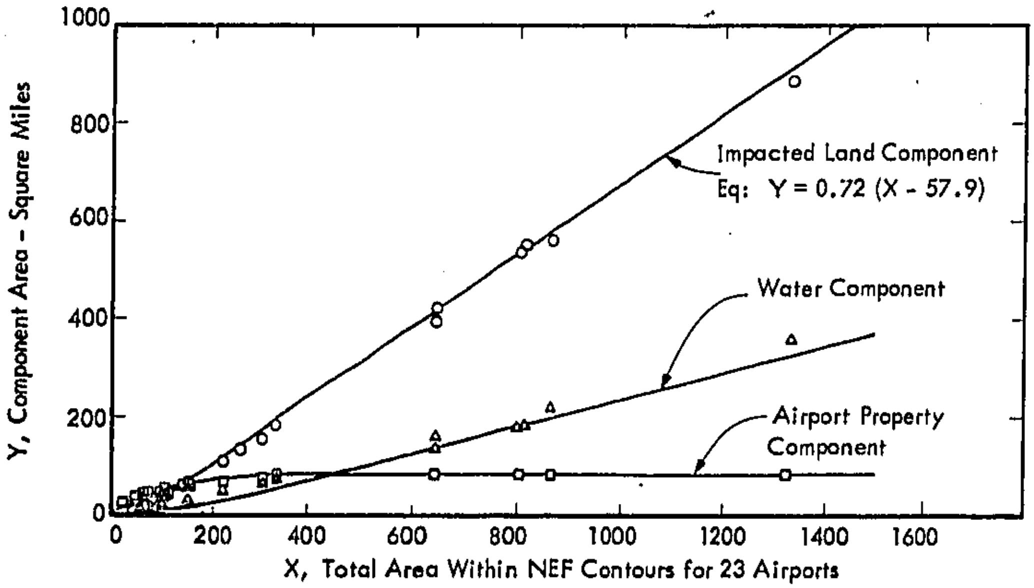

Figure 3.3-1. Comparison of Composite Areas Within NEF Contours for 23 Airports.

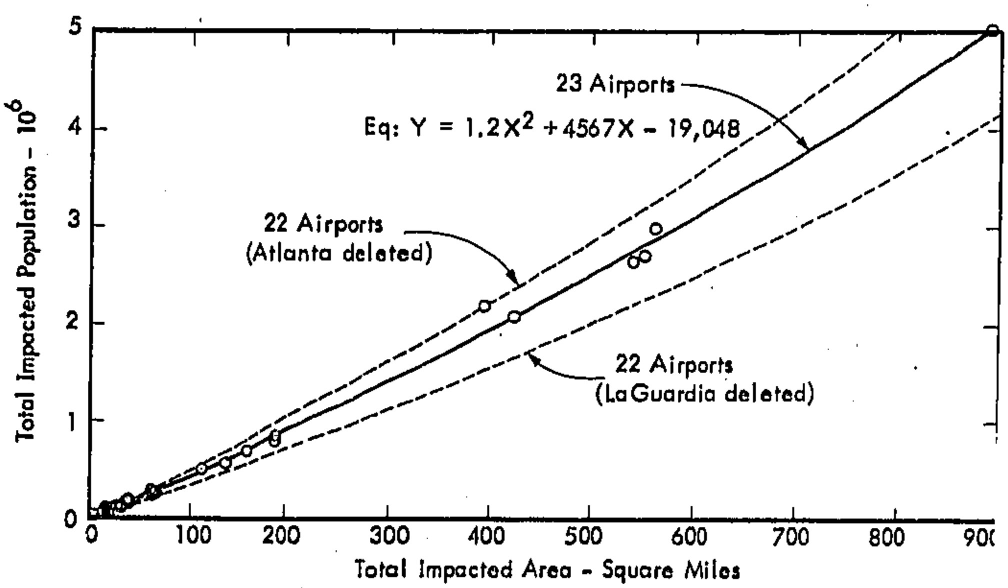

Figure 3.3-2. Comparison of Total Impacted Land Area and Total Impacted Population Within NEF Contours for 23 Airports

Table 3.3-1

Water and Airport Property Areas Inside NEF Contours for 23 Airports

(a) Airport Property Area Inside Contour - Square Miles

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	85	66	49									
6°/3° Glideslope				85	62	42	86	58	43	86	81	63
6°/3° Glideslope SAM 3D and 8D				84	52	34				86	77	56
6°/3° Glideslope SAM 3D, REFAN 8D							78	41	22	79	65	44

(b) Area Over Water Inside Contour - Square Miles

ALTERNATIVE	YEAR											
	1972			1978			1981			1987		
	30	40	45	30	40	45	30	40	45	30	35	40
Baseline	360	50	15									
6°/3° Glideslope				221	30	10	178	29	8	180	68	25
6°/3° Glideslope SAM 3D and 8D				163	20	6				135	50	18
6°/3° Glideslope SAM 3D, REFAN 8D							72	9	2	74	28	10

4.0 COST ANALYSIS

4.1 Investment/Operating Cost Model

A cost computation model has been developed to calculate marginal implementation and operating costs associated with each retrofit alternative described in Section 2.7. The computer-based model has been designed to accommodate the scope of input variables summarized on Table 4.1-1. The model may be operated to provide detailed cost summaries for any selected base year and discount rate to derive "current dollar" and "present value" totals of discounted cash flow for each type of aircraft fleet.

An example of the cost model computations for the B-707 fleet, forecast to be in operation during and after completion of the SAM retrofit program, is shown on Table 4.1-2. This model output summarizes the controlled variables used in the computation, the program totals of current dollar costs of $423,107,000 and discounted costs of $268,524,000 and the totals for each of the four cost elements evaluated in the analysis. This output also summarizes the detail of implementation costs contributing to the totals above for each year during which aircraft are forecast to undergo modification in accordance with the established schedule. Similar detail for the added operating cost is shown for each year that modified aircraft are forecast to be in operation after retrofit. The printout illustrates the effect of the selected inflation rates applied to the recurring operating costs, and the year-by-year values of the current dollar costs and discounted cash flow for each of the four cost elements.

The cost model is also used to summarize the cost elements for each aircraft fleet, and the fleet costs into the total costs for each retrofit program. Tables 4.1-3, -4, and -5 show such summaries for discount rates of 0, 5, and 10 percent respectively. The 0 percent rate is, of course, the "current dollar" summary. The values listed under alternative 1 + 2 are for SAM-3D (B-707 + DC-8); and those for 6 + 7 + 8 are for REFAN -8D (B-727 + B-737 + DC-9) and similarly for the other alternatives.

Table 4.1-1

Input Data Summary -
Aircraft Noise Reduction Forecast
Investment/Operating Cost Model

Item	
1	Aircraft Types
2	Type of Retrofit Program
3	Base Year
4	Discount Rates - Percent
* 5	Retrofit Cost Per Aircraft - $/Aircraft
6	Rate of Inflation - Percent
7	Time Lost in Retrofit - Days
8	Cost Per Day of Lost Time - $/Day
* 9	Schedule of Retrofit Programs - Years
10	Number of Aircraft Modified in Each of the Investment Years
11	Crew Cost - $/Hour
12	Fuel Cost - $/Hour
13	Maintenance Cost - $/Hour
14	Insurance Cost - $/Hour
15	Percent Inflation in Crew Cost - Percent
16	Percent Inflation in Fuel Cost - Percent
17	Percent Inflation in Maintenance Cost - Percent
18	Percent Inflation in Insurance Cost - Percent
19	Inflation Base Year
* 20	Retrofit Change in Cash DOC - Percent
21	Annual Aircraft Utilization - Hours
* 22	Retrofit Change in Aircraft Operating Weight Empty - Pounds
23	Average Payload Before Retrofit - Pounds
24	Annual Available Ton Miles
* 25	Retrofit Change to Specific Fuel Consumption - Percent
26	Effective Change to Productivity - Percent
27	Delta Fuel Weight - Effect on Payload Productivity - Pounds
28	Number of Retrofit Aircraft in Operation in Each Year After Retrofit

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* Data provided by DOT and NASA.

Table 4.1-2

Aircraft Noise Reduction Forecast
Investment/Operating Cost Model

AIRCRAFT TYPE B707
RETROFIT. SAM
BASE YEAR 1974
DISCOUNT RATE 10%

KIT + INSTALLATION + SPARES

COST PER ACFT (1973)	900000
COST INFLATION %	7
EXTRA INST. DAYS	8
COST PER DAY $	8300

BASE CASH DOC (1972)	$/HR	INFLATION
CREW	205	5%
FUEL + OIL	430	5%
MAINTENANCE	210	3%
INSURANCE	10	0%
TOTAL	855	

RETROFIT CHANGE TO CASH DOC	0.50 %
ANNUAL UTILIZATION (BASE)	3200 HOURS
ANNUAL UTILIZATION (RETROFIT)	3236 HOURS
ANNUAL ATMS PER ACFT	31.2 M
RETROFIT CHANGE TO OWE	3300 LBS
RETROFIT CHANGE TO SFC	0.20 %
RETROFIT CHANGE TO PROD	-14.0 %

CURRENT & DISCOUNTED COSTS (000 DOLLARS)

	CURRENT	DISCOUNT		CURRENT	DISCOUNT	TOTALS CURRENT	TOTALS DISCOUNT
INVESTMENT	261680	190768	LOST TIME	14408	10545	276088	201314
ADDED DOC	44745	20455	LOST PROD.	102274	46755	147019	67210
TOTALS	306425	211223		116682	57300	423107	268524

PRESENT VALUE OF IMPLEMENTATION COST (000 DOLLARS)

YEAR	NO.ACFT RETROFIT	ANNUAL INVEST	LOST TIME COST	CUMULATIVE INVEST	CUMULATIVE LOST TIME	CUMULATIVE TOTAL	DISCOUNT TO PV INVEST	DISCOUNT TO PV LOST TIME	DISCOUNT TO PV TOTAL
1976	43	47409	2855	47409	2855	50264	39181	2359	41540
1977	65	76681	4315	124090	7171	131261	96792	5602	102395
1978	109	137589	7237	261680	14408	276088	190768	10545	201314

PRESENT VALUE OF ADDED OPERATING COST (000 DOLLARS*)

YEAR	NO.ACFT RETROFIT	BASE FLEET HOURS (000)	CASH DOC/HR BASE	CASH DOC/HR RETRO	ADDED CASH DOC*	LOST PROD $*	CUMULATIVE DOC*	CUMULATIVE PROD*	CUMULATIVE TOTAL*	DISCOUNT TO PV DOC*	DISCOUNT TO PV PROD*	DISCOUNT TO PV TOTAL*
1976	20	63	1018.2	1023.3	325	744	325	744	1070	269	615	884
1977	75	239	1063.9	1069.2	1276	2917	1602	3662	5264	1228	2807	4035
1978	160	511	1111.7	1117.3	2845	6503	4447	10165	14613	3171	7249	10421
1979	217	694	1161.8	1167.6	4032	9218	8480	19383	27864	5675	12973	18649
1980	217	694	1214.2	1220.3	4214	9634	12695	29017	41713	8055	18411	26466
1981	217	694	1269.1	1275.4	4405	10069	17100	39087	56188	10315	23578	33894
1982	217	694	1326.6	1333.2	4604	10525	21705	49613	71318	12463	28488	40952
1983	217	694	1386.7	1393.7	4813	11003	26519	60616	87135	14505	33155	47660
1984	200	639	1449.8	1457.0	4638	10601	31158	71217	102376	16293	37242	53536
1985	170	543	1515.8	1523.3	4122	9421	35280	80639	115919	17738	40545	58283
1986	135	431	1584.9	1592.8	3422	7823	38702	88463	127165	18829	43037	61867
1987	105	335	1657.3	1665.6	2783	6362	41486	94825	136312	19635	44881	64516
1988	70	223	1733.1	1741.8	1940	4435	43427	99261	142688	20146	46049	66195
1989	35	111	1812.5	1821.6	1014	2319	44442	101581	146023	20389	46604	66994
1990	10	31	1895.7	1905.2	303	693	44745	102274	147019	20455	46755	67210
1991	0	0	1982.8	1992.7	0	0	44745	102274	147019	20455	46755	67210

Table 4.1-3

Summary of Noise Retrofit Programs
Implementation and Added Operating Costs
Current Dollars

DISCOUNT RATE 0% TO 1974

	1 INVEST	2 DOOC	A 1 + 2	3 LOST TIME	B 1 + 3	C B + 2	4 LOST PROD	D C + 4
1 B707 SAM	261680	44745	306425	14408	276088	320834	102274	423108
2 DC-8 SAM	133005	33343	166348	9287	142293	175637	48886	224524
3 B727 SAM	152539	21542	174081	0	152539	174081	5569	179651
4 B737 SAM	40971	8823	49794	0	40971	49795	793	50588
5 DC-9 SAM	79303	8789	88092	0	79303	88092	1391	89484
6 B727 RFN	1559508	451353	2010861	31463	1590971	2042324	922582	2964907
7 B737 RFN	363893	89641	453534	2183	366077	455719	123939	579658
8 DC-9 RFN	497598	161386	658984	6311	503909	665296	143809	809105
AERO ALTERNATIVES								
2. 1+2+3+4+5	667498	117242	784740	23695	691194	808439	158913	967355
3. 1+2	394685	78088	472773	23695	418381	496471	151160	647632
4. 3+4+5	272813	39154	311967	0	272813	311968	7753	319723
5. 6+7+8	2420999	702380	3123379	39957	2460957	3163339	1190330	4353670
6. 1+2+6+7+8	2815684	780468	3596152	63652	2879338	3659810	1341490	5001302
7. 1+2+4+5+6	2074467	547053	2621520	55158	2129626	2676682	1075926	3752611

Table 4.1-4

Summary of Noise Retrofit Programs
Implementation and Added Operating Costs
Present Values (5 Percent Discount Rate)

DISCOUNT RATE 5% TO 1974

	1 INVEST	2 DDOC	A 1 + 2	3 LOST TIME	B 1 + 3	C B + 2	4 LOST PROD	D C + 4
1 B707 SAM	222437	29642	252079	12272	234710	264352	67753	332105
2 DC-8 SAM	113111	21861	134972	7914	121026	142887	32050	174938
3 B727 SAM	131496	14348	145844	0	131496	145844	3709	149554
4 B737 SAM	35330	5677	41007	0	35330	41007	510	41518
5 DC-9 SAM	68371	5784	74155	0	68371	74156	916	75072
6 B727 RFN	1161318	260264	1421582	23507	1184825	1445089	531990	1977080
7 B737 RFN	271061	53899	324960	1632	272693	326593	74521	401115
8 DC-9 RFN	370492	98747	469239	4714	375207	473954	87992	561946
AERO ALTERNATIVES								
2. 1+2+3+4+5	570745	77312	648057	20186	590933	668246	104938	773187
3. 1+2	335548	51503	387051	20186	355736	407239	99803	507043
4. 3+4+5	235197	25809	261006	0	235197	261007	5135	266144
5. 6+7+8	1802871	412910	2215781	29853	1832725	2245636	694503	2940141
6. 1+2+6+7+8	2138419	464413	2602832	50039	2188461	2652875	794306	3447184
7. 1+2+4+5+6	1600567	323228	1923795	43693	1644262	1967491	633219	2600713

Table 4.1-5

Summary of Noise Retrofit Programs
Implementation and Added Operating Costs
Present Values (10 Percent Discount Rate)

DISCOUNT RATE 10% TO 1974

	1 INVEST	2 DDOC	A 1 + 2	3 LOST TIME	B 1 + 3	C B + 2	4 LOST PROD	D C + 4
1 B707 SAM	190768	20455	211223	10545	201314	221770	46755	268525
2 DC-8 SAM	97051	14971	112022	6804	103855	118826	21949	140775
3 B727 SAM	114391	9973	124364	0	114391	124364	2578	126943
4 B737 SAM	30743	3830	34573	0	30743	34573	344	34917
5 DC-9 SAM	59486	3975	63461	0	59486	63461	629	64091
6 B727 RFN	878659	158254	1036913	17843	896502	1054756	323477	1378234
7 B737 RFN	205148	33703	238851	1239	206387	240090	46598	286688
8 DC-9 RFN	280276	62690	342966	3577	283853	346544	55862	402407
AERO ALTERNATIVES								
2. 1+2+3+4+5	492439	53204	545643	17349	509789	562994	72255	635251
3. 1+2	287819	35426	323245	17349	305169	340596	68704	409300
4. 3+4+5	204620	17778	222398	0	204620	222398	3551	225951
5. 6+7+8	1364083	254647	1618730	22659	1386742	1641390	425937	2067329
6. 1+2+6+7+8	1651902	290073	1941975	40008	1691911	1981986	494641	2476629
7. 1+2+4+5+6	1256707	201485	1458192	35192	1291900	1493386	393154	1886542

4.2 Program Total Costs

The total investment required to accomplish each of the alternative retrofit programs is summarized graphically on Figure 4.2-1. These total values reflect the sum of kit, installation, and spares costs for each fleet of aircraft involved in each respective modification program.

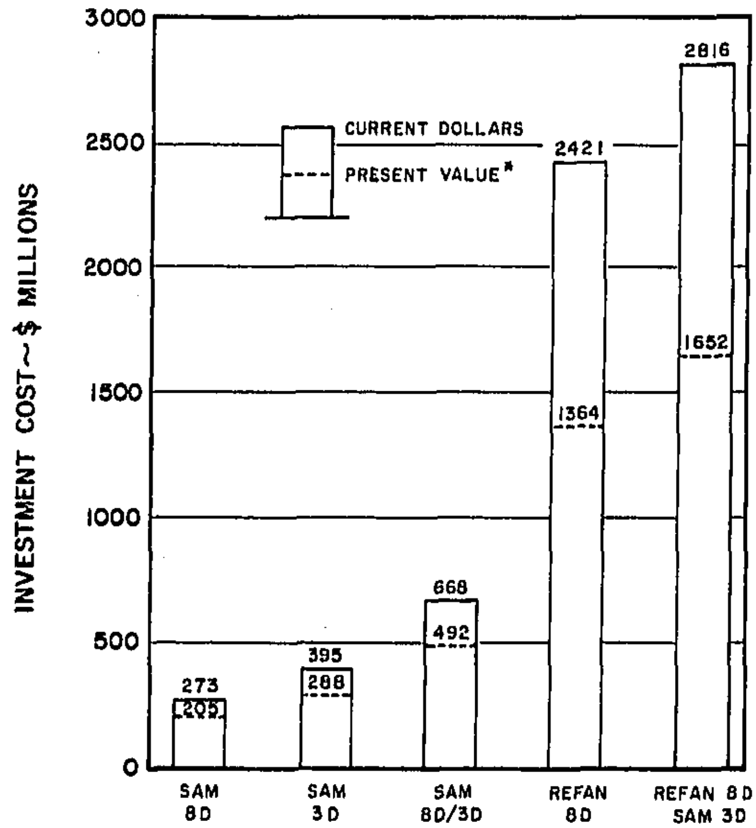
It can be seen that for the two retrofit programs that cover all aircraft, the REFAN-8D/SAM-3D investment is about 4.2 times that for SAM-8D/3D when considering the "current dollar" totals. On the "present value" basis, this comparison reduces to about 3.3 times.

The total of all of the four elements of the marginal costs required to implement each of the retrofit programs, and to operate all of the retrofit aircraft in each program for as long as they are forecast to continue in service after retrofit, is summarized on Table 4.2-1. These same data are shown graphically for comparison on Figure 4.2-2.

Again, it can be seen that for the two retrofit programs that cover all aircraft, the REFAN-8D/SAM-3D total costs are about 5.2 times those for SAM-8D/3D when considering the "current dollar" totals. On the "present value" basis, this comparison reduces to about 3.9 times.

4.3 Sample Financing Scheme

The concept of an aviation user trust fund has been analyzed to illustrate the rate at which revenue generated from a separate user tax structure could pay off the investment costs of the alternative retrofit programs. Figure 4.3-1 illustrates the application of this concept to pay off the SAM-8D/3D retrofit program, as an example. The cumulative user tax revenues starting in 1975 are shown based on a 1 percent domestic passenger tax, plus a 1 percent domestic cargo tax, plus a $1.00 international enplanement tax. The cumulative retrofit payout is shown as required to support the investment costs as incurred over the 4-year implementation period for



*COSTS DISCOUNTED AT 10% TO 1974

Figure 4.2-1. Noise Retrofit Program Investment Cost (Kits + Installation + Spares)

Table 4.2-1

Noise Retrofit Program Costs (Millions)
Current Dollars and Present Value*

	SAM -8D	SAM -3D	SAM -8D/3D	REFAN -8D	REFAN -8D SAM -3D
CURRENT DOLLARS					
Lost Prod.	7.8	151.1	158.9	1,190.4	1,341.5
Cash DOC	39.1	78.1	117.2	702.4	780.5
Lost Time	0.0	23.7	23.7	39.9	63.6
Investment	272.8	394.7	667.5	2,421.0	2,815.7
Total	$319.7	$647.6	$967.3	$4,353.7	$5,001.3
PRESENT VALUE (10%)*					
Lost Prod.	3.5	68.7	72.3	425.9	494.6
Cash DOC	17.8	35.5	53.2	254.6	290.1
Lost Time	0.0	17.3	17.3	22.7	40.0
Investment	204.6	287.8	492.4	1,364.1	1,651.9
Total	$225.9	$409.3	$635.2	$2,067.3	$2,476.6

* Costs discounted at 10% to 1974.

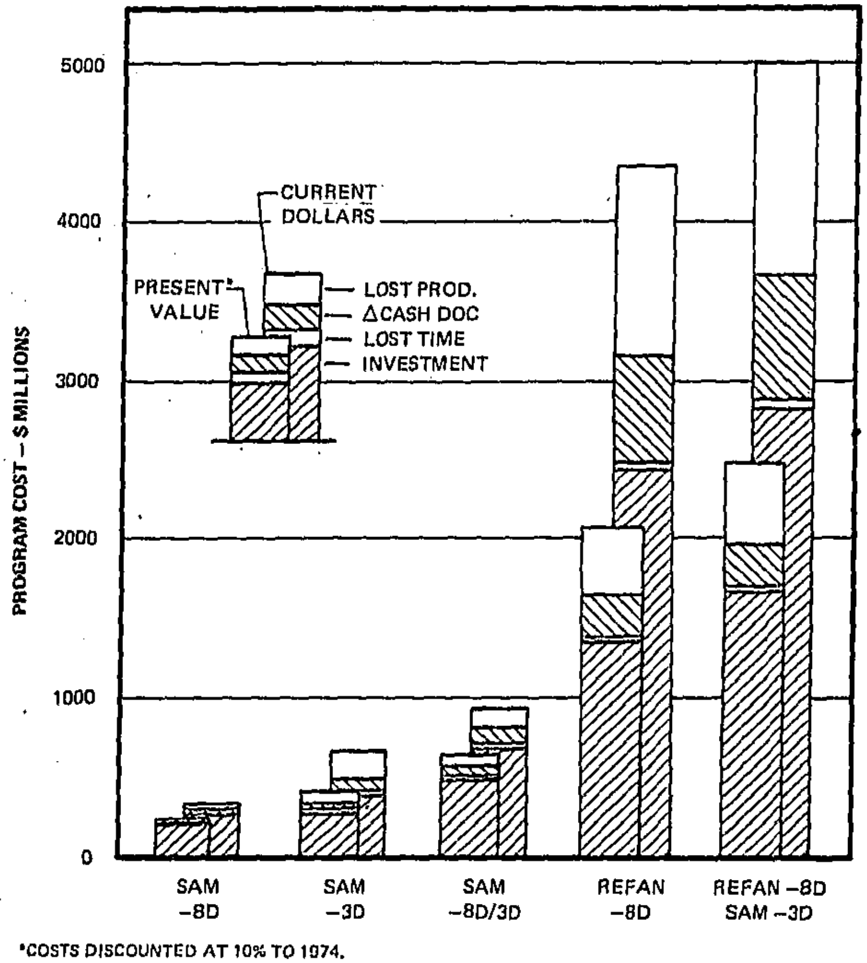
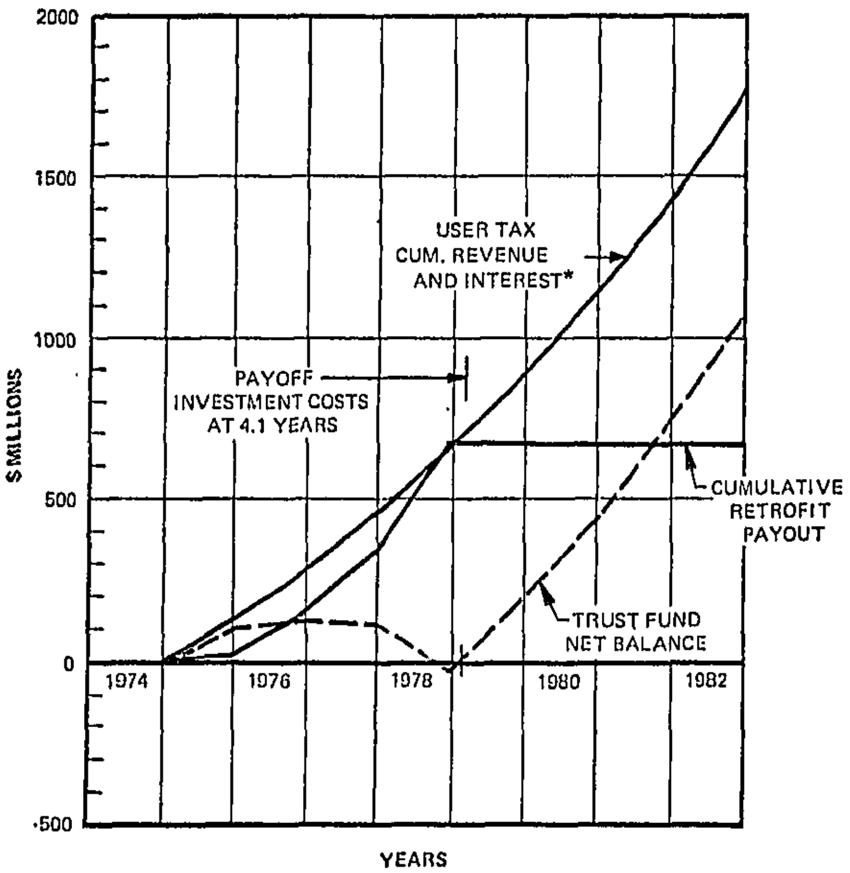


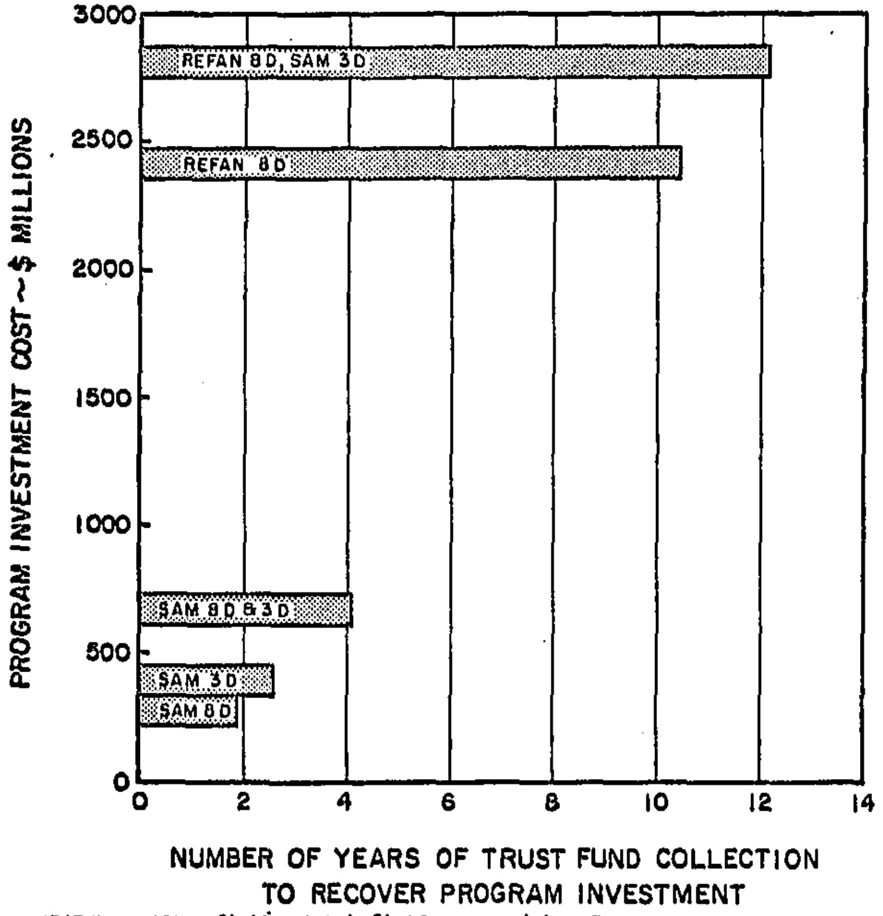
Figure 4.2-2. Noise Retrofit – Program Total Costs



* REVENUE: 1% Dom. Pax. + 1% Dom. Cargo + $1 Int'l. Pax.

Figure 4.3-1. Noise Retrofit Trust Fund Revenue and Payout Example SAM-8D/3D the SAM program. The revenue projection has been adjusted, at a 5 percent rate, for interest earnings on balance, or cost of borrowing, when the fund revenues are ahead or behind the payout requirement. It can be seen that the SAM-8D/3D program investment costs could be paid off in approximately 4.1 years at the indicated level of user taxes.

A summary of the estimated payoff periods for each of the alternative retrofit programs with such a trust fund concept is shown on Figure 4.3-2. A doubling of the tax rates would reduce the payoff periods to approximately one-half of the number of years shown in these examples.



NOTE: FUND INCOME 1% DOM. PAX + 1% DOM. CARGO + $1 INT'L PAX USER TAXES. COSTS INCLUDE KITS, INSTALLATION AND SPARES. COLLECTIONS START IN CY 1975

Figure 4.3-2. Summary of Estimated Payoff Periods for a Noise Retrofit Trust Fund

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Cost-Effectiveness Analysis

The primary impact parameters utilized for this study are the number of people and area of nonairport land residing within the NEF 30 and NEF 40 contours for 23 airports. Three noise reduction strategies have been analyzed at each of the 23 airports for 3 future years. The measure of effectiveness chosen to evaluate the results of applying each strategy was the percent reduction in the area under the time-effectiveness curves over the period of the study - 1972 to 1987. The relative measures of effectiveness for each of the alternative strategies have been developed and are tabulated in Section 3.2, Table 3.2-4. The costs of implementing and maintaining each of the strategies have been determined and are tabulated in Section 4.2, Table 4.2-1.

Figures 5-1 and 5-2 illustrate the combination of the cost and effectiveness data for the alternative strategies, for the NEF 30 and NEF 40 impact criteria, for impacted land and impacted population and, finally, for two different baseline comparators.

First, considering the cost-effectiveness curves in Figure 5-1 for impacted land, it is apparent that although the curve sets for the two baseline criteria are offset from each other, the relative ranking of the alternatives is the same. The implementation of the $6^{\circ}/3^{\circ}$ glide slope procedure at an estimated cost of $75 million produces a reduction in percent-years of 30 percent for the NEF 30 and 34 percent for the NEF 40 criteria. A major part of this reduction is caused by the influx of new quiet aircraft into the fleet coupled with the retirement of the older noisier aircraft - and a minor part of the reduction is caused by the implementation of the $6^{\circ}/3^{\circ}$ approach procedure. The implementation of the $6^{\circ}/3^{\circ}$+SAM 3D/8D alternative, at an estimated cost of $967.3 million, results in a reduction in percent-years for the NEF 30 and NEF 40 of 17 percent and 24 percent, respectively, for the $6^{\circ}/3^{\circ}$ baseline and 43 percent and 50 percent, respectively, for the 1972 baseline. The implementation of the $6^{\circ}/3^{\circ}$+SAM 3D + REFAN 8D alternative, at an estimated cost of $5001.3 million, results in a reduction in percent-years for the NEF 30 and NEF 40 of 34 percent and 35 percent, respectively, for the $6^{\circ}/3^{\circ}$ baseline and 54 percent and 57 percent, respectively, for the 1972 baseline.

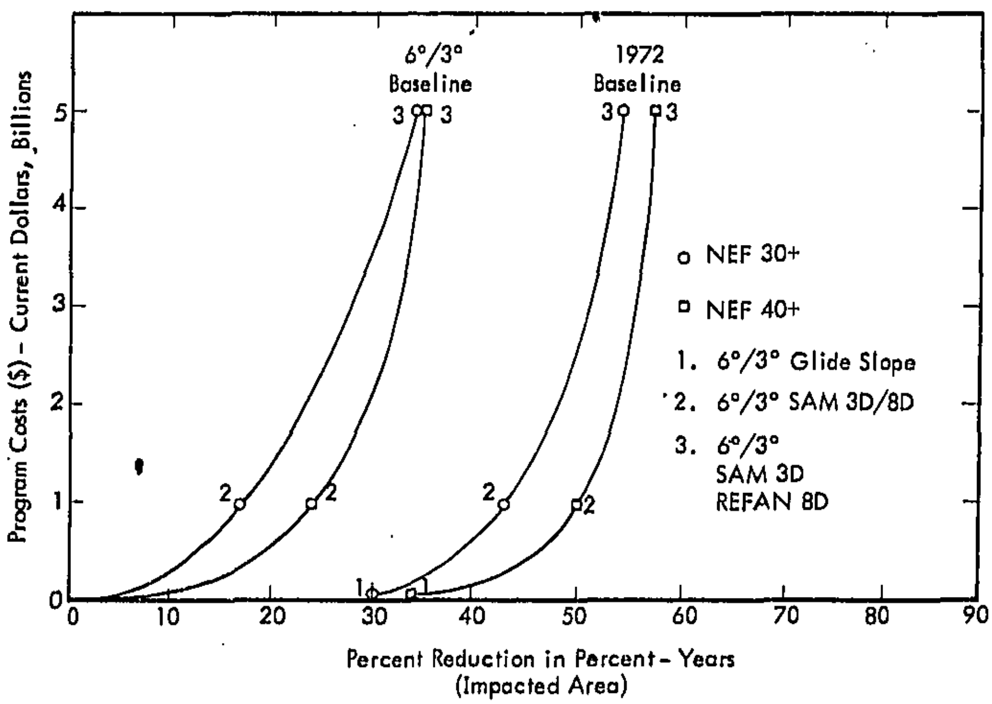


Figure 5-1. Cost-Effectiveness Curves for Impacted Land Area Within the NEF 30 and NEF 40 Contours at 23 Airports.

Figure 5-2 presents similar cost-effectiveness curves for impacted population within the NEF 30 and NEF 40 contours. The cost values for each of the programs are the same as stated in the previous paragraph. For the NEF 30 and NEF 40 cost-effectiveness curves, the projected changes in fleet mix along with the 6°/3° procedure produce a reduction of 35 percent and 35 percent in percent-years, respectively. The 6°/3° + SAM 3D/8D alternative produces a reduction of 14 percent and 22 percent, respectively, for the 6°/3° baseline and 44 percent and 49 percent, respectively, for the 1972 baseline. The 6°/3° + SAM 3D + REFAN 8D alternative produces reductions of 34 percent and 37 percent, respectively, for the 6°/3° baseline and 57 percent and 59 percent, respectively, for the 1972 baseline.

5.2 Recommendations

The results provided by this study have immediate and significant application to the development of background data on cost-effectiveness of several viable noise abatement concepts. Both parameters of the output cost and effectiveness have been based on a detailed study of operations for a major portion of the civil aviation system. Once such an in-depth analysis has been completed, one naturally seeks to examine ways in which the analytical tools and findings developed in the study can be applied to other major engineering-economics systems evaluations. Examples of such applications and areas for further improvement in the results obtained or approaches taken in this study are suggested in the following:

- Further sensitivity analyses for the accuracy of the findings relative to perturbations in the various input assumptions.
- Application of the results and techniques to the development of absolute values of aircraft noise impact throughout the nation, i.e., the determination of the total number of people impacted by the civil, private and military aviation systems throughout the nation.

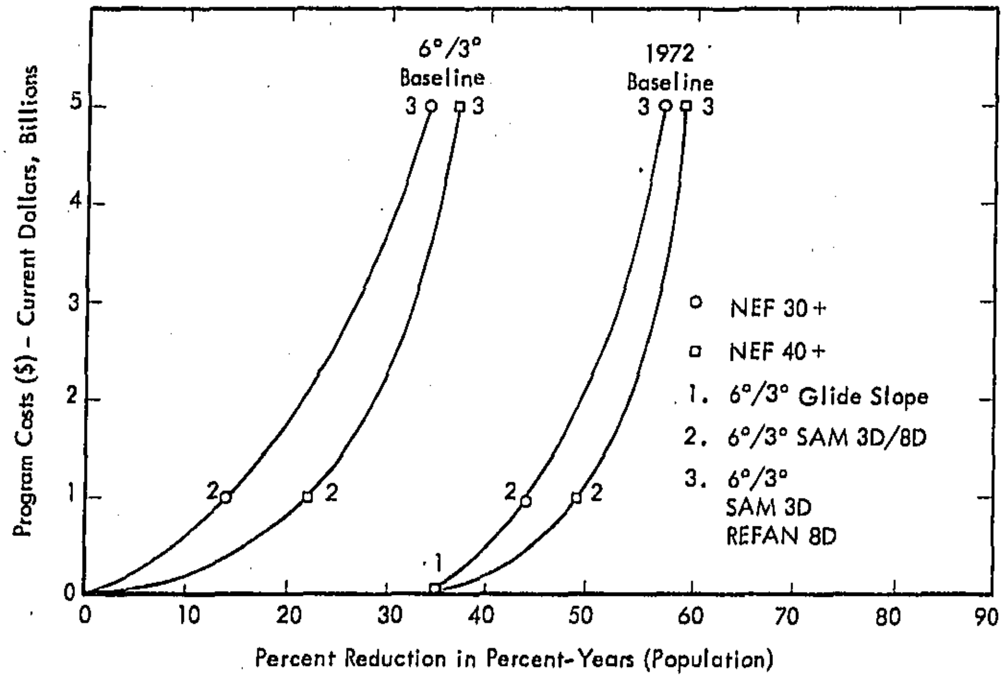


Figure 5-2. Cost-Effectiveness Curves for Population Residing Within NEF 30 and NEF 40 Contours at 23 Airports.

- Further evaluation of the results obtained to establish the feasibility of using a preselected sample of fewer airports and/or an artificially designed airport model to allow approximate cost-effectiveness studies to be made efficiently with minimum effort.
- Application of the techniques to cost-effectiveness analysis of other noise or related air pollution abatement systems.

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APPENDIX A

SUMMARY OF MAJOR CONTACTS WITH INDUSTRY AND OTHER GOVERNMENT AGENCIES RELATIVE TO DIRECTION OF STUDY

- June 30, 1972 — Contract Award
- August 10, 1972 — Initial program definition. Presentation by DOT, Wyle, and Speas to representatives from DOT, FAA, NASA, EPA, airlines, airport operators, and engine manufacturers.
- August 30, 1972 — Initial program briefing before ATA Environmental Committee by representatives from DOT, Wyle, and Speas.
- September 22-28, 1972 — Initial program briefings to United Aircraft Corporation, The Boeing Company, and McDonnell Douglas by representatives from DOT, Wyle, and Speas.
- February 26, 1973 — Initial disclosure of economics data. Letter from Director, Office of Noise Abatement, DOT, to The Boeing Company and McDonnell Douglas requesting review and comments.
- July 25, 1973 — Progress Report to government and industry. Presentation of initial results on the six largest airports by DOT, Wyle and Speas to representatives from DOT, FAA, NASA, EPA, airlines, airframe and engine manufacturers. Presentation was part of a Retrofit Program Status Review by the Joint DOT/NASA Office of Noise Abatement. This meeting was followed up by requests from the Office of Noise Abatement, DOT, for comments on the results, program direction, and key assumptions, and resulted in a series of changes to the program (see Section 2.1.5 for discussion).
- February 14, 1974 — Preliminary results of Cost Study. Presentation by DOT and Speas to representatives from DOT, FAA, EPA, OMB, and NASA of retrofit costs. Final noise impact results were also presented on two airports based on new aircraft noise and performance data.

APPENDIX B

SUMMARY OF SOURCES FOR AIRCRAFT NOISE AND PERFORMANCE DATA (13)

Aircraft Type		Sources (See Page B-2) Noise	Performance
707-120/320		B-21, (7)	(2)
707-120B		B-4	(11)
707-320B/C	- Base, SAM	B-4, (9)	(2), (10)
720		B-1	(2), (8)
720B		B-4	B-2, (3)
727-100/200	- Base, SAM	B-4	B-2, (3)
	- REFAN	B-3	B-2, (3)
737-100/200	- Base, SAM	B-3	B-2, (3)
	- REFAN	B-3	B-2, (3)
747-100/200B		B-3	B-2, (3)
DC-8-30		B-10	B-10, (3)
DC-8-55/61/63	- Base, SAM	B-4	B-5, B-7, B-8, (3)
DC-9-15/32	- Base, SAM	B-4	B-5, B-9, (3)
	- REFAN	B-3	B-3, (3)
DC-10-10		B-4	B-5, (3)
L-1011		B-6	(4)
BAC-111		B-21	(5)
VC-10		B-21	(2)
Two-Eng. W.B. (A-300B)		(1)	(6)
Caravelle		(12)	(5)
STOL, Turboprop (F-20)		(3)	(3)

(1) DC-10 minus 1.8 EPNdB
(2) Calculated from DC-8 data
(3) Supported with engineering calculations by Wyle Research – reviewed informally by Industry
(4) Assumed equal to DC-10
(5) Assumed equal to DC-9
(6) Calculated from DC-10 performance
(7) Also used for CV-880 noise
(8) Modified for CV-880 performance
(9) Also used for CV-990 noise
(10) Also used for CV-990, VC-10 performance
(11) Calculated from 720B data
(12) Calculated from 707-320B/C data
(13) Additional support provided by data in References B-10, B-17 and B-20

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