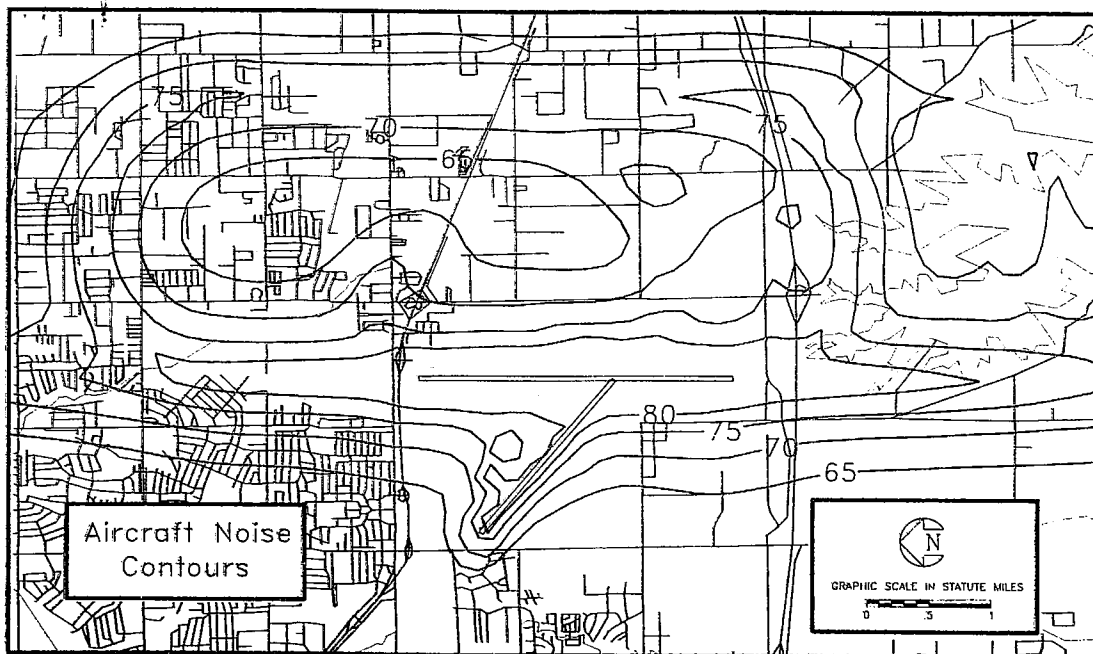


FEDERAL AGENCY REVIEW OF SELECTED AIRPORT NOISE ANALYSIS ISSUES

FEDERAL INTERAGENCY COMMITTEE ON NOISE

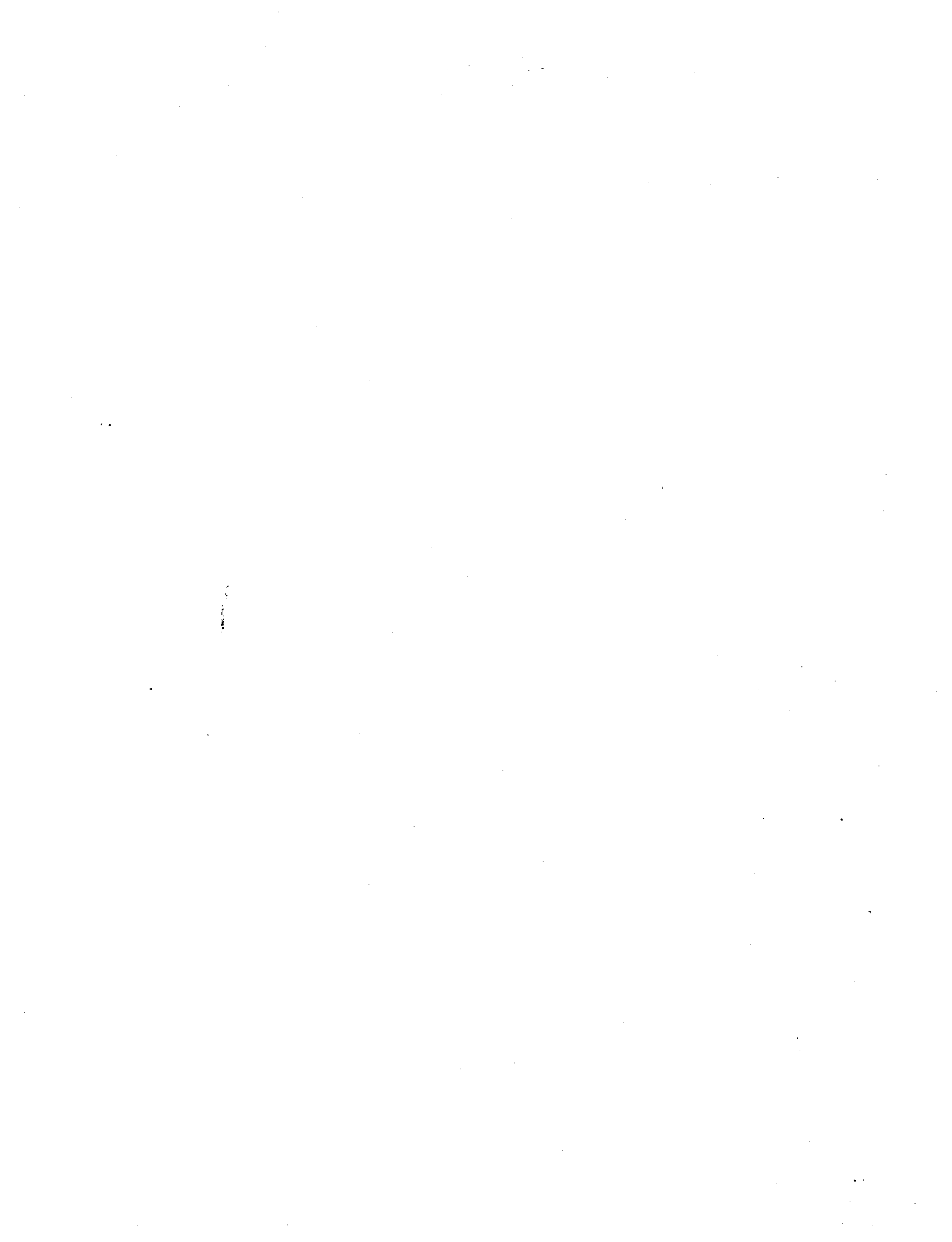


AUGUST 1992

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FEDERAL INTERAGENCY COMMITTEE ON NOISE

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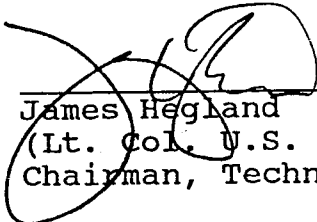
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ON NOISE


The Federal Interagency Committee on Noise has completed its study and is pleased to submit this report, with recommendations, for consideration by member agencies.

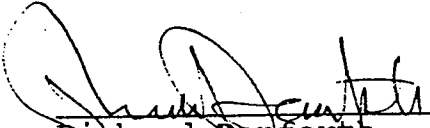
The Committee, composed of representatives of the Departments of Transportation (Office of the Secretary and the Federal Aviation Administration), Defense, Justice, Veterans Affairs, Housing and Urban Development; the Environmental Protection Agency; and the Council on Environmental Quality, was chartered to review specific elements of federal agency procedures for the assessment of airport noise impacts and to make appropriate recommendations.

The Committee formed three subgroups: Technical, Policy and Legal. The initial work was performed by the Technical Subgroup, and its study provided the basis for the Policy and Legal Subgroups' findings, conclusions and recommendations. The Legal Subgroup provided an overall legal review of the policy recommendations. The Committee's Report reflects the efforts of all three subgroups. To maximize its utility, the report is formatted with an Executive Summary, a Policy Section which contains the recommendations, and a Technical Section to provide detailed background and support for the recommendations.

Pursuant to agreement by the Legal Subcommittee, this transmittal constitutes the final action of the Federal Interagency Committee on Noise and terminates the Committee.

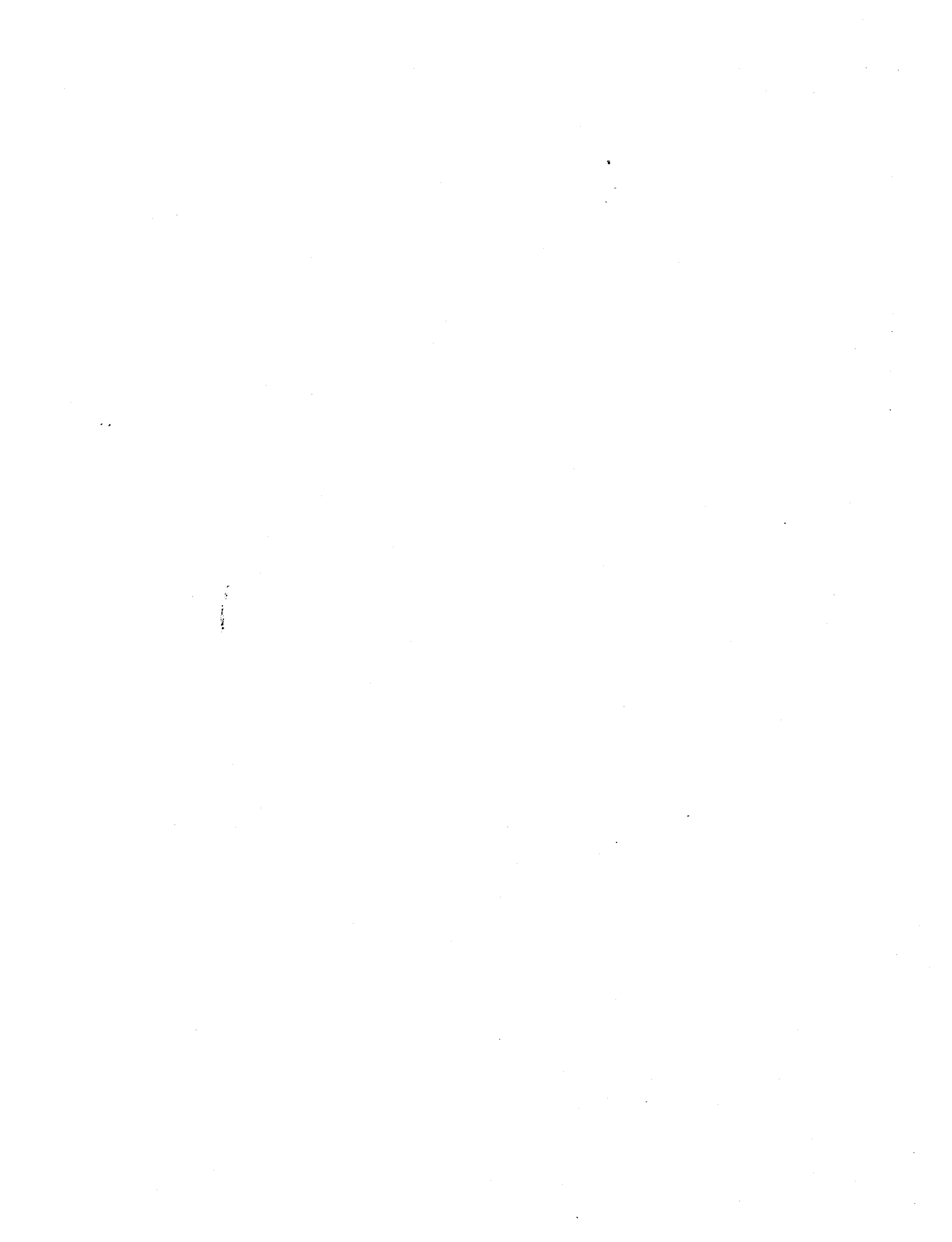

James Hegland
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August 21, 1992

(Date)



EXECUTIVE SUMMARY

INTRODUCTION

The 1990 Federal Interagency Committee on Noise (FICON) was formed to review Federal policies that govern the assessment of airport noise impacts. The FICON review focused primarily on:

- The manner in which noise impacts are determined, including whether aircraft noise impacts are fundamentally different from other transportation noise impacts;
- The manner in which noise impacts are described;
- The extent of impacts outside of Day-Night Average A-Weighted Sound Level (DNL) 65 decibels (dB) that should be reviewed in a National Environmental Policy Act (NEPA) document;
- The range of Federal Aviation Administration (FAA)-controlled mitigation options (noise abatement and flight track procedures) analyzed; and,
- The relationship of the FAA Federal Aviation Regulation (FAR) Part 150 process to the NEPA process; including ramifications to the NEPA process if they are separate, and exploration of the means by which the two processes can be handled to maximize benefits.

The FICON was organized into three subgroups to appropriately focus on the technical, legal and policy issues associated with the assessment of airport noise impacts. The Technical Subgroup #1 was tasked to review the body of science associated with methodologies and metrics for assessing airport noise impacts which have evolved since the 1980 meetings of the Federal Interagency Committee on Urban Noise (FICUN). The Policy Subgroup #2 was tasked to review Federal policies that govern the assessment of airport noise impacts. The Legal Subgroup #3 reviewed the legal aspects of current and proposed Federal policies for assessing airport noise impacts. The Subgroup #1 Technical report was used as a basis for the policy report development.

The results of the work of the Policy and Technical Subgroups are contained herein as Volume I: Policy Review and Volume II: Technical Report. Key conclusions from the Technical Report and the overall FICON recommendations are summarized below.

TECHNICAL CONCLUSIONS

General

- There are no new descriptors or metrics of sufficient scientific standing to substitute for the present DNL cumulative noise exposure metric.
- The methodology employing DNL as the noise exposure metric and appropriate dose-response relationships (primarily the Schultz curve for Percent Highly Annoyed) to determine noise impacts on populations is considered the proper one for civil and military aviation scenarios in the general vicinity of airports.
- Federal agencies generally conduct noise assessments at DNL levels of ≥ 65 dB. For a variety of reasons, noise predictions and interpretations are frequently less reliable below DNL 65 dB. DNL prediction models tend to degrade in accuracy at large distances from the airport. Therefore, predictions of noise exposure and

impact below DNL 65 dB should take the possibility of such inaccuracy into account.

- DNL is sometimes supplemented by other metrics, on a case-by-case basis.
- Noise analyses should address impacts in the following areas: (1) health and welfare, (2) environmental degradation/impact and (3) land use planning.
- Complaints are an inadequate indicator of the full extent of noise effects on a population.

Health and Welfare:

- The dose-effect relationship, as represented by DNL and "Percent Highly Annoyed" (%HA), remains the best available approach for analyzing overall health and welfare impacts for the vast majority of transportation noise analysis situations.
- The 10 dB nighttime penalty levied against noise during the 10 PM to 7 AM period is specifically designed to account for the intrusiveness of noise during this period, and its potential impact on sleep. There are no new hard data which would justify a change in this penalty.
- If supplemental analysis for sleep disturbance is desired, use may be made of an interim dose-response model developed by the AF Armstrong Laboratories (AL) (see Volume II, Section 3.2.2.3). Although this relationship is described in terms of Sound Exposure Level (SEL), single event metrics are of limited use in predicting and interpreting cumulative noise exposure impacts
- Annoyance is a summary measure of the general adverse reaction of people to living in noisy environments that causes speech interference, sleep disturbance, desire for a tranquil environment; and the inability to use the telephone, radio or television satisfactorily.
- No definitive evidence of nonauditory health effects from aircraft noise exists, particularly below DNL 70 dB.
- For supplemental analysis Long-Term Equivalent Sound Level [$L_{eq(x)}$] (where X represents the time period of concern) or Time Above (TA) may be used for analysis of school and communications requirements indoors during specific hours.
- Public health and welfare effects below DNL 60 dB have not been established, but are assumed to decrease according to the decrease in percent of people highly annoyed.

Environmental Degradation/Impact

- Under NEPA, environmental degradation might have to be assessed around airports even if there is no clear effect on public health and welfare. Other criteria might be appropriate.
- A 3 dB increase in the DNL environment represents a doubling of sound energy, and clearly is an indicator of the need for further analysis, although smaller increases may indicate similar need. In other words, the impact of a given incremental amount of change in noise levels depends, in part, upon the existing level of the noise environment.
- Recent technology and software advances in geographic information systems (GIS), noise methodology and census data present an enhanced potential for

detailed analysis of sound impacts on population and noise-sensitive areas. These technologies should be considered for use to determine noise impacts of present and proposed actions.

Land Use Planning

- DNL represents the accepted noise metric for input to compatible land use planning.
- For cumulative speech interference, Table 3-2 "Effects of Noise on People" contained in FICON Volume II: Technical Report, provides a rough approximation of both outdoor and indoor predicted speech interference parameters for various levels of noise exposure as measured in DNL for residential land use only.
- There is a need for selective updating [including Standard Land Use Coding Manual (SLUCM) updating] and enhanced public understanding of the land-use compatibility guidelines, its application and interpretation through incentives and other programs.

Education of the Public

Education of the public should concentrate on the following frequently misunderstood issues:

- Environmental noise exposure is measured and described most generally by Day-Night Average A-Weighted Sound Level (DNL). DNL should be defined clearly and its significance and use explained clearly.
- Relation of DNL to Percent Highly Annoyed describes long-term community response to the overall sound environment (indices of health and welfare effects).
- Although the A-Weighted Maximum Sound Level (L_{max}) for a single flyover is easily understood, it is useful only for analyzing short-term responses.
- Every change in the noise environment does not necessarily impact public health and welfare.
- Aircraft noise predictions below DNL 65 dB can be less accurate and should be interpreted with caution.

POLICY RECOMMENDATIONS

- Continue use of the DNL metric as the principal means for describing long-term noise exposure of civil and military aircraft operations. [Section 3.1, Volume I]
- Continue agency discretion in the use of supplemental noise analysis. [Section 3.2, Volume I]
- Improve public understanding of the DNL, supplemental methodologies and aircraft noise impacts. [Section 3.3, Volume I]
- If screening analysis shows that noise-sensitive areas will be at or above DNL 65 dB and will have an increase of DNL 1.5 dB or more, further analysis should be conducted of noise-sensitive areas between DNL 60-65 dB having an increase of

- DNL 3 dB or more due to the proposed airport noise exposure. [Section 3.4, Volume I]
- If the DNL 65 dB screening test calls for further analysis between DNL 60-65 dB, agency mitigation options will include noise sensitive areas between 60-65 dB that are projected to have an increase of 3 dB or more as a result of the proposed airport noise exposure. [Section 3.5, Volume I]
 - If a FAA FAR Part 150 program is included by the FAA as a NEPA mitigation measure, the FAA and the airport operator are responsible for ensuring that the commitment is carried out and the Part 150 study scope conforms to the NEPA scope of analysis. [Section 3.6, Volume I]
 - Increase research (R&D) on methodology development and on the impact of aircraft noise. To foster this, a standing Federal interagency committee should be established to assist agencies in providing adequate forums for discussion of public and private sector proposals identifying needed research and in encouraging R&D in these areas. The following initial R&D issues are recommended:
 - Evaluate potential modifications to the 1980 FICUN land use compatibility table to improve its usefulness for both routine land use planning and planning for noise-sensitive land uses.
 - Continue research into community reaction to aircraft noise, including sleep disturbance, speech interference, and non-auditory health effects of noise.
 - Investigate differences in perceptions of aircraft noise, ground transportation noise (highways and railroads), and general background noise.
 - Continue and expand research on the airport noise impacts of rotary-wing operations. [Section 3.7, Volume I]

It is the FICON's belief that these recommendations will provide both immediate and long-term improvements in airport noise analysis. Federal interagency encouragement of a continuing review of airport noise analysis will provide for future incorporation of improved airport noise analysis techniques and provide a forum to address related public concerns.

While the FICON is seeking to achieve improved uniformity among Federal agencies in airport noise impact analysis, it must also be recognized that agencies have differing legislative mandates and operating environments. These recommendations should be viewed as general guidance. Each Federal agency must determine how it can best use this guidance, supplementing it as appropriate to meet agency needs, within the framework of the NEPA requirements.

The FICON Report itself neither addresses the adequacy of compliance with NEPA to-date by the participating agencies, attempts to redefine thresholds of significance of impacts under NEPA, nor modifies the NEPA regulations or procedures of the agencies.

FEDERAL INTERAGENCY COMMITTEE ON NOISE

TABLE OF CONTENTS

| | |
|--|------|
| LIST OF TABLES | i |
| ABBREVIATIONS AND ACRONYMS | iii |
| SECTION 1 INTRODUCTION | 1-1 |
| 1.1 Introduction | 1-1 |
| 1.2 The National Environmental Policy Act (NEPA) Process | 1-1 |
| 1.3 Study Purpose | 1-2 |
| 1.4 Study Approach | 1-3 |
| 1.5 Summary of Recommendations | 1-4 |
| SECTION 2 BACKGROUND | 2-1 |
| 2.1 Background | 2-1 |
| 2.2 Noise Evaluation Methodologies | 2-2 |
| 2.3 Supplemental Noise Evaluation Methodologies and Metrics | 2-3 |
| 2.4 Noise Effects | 2-4 |
| 2.4.1 Annoyance | 2-4 |
| 2.4.2 Health Effects | 2-6 |
| 2.5 Land Use Compatibility | 2-6 |
| SECTION 3 AIRPORT NOISE POLICY RECOMMENDATIONS | 3-1 |
| 3.1 DNL Metric | 3-1 |
| 3.2 Supplemental Noise Analysis | 3-3 |
| 3.3 Improvements in Explanation of Noise Metrics and Supplemental Methodologies .. | 3-4 |
| 3.4 Scope of Airport Noise Analysis between DNL 60 dB and 65 dB | 3-5 |
| 3.5 Scope of Noise Analysis That Will Guide Potential Mitigation Measures | 3-7 |
| 3.6 Relationship between NEPA and FAA FAR Part 150 Actions | 3-8 |
| 3.7 Research and Development | 3-10 |
| SECTION 4 REFERENCES | 4-1 |
| APPENDIX A DESCRIPTION OF FEDERAL AVIATION REGULATION (FAR) PART 150 | A-1 |
| APPENDIX B PARTICIPANTS (POLICY/LEGAL SUBGROUPS) | B-1 |

LIST OF TABLES

| | |
|--|-----|
| Table 2.1 Federal Agency Policy and Programs Summary | 2-5 |
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FEDERAL INTERAGENCY COMMITTEE ON NOISE

ABBREVIATIONS AND ACRONYMS

| | |
|--------------|---|
| %HA | Symbol for Percent Highly Annoyed |
| AAMRL | Armstrong Aerospace Medical Research Laboratory, now known as Armstrong Laboratory (USAF) |
| AL/OEBN | Armstrong Laboratory, Noise Effects Branch (USAF) |
| AEM | Area Equivalent Method |
| AF | Air Force |
| AFB | Air Force Base |
| AFM | Air Force Manual |
| AGL | Above Ground Level (Altitude in Feet) |
| AICUZ | Air Installation Compatible Use Zone |
| ANSI | American National Standards Institute |
| ASNA | Aviation Safety and Noise Abatement Act of 1979 |
| CAB | Civil Aeronautics Board |
| CEQ | Council on Environmental Quality |
| CFR | Code of Federal Regulations |
| CHABA | Committee on Hearing, Bioacoustics, and Biomechanics (of the National Academy of Science) |
| CNEL | Community Noise Equivalent Level (used in California) |
| dB | Decibel |
| DNL | Day-Night Average A-Weighted Sound Level |
| DoD | (U.S.) Department of Defense |
| DOJ | (U.S.) Department of Justice |
| DOT | (U.S.) Department of Transportation |
| EA | Environmental Assessment |
| EECP | Expanded East Coast Plan |
| EIS | Environmental Impact Statement |
| EPA | (U.S.) Environmental Protection Agency |
| FAA | (U.S. DOT) Federal Aviation Administration |
| FAR | Federal Aviation Regulation |
| FHWA | (U.S. DOT) Federal Highway Administration |
| FI | Fractional Impact Method |
| FICON | Federal Interagency Committee on Noise (1992) |
| FICUN | Federal Interagency Committee on Urban Noise (1980) |
| GIS | Geographic Information System |
| HUD | (U.S.) Department of Housing and Urban Development |
| Hz | Hertz (formerly cycles/second) |
| INM | Integrated Noise Model (FAA) |
| L_{dn} | Symbol for Day-Night Average A-Weighted Sound Level (DNL) |
| L_{eq} | Long-Term A-Weighted Equivalent Sound Level |
| $L_{eq(24)}$ | Equivalent Sound Level during a 24 hour time period |
| $L_{eq(x)}$ | Equivalent Sound Level during a given time period |
| L_{max} | A-weighted Maximum Sound Level |
| LWP | Level Weighted Population |
| NCA | Noise Control Act |
| NEPA | National Environmental Policy Act |
| NIHL | Noise-Induced Hearing Loss |
| NIOSH | National Institute for Occupational Safety and Health |
| NIPTS | Noise-Induced Permanent Threshold Shift |

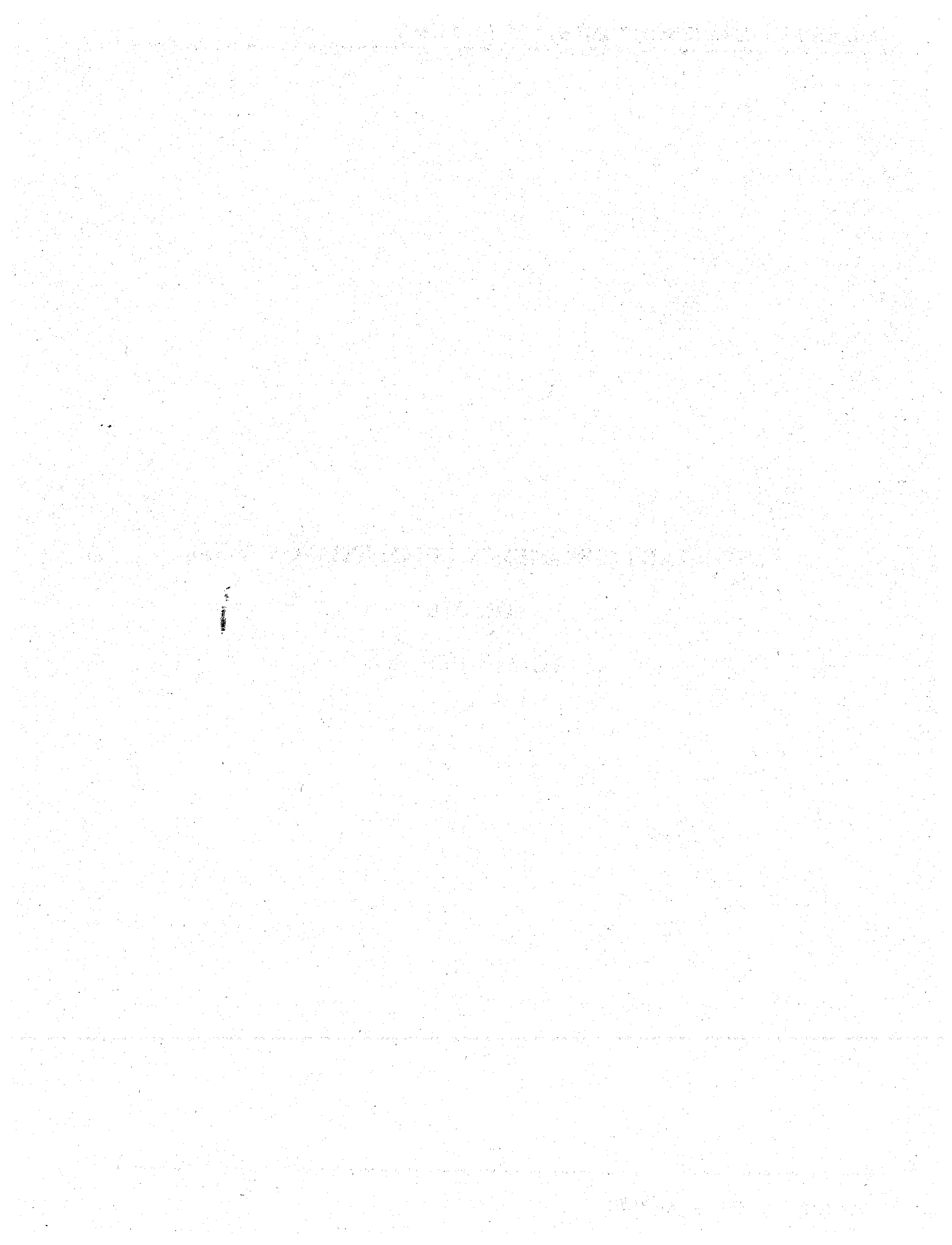
FEDERAL INTERAGENCY COMMITTEE ON NOISE

| | |
|----------|---|
| NITTS | Noise-Induced Temporary Threshold Shift |
| NOISEMAP | DoD Noise Model |
| NSBIT | Noise and Sonic Boom Impact Technology (Air Force Armstrong Laboratory) |
| SEL | Sound Exposure Level |
| SIL | Speech Interference Level |
| SLUCM | Standard Land Use Coding Manual |
| SPL | (Third Octave Band) Sound Pressure Level |
| TA | Time Above |
| USAF | United States Air Force |
| USGS | U.S. Geological Survey |
| VA | (U.S.) Department of Veterans Affairs |
| YDNL | Yearly Day-Night Average A-Weighted Sound Level |

FEDERAL INTERAGENCY COMMITTEE ON NOISE

VOLUME 1

POLICY REPORT



SECTION 1 INTRODUCTION

1.1 Introduction

This report describes the purpose and recommendations of the Federal Interagency Committee on Noise (FICON). The FICON was formed in December 1990 with a basic charter to review specific elements of the assessment of airport noise impacts contained in documents prepared pursuant to the National Environmental Policy Act (NEPA) and to Federal Aviation Regulation (FAR) Part 150, and to make recommendations regarding potential improvements to that process. The technical foundation of this report is contained herein as Volume II: FICON Technical Report.

1.2 The National Environmental Policy Act (NEPA) Process

The National Environmental Policy Act (NEPA), enacted in 1970, declares a national policy of "encourage(ing) productive and enjoyable harmony between man and his environment," and declares that protection and enhancement of the environment is the "continuing responsibility" of the federal government [42 USC § 4321, 4331(b)]. To ensure that such environmental goals are met, NEPA requires federal agencies to analyze the environmental impacts of proposed actions, to document that such analyses were performed, and to provide the public with an opportunity to comment on those analyses [Sec 42 USC § 4332(2)(c) and 40 CFR Parts 1500-1508]. This process of considering the environmental impacts of proposed federal actions is known as the "NEPA process."

Briefly, under NEPA and regulations promulgated by the Council on Environmental Quality (CEQ) to implement the procedural provisions of the statute (CEQ 1986), an Executive Branch federal agency is required to prepare an environmental impact statement (EIS) for a proposed action if that action is expected to have a "significant" effect on the quality of the human environment (See 40 CFR Part 1502). When the significance of the anticipated environmental effects of a proposed agency action is unclear, the agency must prepare an environmental assessment (EA) to assist in making that determination (See 40 CFR Part 1508.9). If, on the basis of an EA, the agency determines that the environmental impact(s) of its proposal may be significant, then the agency must prepare an EIS. If the agency determines that the impacts will not be significant, it may issue a "Finding of No Significant Impact" (FONSI) and proceed with its proposal. Only those actions that an agency has determined in advance to have no significant environmental effects, individually or cumulatively (categorical exclusions), are exempt from NEPA documentation (See 40 CFR Part 1508.4).

As required by the CEQ regulations, each Executive Branch federal agency also has its own NEPA implementing regulations that supplement the CEQ regulations (See 40 CFR Part 1507.3). Each agency identifies both those types of actions that typically have significant environmental

impacts and thus require preparation of EISs, and those actions that typically have no significant environmental impacts and thus are categorically excluded from NEPA requirements. All other actions require at least the preparation of EAs.

While CEQ is authorized to oversee Executive Branch federal agency implementation of NEPA, the Environmental Protection Agency (EPA) is directed in Section 309 of the Clean Air Act to "review and comment in writing" on all EISs prepared by federal agencies (42 USC 7609). If the EPA Administrator determines that a particular agency action is unsatisfactory from the standpoint of public health and welfare or environmental quality, he or she is required to refer the matter to CEQ for review.

1.3 Study Purpose

Pursuant to its Section 309 authority, EPA reviewed a draft EIS prepared by the Federal Aviation Administration (FAA) for a proposed expansion of the Toledo Express Airport in Toledo, Ohio. EPA raised specific objections to the draft EIS relating to the analysis and mitigation of noise impacts. Although these issues were eventually resolved at the final EIS stage for the Toledo project, the FAA and EPA agreed to jointly study the underlying basis for the disagreements and to attempt to resolve the identified differences between the two agencies on noise analysis in NEPA documents.

To facilitate resolution of the issues, the respective Deputy Administrators of FAA and EPA initiated an interagency working group to review the technical and policy issues involved (U.S. DOT, FAA 1990; U.S. EPA 1990). Five specific issues were identified that formed the basis for the work group focus. These five issues are:

- The manner in which noise impacts are determined, including whether aircraft noise impacts are fundamentally different from other transportation noise impacts;
- The manner in which noise impacts are described;
- The extent of impacts outside of Day-Night Average A-Weighted Sound Level (DNL) 65 decibels (dB) that should be reviewed in a National Environmental Policy Act (NEPA) document;
- The range of Federal Aviation Administration (FAA)-controlled mitigation options (noise abatement and flight track procedures) analyzed; and,
- The relationship of the FAA Federal Aviation Regulation (FAR) Part 150 process to the NEPA process; including ramifications to the NEPA process if they are separate, and exploration of the means by which the two processes can be handled to maximize benefits.

Although the origin of these issues was specific to FAA and EPA, it was recognized that the issues relating to the use and application of the DNL metric were of vital interest to other Federal agencies involved in aircraft noise related decisions. Since the DNL metric was formally recommended by EPA in 1974 (U.S. Environmental Protection Agency 1974) and agreed upon in 1980 by the Federal Interagency Committee on Urban Noise for use in their Guidelines for

FEDERAL INTERAGENCY COMMITTEE ON NOISE

Considering Noise in Land Use Planning and Control (FICUN 1980)¹, the working group was expanded to include those FICUN agencies involved in airport noise issues.

The agencies that participated in the 1980 FICUN included the Department of Defense (DoD), the Department of Housing and Urban Development (HUD), the Environmental Protection Agency (EPA), the Department of Transportation (DOT), and the Department of Veterans Affairs (VA). The policies and programs discussed in the 1980 FICUN all shared a common goal of protecting the public health and welfare with regard to noise. Most FICUN policies also stated additional goals in recognition that noise is a specific constraint on particular agency missions. DoD, for example, stated as a primary goal of its noise policy the continuance of operational integrity at its airfields (FICUN 1980).

By involving these Federal agencies, it was envisioned that any conclusions reached would provide guidance for each agency to adopt and implement consistent with their operational requirements, thereby improving consistency in the federal approach for aircraft noise analysis in NEPA documents.

In addition to the FICUN agencies, the Council on Environmental Quality (CEQ) and the Department of Justice (DOJ) were added to the current working group because of their roles in NEPA issues. This working group has become known as the Federal Interagency Committee on Noise (FICON). The charter of the group is limited to the examination of the issues specified above. The working parameters of the FICON are:

- Review of the issues will be done within the context of the NEPA process and the CEQ regulations and guidance.
- Issues that relate to the operation of fixed wing aircraft in and around airports.
- The review will be limited to existing information, with no conduct of new research.
- Analysis of the issues and presentation of recommendations on these issues will be made to the various agencies for decision on all five issues. No decision making or implementation will occur prior to that presentation.
- Any resulting change in regulations and/or procedures will follow individual agency's rules for public review and comment prior to adoption.

1.4 Study Approach

To address these issues systematically, three subgroups were formed to examine and analyze the technical, policy and legal implications separately.

Subgroup 1, chaired by the Air Force on the behalf of DoD, reviewed technical and scientific matters related to the adequacy of current data and methodology for use in NEPA (EIS/EA) analysis of airport operations. Their technical report (Volume II) summarizes the results of that evaluation, and was used as the basis for work by the Subgroups 2 and 3.

Subgroup 2, chaired by the EPA, reviewed all the issues from the perspective of agency policy and procedures and the requirements of NEPA/CEQ regulations.

¹ See Section 2.1 for origin and description of 1980 FICUN.

Subgroup 3, chaired by the FAA, reviewed the legal aspects of all issues. The results of their review have been incorporated into the reports of the Technical and Policy Subgroups. Participating agencies and their representatives are listed in Appendix B, Volume I and Appendix C, Volume II.

1.5 Summary of Recommendations

Following its review, the FICON concluded that the federal noise assessment process can and should be improved. The improvements suggested are not radical. They fall within the normal process of periodically reassessing present procedures and techniques to ensure that the most practical and realistic approaches are being used. The specific recommendations are summarized below and are discussed in detail in the section noted at the end of each recommendation.

- Continue use of the DNL metric as the principal means for describing the long-term noise impact of civil and military aircraft operations. [Section 3.1]
- Continue agency discretion in the use of supplemental noise analysis. [Section 3.2]
- Improve public understanding of the DNL, supplemental methodologies and aircraft noise impacts. [Section 3.3]
- If screening analysis shows that noise sensitive areas will be at or above DNL 65 dB and will have an increase of DNL 1.5 dB or more, further analysis should be conducted of noise-sensitive areas between DNL 60-65 dB having an increase of DNL 3 dB or more due to the proposed airport noise exposure. [Section 3.4]
- If the DNL 65 dB screening test calls for further analysis between DNL 60-65 dB, agency mitigation options may include noise sensitive areas between DNL 60-65 dB that are projected to have an increase of 3 dB or more as a result of the proposed airport noise exposure. [Section 3.5]
- If a FAA FAR Part 150 program is included by the FAA as a NEPA mitigation measure, the FAA and the airport operator are responsible for ensuring that the commitment is carried out and the Part 150 study scope conforms to the NEPA scope of analysis. [Section 3.6]
- Increase research (R&D) on methodology development and on the impact of aircraft noise. To foster this, a standing Federal interagency committee should be established to assist agencies in providing adequate forums for discussion of public and private sector proposals, identifying needed research, and encouraging R&D in these areas. [Section 3.7]

It is the FICON's belief that these recommendations will provide for both immediate and long-term improvements in airport noise analysis. Federal interagency encouragement of the continuing review of airport noise analysis will provide for future incorporation of improved airport noise analysis techniques and provide a forum to address related public concerns.

While the FICON is seeking to achieve improved uniformity among Federal agencies in airport noise analysis, it must also be recognized that agencies have differing legislative mandates and operating environments. Thus, these recommendations should be viewed as general guidance. Each Federal agency must determine how it can best use this guidance, supplementing it as appropriate to meet agency needs within the framework of its NEPA requirements.

SECTION 2 BACKGROUND

2.1 Background

In 1972, Congress enacted the Noise Control Act (NCA), Public Law 92-574. Among the requirements under NCA was a directive to the Administrator of the Environmental Protection Agency (EPA) to "...publish information on the levels of environmental noise, the attainment and maintenance of which in defined areas under various conditions are requisite to protect the public health and welfare with an adequate margin of safety." The resulting report was published as EPA-550/9-47-004, Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, (1974) commonly referred to as the "Levels Document."

In the "Levels Document," the EPA reported that the best metrics to describe the effects of environmental noise in a simple, uniform and appropriate way were:

- the Long-Term Equivalent A-Weighted Sound Level (L_{eq}); and
- the Day-Night Average Sound Level (DNL), which may be symbolized as L_{dn} ; it is a variant of L_{eq} that incorporates a 10 dB "penalty" for nighttime noise.

The protective levels identified in the "Levels Document" do not constitute "standards" since they do not account for the cost or feasibility of achievement. It is also pertinent that the "Levels Document" defines the public health and welfare in broad terms, based on the World Health Organization's definition of "health" as "complete physical and mental well-being and not merely the absence of disease and infirmity".

In response to a request in 1972 by EPA, the National Academy of Science's Committee on Hearing, Bioacoustics and Biomechanics (CHABA) Working Group 69 held deliberations from 1972 to 1976. The result of this effort was the publication of CHABA's Guidelines for Preparing Environmental Impact Statements on Noise (1977). These guidelines were proposed for the uniform description and assessment of the various noise environments potentially requiring an EIS.

Following the publication of the CHABA Guidelines, Schultz published his "Synthesis of Social Surveys on Noise Annoyance" in 1978. Schultz's synthesis of the dosage-effect relationship provided the best tool available to environmental planners to predict noise-induced chronic annoyance. In fact, chronic annoyance is the implicit basis for noise related habitability criteria, such as those adopted by various government agencies (U.S. Department of Defense 1978).

In late 1979, the FICUN was formed to put the various Federal agencies' policy and guidance packages on environmental noise into perspective. The result was the publication of Guidelines for Considering Noise in Land Use Planning and Control (1980). The Guidelines do not replace individual Federal agency criteria, but serve as a point-of-departure for each agency's programs, and for facilitating the consideration of noise in all land use planning and

interagency/intergovernmental processes. The FICUN established DNL as the descriptor to be used for all noise sources. The L_{eq} descriptor was included because some highway noise is described in terms of an equivalent sound level for the highway "design hour." Table 2 of the FICUN Guidelines contained land use compatibility guidelines and Table D-1 describes the chronic effects of noise on people in terms of annoyance, speech interference, and hearing loss.

In 1982, the EPA published Guidelines for Noise Impact Analysis based on the CHABA Guidelines. The purpose of the EPA Guidelines was to provide decision-makers, both in the public and private sectors, with analytic procedures that could be used uniformly to express and quantify impacts from noise (U.S. Environmental Protection Agency 1982). Individual agencies have developed their own guidance for assessing aircraft noise in NEPA documents.

In 1990, the American National Standards Institute (ANSI) revised their 1980 Standard on Sound Level Descriptors for Determination of Compatible Land Use (ANSI S12.40-1990). This new standard continues to identify DNL as the "acoustical measure to be used in assessing compatibility between various land uses and outdoor noise environment." The standard further states:

Ordinarily, land uses are of long-term, continuing nature, and the yearly day-night average sound level is appropriate for these land uses. For other land uses, compatibility is to be assessed by the average sound level during the time interval of interest for the land use involved.

2.2 Noise Evaluation Methodologies

As outlined above, the Long-Term A-Weighted Equivalent Sound Level (L_{eq}) and the Day-Night Average Sound Level (DNL or L_{dn}) were selected as the appropriate descriptors for noise because they reliably correlate with health and welfare effects. From data on many community social surveys, DNL has been found to correlate well with community annoyance, as measured in terms of percentage of exposed persons who are "Highly Annoyed."

In general, the noise exposure is defined by use of computed DNL contours. While endorsing DNL, not all agencies apply the DNL methodology in the same manner. Most agencies plot noise contours only for $DNL \geq 65$ dB. Some plot contours down to $DNL \geq 60$ dB, but generally on a case-by-case basis only. Others conduct point analysis down to $DNL 60$ dB for noise-sensitive areas such as schools, hospitals and churches.

Variations among agencies also exist in how DNL is calculated. For example, the 24-hour averaging time is sometimes based on average yearly operations and sometimes on variations of average busy day, whichever is considered most representative of flying conditions. Although seasonal corrections are not included in the definition of the DNL metric, the methodology does not preclude such corrections in any analysis of a special, well-defined noise exposure scenario. Agencies have different policies on whether ground run-up operations are included in the DNL models. Agencies apply various screening criteria for evaluating whether incremental or additional proposed changes warrant further noise analysis. Finally, agencies' methods of summarizing noise impacts vary. Most typically, impacts are summarized in one or more of the following ways: (1) by percent of number of people highly annoyed and the number of people highly annoyed at $DNL \geq 65$

dB; (2) by number of people or acres exposed to $DNL \geq 65$ dB; and (3) by identification of specific noise-sensitive land uses and areas.

Noise predictions are less reliable at lower noise levels, and at increasing distances from the airport since the ability to determine the contribution of different noise sources decreases with diminishing intensity and increasing distance from the source. There are also problems in interpreting predictions at lower levels since public health and welfare effects below $DNL 60$ dB ($DNL 60$ dB includes a 5 dB margin of safety) have not been established. These effects are assumed to decrease according to the decrease in percent of people highly annoyed.

Much of the criticism of the use of DNL for community annoyance (U.S. EPA 1991) and land use compatibility around airports stems from a failure to understand the basis for the measurement or calculation of that metric. This misunderstanding may arise from the fact that although DNL is strongly influenced by the maximum sound level, it is much lower in value, and therefore may not convey to the public the loudness of individual flyovers. DNL takes into account the magnitude of the sound levels of all individual events that occur during the 24-hour period, the number of events, and an increased sensitivity to noise during typical sleeping hours. DNL is an average in that it accumulates all the noise exposure over a 24-hour period and divides the total by the number of seconds in a day. As described in the FICON Technical Report, the logarithmic nature of the decibel (dB) unit on which DNL is based causes sound levels of the loudest events to control the 24-hour average.

2.3 Supplemental Noise Evaluation Methodologies and Metrics

DNL is sometimes supplemented by other metrics to characterize specific effects on a case-by-case basis. This may include the cumulative metric of L_{eq} (Equivalent Sound Level) for varying representative time periods. Single event metrics used for supplemental analysis may include SEL (Sound Exposure Level), Third Octave Band Sound Pressure Level (SPL), L_{max} (A-weighted Maximum Sound Level), and TA (Time Above - expressed in minutes for which aircraft-related noise exceeds specified A-weighted sound levels). In addition, to comply with various State requirements, metrics such as the Community Noise Equivalent Level² (CNEL), used in California, and the level exceeded a specified percentage of the time, ($L_{Percent}$) (L_{10} is used in Minnesota) are sometimes included.

The DNL methodology includes a 10-dB nighttime penalty that reflects the potential for added annoyance due to sleep disturbance, speech interference, and other effects. However, supplemental single event analysis is sometimes conducted to evaluate sleep disturbances and, less frequently, speech interference issues, primarily at specific locations where the DNL is below 65 dB. The use of single event analysis is limited because there is no accepted methodology for aggregating these values into some form of cumulative or overall impact description. TA is sometimes considered for evaluating speech interference in schools.

² The Community Noise Equivalent Level includes a 5 dB penalty for noise between 7 and 10 p.m. and a 10 dB penalty for noise between 10 p.m. and 7 a.m. California accepts DNL as equivalent to CNEL for planning purposes.

Single event prediction methods have limited application to land use planning. One should not infer that an area is simultaneously exposed to a given single event level, since noise decays with increasing distance from the flight track. Single event levels have been calculated and published for given aircraft, at given distances and power settings (See Volume II, Appendix B, Tables B.2 and B.3). However, in determining the single event level for a given event, one must consider the variations in an aircraft flight profile caused by variations in weight, daily and seasonal weather changes, wind, power settings, etc. Consequently, the single event metric has limited use in determining long-term noise impacts. When single event metrics are used to supplement DNL, they serve only to provide additional information. Single event metrics have been used to evaluate sleep interference, but do not predict long-term human health impacts.

The various approaches to airport noise assessment methodology used by Federal agencies are summarized in Table 2.1

2.4 Noise Effects

2.4.1 Annoyance

Until the 1950s, the effects of aircraft noise were evaluated largely on the basis of anecdotal evidence, case studies, laboratory studies, and a very few social surveys. Even in early days, "annoyance" was given prominence and the severity of annoyance was thought to be very important. In more recent years, there has been emphasis on obtaining data on community response from social surveys of the affected communities. A major effort has been directed toward finding a relationship between noise exposure metrics and a measure of activity interference (assumed by most researchers to be primarily communication interference) or annoyance as measured by a social survey. A wide variety of responses have been used to determine intrusiveness of noise and disturbances such as speech interference, sleep disturbance, interference with TV or radio listening, and interference with outdoor living. The concept of "percent highly annoyed" has provided the most consistent response of a community to a particular noise environment.

In an attempt to meet the demand for a usable and uniform relationship, Schultz reviewed the results of a number of social surveys where data were available to make a consistent judgement concerning what percent of the population was "highly annoyed" (%HA) (Schultz 1978). The surveys were of community reactions to several types of transportation noises such as road traffic, railroad, and aircraft noises. The results agreed fairly well with one another and Schultz developed an equation for describing the relationship between the level of exposure (in DNL) and %HA. This relationship was adopted by CHABA Working Group 69 (National Academy of Sciences 1977) in the guidelines previously discussed. EPA proposed %HA as the appropriate impact criterion to use for evaluating the effects of noise on communities (U.S. Environmental Protection Agency 1982).

The Schultz relationship has been validated in several subsequent studies. Fidell and associates (Fidell 1989) updated the data base originally used by Schultz. Subsequent research documented in the update added 239 data points to the original 161 data points analyzed by Schultz, for a total of 400 points. The Department of the Air Force's Armstrong Laboratory used a

