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Guidance on the Balanced Approach to Aircraft Noise Management

Approved by the Secretary General
and published under his authority

Second Edition — 2008

International Civil Aviation Organization

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GLOSSARY

Action plan. Action plans are designed to manage noise issues and effects, including noise reduction if necessary.

Area navigation (RNAV). A method of navigation that permits aircraft operation on any desired flight path with the coverage of station-referenced navigation aids within the limits of the capability of self-contained aids, or a combination of these.

Authority (the). In this context, it is the entity delegated by an ICAO Contracting State to conduct a Balanced Approach study at an airport.

Balanced Approach to noise management. The Balanced Approach to noise management developed by ICAO is an approach to managing noise at an airport that consists of identifying the noise problem at an airport and then analysing the various measures available to reduce noise through the exploration of four principal elements, namely, reduction at source, land-use planning and management, noise abatement operational procedures and operating restrictions, with the goal of addressing the noise problem in the most cost-effective manner.

Baseline noise situation. The “baseline” noise situation is the variation between that which currently exists and that which is expected to exist at a given point in the future taking into account all noise mitigation actions that are already planned without further action.

Cap rule. A global measure that defines that the maximum number of operations not to be exceeded at an airport often for a given time period of the year.

Compatible land use. The use of land (for example, commercial, industrial, agricultural) that is normally compatible with aircraft and airport operations, or sound-insulated land uses (for example, sound-insulated homes, schools, nursing homes, hospitals, libraries) that would otherwise be considered incompatible with aircraft and airport operations.

Competent authority. Any national body or authority designated or otherwise recognized as such for any purpose in connection with the United Nations regulations.

Continuous descent approach (CDA). Commonly referring to the initial approach phase between 6 000 ft and the interception of the glide slope, CDA ideally allows an uninterrupted descent from cruising altitude; in practice, it is usually defined as a descent with no segment of level flight exceeding 2 or 2.5 NM. CDA reduces the noise experienced on the ground by reducing the overall thrust required during initial descent and keeping the aircraft higher for longer. In addition to noise reduction, CDA can provide emission benefits.

Contracting State. A State that is a member of the International Civil Aviation Organization (ICAO) as being party to the 1944 Chicago Convention.

Cost-benefit analysis (CBA). An evaluation method that provides a logical and consistent framework for assessing a particular option or options. A CBA gives an indication of the total economic welfare effects of a project by comparing all costs and benefits.

Cost-effectiveness analysis (CEA). An evaluation method to be used when the objective of a measure is a given. It differs from a CBA in that it asks a different question; namely, given a particular objective, which is the least costly way of achieving it?

Curfew. An airport curfew is a global or aircraft-specific partial operating restriction that prohibits take-off and/or landing during an identified time period.

Day-night average sound level (DNL). A noise measure used to describe the average aircraft noise levels over a 24-hour period, typically an average day over the course of a year. DNL considers aircraft operations occurring between the hours of 10 p.m. and 7 a.m. to be ten decibels louder than operations occurring during the daytime to account for increased annoyance when ambient noise levels are lower and residents are sleeping. The symbol for DNL is L_{dn} .

Dispute resolution. In this context, dispute resolution is the agreed-upon process by which participants of a Balanced Approach study at an airport can resolve their differences.

Encroachment analysis. Financial evaluation over a time frame, usually ten to twenty years, of the percentage of change in population/households within the airport noise-regulated area where land-use planning is applicable as defined by the authority.

Financial instruments. Financial instruments include capital improvements, tax incentives and noise-related airport charges for revenue generation to fund land-use initiatives.

Incompatible land use. The use of land which is normally incompatible with aircraft and airport operations for homes, schools, nursing homes, hospitals and libraries.

Land-use compatibility. The coexistence of land uses surrounding the airport with airport-related activities.

Land-use zones. Land areas that are defined as noise impacted through the use of noise contours prepared as an aspect of a Balanced Approach programme.

Management/airport master plan. Presents the planner's conception of the ultimate development of a specific airport. It effectively presents the research and logic from which the plan was evolved and artfully displays the plan in a graphic and written report. Master plans are applied in the modernization and expansion of existing airports and in the construction of new airports, regardless of their size or functional role. In the context of this definition, the term "development" is taken to mean inclusion of the entire area of the airport — both aviation and non-aviation uses. It also includes suggested land use on land adjacent to the airport. The master plan should establish a schedule of priorities and phasing for the various improvements described in the master plan.

Measures. In the context of this document, measures under the four principal elements are actions that if implemented may alleviate adverse noise impacts or achieve environmental benefits.

Mitigating instruments. The measures in this category include building codes, noise insulation programmes, land acquisition and relocation, transaction assistance, real estate disclosure and noise barriers.

Navigation aids. Any facility used by an aircraft for guiding or controlling flight in the air or on the landing or take-off of an aircraft.

Net present value (NPV). Net present value (NPV) or life cycle methodology is a rigorous approach for developing a measure of the expected economic performance of a project. An NPV analysis focuses on the annual cash flows (monetary values) of costs and benefits related to the project.

Noise abatement operational procedures. Take-off and climb procedures that alleviate noise at some noise-sensitive locations around the airport.

Noise contour. A line of constant value of a cumulative aircraft noise level or index around an airport.

Noise impact. The adverse effect(s) of noise on its recipients; importantly, it is implied that noise metrics are indicators of noise impact.

Noise index. A measure of long-term or cumulative sound that correlates with (i.e. is considered to be a predictor of) its effect on people. May take some account of factors in addition to the magnitude of sound (especially time of day).

Noise level. A decibel measure of sound on a scale which indicates its loudness or noisiness. For environmental noise from aircraft, two scales are generally used: A-weighted sound level and perceived noise level. These scales apply different weights to the sound of different frequencies to mimic human perception.

Noise quota. A noise quota (sometimes expressed as a “noise budget”) caps the total noise level from aircraft operations within a given area over or around the airport to some established total value over a given period of time (six months, a year, etc.). This may be expressed in established noise energy over a period of time or in the allocation of a maximum number of operations weighted by noise certification levels of the aircraft over a period of time.

Noise-sensitive area. An area where aircraft noise may interfere with existing or planned use of the land. Whether noise interferes with a particular use depends upon the level of noise exposure and the types of activities that are involved. Residential neighbourhoods and educational, health and religious structures and sites as well as outdoor recreational, cultural and historic sites may be noise-sensitive areas.

Operating restrictions. An operating restriction is any noise-related action that limits or reduces an aircraft’s access to an airport.

Principal elements. Under the Balanced Approach are four principal elements that should be considered: reduction of noise at source, land-use planning and management, noise abatement operational procedures and operating restrictions on aircraft.

Social opportunity cost of capital (SOC). Can be approximated by the variable, before tax, real rate of return for business investments. SOC provides a high-bound for the discount rate sooner rather than later.

Social rate of time preference (SRTP). The rate at which society is willing to trade consumption between different time periods. An indicator of SRTP is the earning rate on personal savings.

Sound. Energy transmitted through air by (longitudinal) wave motion that is sensed by the ear.

Sound level. A measure of sound energy expressed in decibel units. Received sound is measured with or without frequency weighting; levels measured with a weighting are often termed noise levels.

Stakeholder. In this context, a party with an interest in or concern about the operations at an airport for which a Balanced Approach study is being or will be conducted. This includes governmental bodies, local authorities, airport authorities, operators, community members and bodies representing community members impacted by aircraft noise.

Standard instrument departure (SID). A designated instrument flight rule (IFR) departure route linking the aerodrome or a specified runway of the aerodrome with a specified significant point, normally on a designated ATS route, at which the en-route phase of a flight commences.

Standard terminal arrival (STAR). A designated instrument flight rule (IFR) arrival route linking a significant point, normally on an ATS route, with a point from which a published instrument approach procedure can be commenced.

PART I

THE BALANCED APPROACH TO AIRCRAFT NOISE MANAGEMENT

Chapter 1

INTRODUCTION

1.1 ASSEMBLY RESOLUTION A37-18: CONSOLIDATED STATEMENT OF CONTINUING ICAO POLICIES AND PRACTICES RELATED TO ENVIRONMENTAL PROTECTION — GENERAL PROVISIONS, NOISE AND LOCAL AIR QUALITY

1.1.1 At the 37th Session of the ICAO Assembly in September/October 2010, all participating Contracting States adopted Resolution A37-18, which expressed the unanimous consensus of the worldwide aviation community on both aircraft noise and gaseous emissions.

1.1.2 Appendices C, D, E, F and G to Resolution A37-18 cover the issue of aircraft noise in general, while Appendices C, E and F, in particular, contain the principal elements and the basic components of a process for implementing the concept of the “Balanced Approach” to manage aircraft noise at international airports.

1.1.3 The ICAO Assembly considered that the effectiveness of the policies at some airports for improving the noise climate could be enhanced with regard to the lack of consistency between the measures implemented and the difficulties encountered in preserving the benefits gained. It especially highlighted situations at many airports where land-use planning and management and noise abatement operational procedures are already being used and other noise mitigation measures are in place.

1.1.4 The ICAO Assembly, while recognizing that the “uncoordinated development of national and regional policies and programmes for the alleviation of aircraft noise could hinder the role of civil aviation in economic development,” also recognized that “States have relevant legal obligations, existing agreements, current laws and established policies which may influence their implementation of the ICAO ‘Balanced Approach’” and that “some States may also have wider policies on noise management.” However, the Assembly also recognized that “the process for implementation and decisions between elements of the Balanced Approach is for Contracting States and it is ultimately the responsibility of individual States to develop appropriate solutions to the noise problems at their airports, with due regard to ICAO rules and policies.”

1.1.5 The ICAO Assembly also considered that improvements in the noise climate achieved at many airports by the introduction or revision of aircraft-related measures (for example, the phase-out of Chapter 2 aircraft) should be safeguarded by taking into account the sustainability of future growth and should not be eroded by incompatible urban encroachment whenever possible in areas where reductions in noise levels have been achieved.

1.1.6 Taking these points into consideration, the ICAO Assembly adopted a new approach for managing aircraft noise at international airports — the Balanced Approach. The concept of the Balanced Approach particularly emphasizes the need to consider various measures available, as appropriate, according to the assessment made of the evolution in the noise situation at each airport with a view to achieve maximum environmental benefit most cost-effectively while preserving potential benefits gained from aircraft-related measures. Consistency between aircraft-related measures of different natures and land-use management measures are necessary to achieve improvements in the noise climate around airports in the long term.

1.2 THE BALANCED APPROACH

1.2.1 The Balanced Approach, as envisioned in A37-18, provides ICAO Contracting States with an internationally agreed approach to address aircraft noise problems where they occur — at individual airports — in an environmentally responsive and economically responsible way. The Balanced Approach gives ICAO Contracting States a flexible way to identify a specific noise problem and remedies that are targeted and tailored to the individual airport situation in a transparent process.

1.2.2 The Balanced Approach encompasses four principal elements: reduction of noise at source, land-use planning and management, noise abatement operational procedures and operating restrictions on aircraft.

1.2.3 ICAO Contracting States acknowledged that it was important to consider equally all of these elements, and they agreed to the principle that operating restrictions should not be applied as a first resort, but only after consideration of the benefits to be gained from other elements in a manner that is consistent with the Balanced Approach.

1.2.4 The process to implement the Balanced Approach would typically consist of an assessment of the noise situation at an individual airport, definition of the objective, provision for consultation, identification of measures available to reduce the noise impact, evaluation of the likely costs and benefits of the various measures available in order to identify the relative cost-effectiveness of the measures, selection of measures, adequate public notification of intended actions, implementation of measures, and a provision for dispute resolution available to stakeholders.

1.2.5 The goal is to address noise problems on an individual airport basis and to identify the noise-related measures that achieve maximum environmental benefit most cost-effectively using objective and measurable criteria.

1.3 SAFETY AND EFFICIENCY

This guidance material is based on the understanding that there are many ways to address aircraft noise. In certain cases, it suggests measures that affect the operation of the aircraft, both in the air and on the ground, with the goal of minimizing noise exposure around airports. It is to be noted that the content is not of a regulatory nature and the choice of measures that may impact the operation of an aircraft and the management of air traffic must be carefully considered. In daily operations, factors such as current and forecast weather, runway conditions, available navigation aids, etc., must always be considered. **Safety must always be the overriding consideration** in all civil aviation operations, and the operator, in conjunction with the operating crew, must remain the ultimate judge of what can be done to maintain the necessary safety margins.

1.4 GUIDANCE MATERIAL

1.4.1 In order to assist ICAO Contracting States, the ICAO Council decided that guidance material needed to be developed containing the necessary advice and practical information States might need in implementing a Balanced Approach to noise management.

1.4.2 This guidance material describes the principal elements of the Balanced Approach, some of the measures available under each element, the relationship between the elements and the measures, and the analytical and methodological tools that might be used to assess and compare their costs and benefits.

1.4.3 The purpose of this material is to provide guidance, inter alia:

- for use in meeting the aviation sector's environmental responsibilities while fostering development within the aviation industry;

- aimed at supporting ICAO's goal of achieving maximum compatibility between the safe, economically effective and orderly development of civil aviation, and the quality of the environment;
- whereby ICAO Contracting States, working with airport and/or other authorities can identify a noise problem at an airport and analyse the various measures available to achieve maximum environmental benefit most cost-effectively, using generally accepted cost-comparative measures;
- to develop possible solutions that meet the specific assessed characteristics of the noise problem of the airport;
- to promote consistency and harmonization worldwide in noise management within an agreed international framework;
- to ensure the degree of flexibility required to accommodate local, national and regional differences;
- whereby particular attention to the cost and implications for operators and other stakeholders from developing countries may be taken into consideration.

1.4.4 Because this guidance material was developed to potentially assist all ICAO Contracting States in implementing the Balanced Approach, it is necessarily broad and extensive. Accordingly, some States may already have some or many of the processes and measures in place that are addressed in this guidance material. In such cases, this guidance material may be used to supplement those processes and measures or as additional reference.

1.4.5 Since the guidance material is broad and extensive, it cannot be expected to provide the level of detail necessary to assist States in addressing every issue that might arise, given that there may be unique legal, technical or political situations at particular localities. As with any guidance material of broad application, it is advised that States use it as a guide, to be shaped and applied to specific circumstances.

Chapter 2

THE BALANCED APPROACH

2.1 RESPONSIBILITY OF ICAO CONTRACTING STATES

2.1.1 The process for implementation and decisions between elements of the Balanced Approach is for Contracting States, and it is ultimately the responsibility of individual States to develop appropriate solutions to the noise problems at their airports, with due regard to ICAO rules and policies. During the different phases of the process, States may choose to delegate their powers to a competent authority to conduct the noise assessment and/or any relevant cost-benefit analysis.

2.1.2 This guidance material sets out building blocks that could be used by those ICAO Contracting States considering implementation of the Balanced Approach to noise management.

2.1.3 ICAO urges Contracting States to adopt this approach to noise management, taking full account of ICAO guidance, relevant legal obligations, existing agreements, current laws and established policies, when addressing noise issues. Many of the building blocks described below may already be in place in many Contracting States, or groups of Contracting States. In any event, the results of the process should be the identification and implementation of the noise measure or measures that achieve maximum environmental benefit in the most cost-effective way.

2.1.4 In implementing the Balanced Approach, a Contracting State may benefit from having an oversight programme. The Contracting State or its delegated competent authority could review the process used and the recommended solution for conformity with ICAO guidance, much as it would to ensure compliance with its own national laws, agreements, policies, etc.

2.2 AN AIRPORT-BY-AIRPORT APPROACH

2.2.1 The Balanced Approach is intended to apply to any airport being served by international air traffic which has a perceived noise problem. ICAO recognizes that solutions to noise problems need to be tailored to the specific characteristics of the airport concerned. This calls for an airport-by-airport approach and recognizes that similar solutions could be applied if similar noise problems are identified.

2.3 A TRANSPARENT PROCESS

2.3.1 ICAO urges States to institute or oversee a transparent process when assessing the noise objective to be achieved and when considering measures to alleviate a noise problem where it exists.

2.3.2 The building blocks of this transparent process include the following:

- assessment of the current and future noise impact at the airport concerned, compared to the noise objective to be achieved;

- evaluation of the likely costs and benefits of the various measures available;
- selection of measures with the goal to achieve maximum environmental benefits most cost-effectively;
- provision for dissemination of the evaluation results;
- provision for consultation with stakeholders at different stages from assessment to implementation;
- provision for dispute resolution.

2.3.3 The information that should be made available for each of the building blocks could be dependent on the noise objective, the airport characteristics, projected traffic growth and mix, relevant legal obligations, existing agreements, current laws and established policies and could include:

- the evolution of the noise impact and noise reduction expected to be achieved through the natural attrition of aircraft and the introduction, over time, of quieter aircraft;
- a description of the various measures available, which may include new certification standards, land-use planning initiatives, noise mitigation measures, voluntary agreements between airport authorities and operators, changes in noise abatement operational procedures, and operating restrictions. The process and information made available during the process may be dependent on the type of available measures;
- the effect of appropriate phase-in periods for new measures; and
- consultation on assessment of the noise problem, proposals for action and the possible impact of measures on stakeholders.

2.4 CONSULTATION WITH STAKEHOLDERS

2.4.1 A provision should be made for consultation with stakeholders, including members of the public whose quality of life may be potentially impacted, entities directly affected economically by operations at the airport level, and aircraft operators whose fleet investment may be impacted. This holds even where authority has been delegated.

2.4.2 When establishing consultation arrangements, careful consideration should be given to defining who is a “stakeholder”. For example, experience has shown that people living in areas outside published noise contours, but under or near busy flight paths, may want to fully participate in consultation processes.

2.4.3 In order to enhance communication within the consultation process, authorities could adopt a collaborative approach involving all stakeholders. Such involvement would enable participants to become fully informed about the noise issues encountered at the airport and the proposed solutions. The collaborative approach could also enable stakeholders to better understand the costs and benefits of an airport’s operations, which may lead to better acceptance of the solutions.

2.4.4 Ideally, an airport should have well established ongoing consultation arrangements in place and should not simply initiate them when a problem arises. This will facilitate open, informed and transparent discussions about evolving noise exposure patterns around an airport and lay the basis for effective interaction between the airport and its communities, when there is a need to change flight paths or airport infrastructure to cope with increasing demand.

2.4.5 In order to enhance the quality of the consultations and build trust between an airport and its communities, it is important to make comprehensible aircraft noise information routinely available. This enables members of the public to easily track how the noise exposure patterns in the vicinity of their homes are changing over time.

2.5 NOTIFICATION OF DECISIONS

2.5.1 The Balanced Approach should include timely and adequate notice of decisions to all stakeholders. For interim decisions, if any, this notice should be given in a reasonable time to allow stakeholders to be involved in any remaining consultations. For final decisions, notice should be given with reasonable time for the interested parties to determine whether any adjustments to their operations are necessary. Further, Resolution A37-18 “invites States to keep the Council informed of their policies and programmes to alleviate the problem of aircraft noise in international civil aviation.”

2.6 IMPLEMENTATION OF MEASURES

2.6.1 Having identified a noise problem at an airport and having determined the measure(s) needed under the Balanced Approach, the authority should consider the method of implementation. In implementing a measure(s), the authority should take into account that some actions may need to be introduced gradually over time.

2.6.2 In considering implementation, the authority is also encouraged to consider activities at the international level taking into account the need for regional flexibility, consideration of developing nations, and the economic and environmental impact on civil aviation or other stakeholders.

2.6.3 It would be appropriate to provide a reasonable period of advance notice prior to implementation and then to allow a mechanism of progressive enforcement of the measures where possible.

2.6.4 As noise control measures are implemented, it is important that compliance with these measures be monitored and reported in such a way that all parties clearly understand.

2.7 DISPUTE RESOLUTION

2.7.1 The authority should provide for dispute resolution for interested stakeholders preferably before any new noise mitigation actions enter into effect. Where such a mechanism or legal remedy is already in place, Contracting States could use that mechanism to address issues arising from the Balanced Approach.

2.7.2 The negotiation or mediation technique can be an important tool when employed to address conflicts or disputes associated with airport noise issues.

2.8 OTHER CONSIDERATIONS

2.8.1 Other considerations can be taken into account by a Contracting State and/or authority in addressing an airport noise problem. These can include:

- **Public education and awareness programmes.** Airports or local planning should provide for public education and awareness in the planning process.
- **Information dissemination.** Dissemination of information is a one-way flow. The type of audience may range from a very narrow one to the community at large. Noise information offices may be established for the purpose of community outreach. Information dissemination methods include brochures, newsletters, paid advertising, newspaper inserts, Internet web pages, etc.

- **Information exchange.** Information exchange is a two-way flow of information. Once the information has been disseminated, a dialogue occurs that may be used to enhance the educational process and ultimately improve planning and determine the public's attitude toward or acceptance of the disseminated message. Information exchange opportunities include public workshops, public advisory committees, radio/television talk shows and speaking engagements.

2.8.2 The use of complex technical aircraft noise descriptors alone can create frustration and negative reactions by the public if sufficient context is not provided. Accordingly, non-technical descriptors should also be used wherever possible when providing aircraft noise information to the public.

2.8.3 There may be unique situations that require special consideration — for example, when infrastructure or capacity improvements are considered. The authority should be aware of the consequences that restrictions put in place during the development of a project may have on the ability to use projected capacity for future growth.

Chapter 3

ASSESSMENT OF THE NOISE SITUATION AT AN AIRPORT

3.1 GENERAL

3.1.1 A fundamental part of the Balanced Approach as defined by the ICAO Assembly is the identification of the noise problem at an airport. To determine whether there is a noise problem at a particular airport that needs to be addressed, it is necessary to assess the evolution of the noise climate at that airport and the surrounding community. To the extent a noise problem is identified, characterization of the problem should assist in determining what measure or measures might mitigate or solve the problem.

3.1.2 The noise objective to be achieved should be identified and defined in order to assist in determining the extent of the noise problem. For the purposes of assessment under the Balanced Approach, an actual noise problem is deemed to exist if any difference between the defined objective and the assessed evolution of the noise climate can be identified. This may be reflected in the evolution of the number of people affected by an unacceptable level of aircraft noise. However, it is recognized that ICAO Contracting States and their airports may have different standards and policies regarding what constitutes a noise problem, how these may be assessed and what objectives are sought in airport-related noise programmes.

3.1.3 Whatever the stated objective is, the goal of the assessment would be to determine if the evolution of the noise climate will satisfy the objective or whether additional measures are required. It is appropriate to compare the evolution of the noise situation with the objective before reviewing the potential measures that could be implemented under the Balanced Approach to improve the noise climate.

3.1.4 The authority undertaking the assessment should have the means to measure, project and compare current and future noise exposures. Sections 3.2 through 3.7 identify some of the tools, procedures and supplemental information useful for assessing noise: noise contours, noise index, supplemental flight path based information, baseline, assessment methodology and management plans.

3.2 NOISE CONTOURS/NOISE INDEX

3.2.1 Although noise annoyance generally is a subjective matter, the ICAO Assembly urges that for the purposes of the Balanced Approach, noise surrounding an airport should be assessed based on objective and measurable criteria.

3.2.2 The noise situation at points on the ground from aircraft flying into and out of a nearby airport depends on a number of factors. These include the types of aircraft using the airport, the overall number of take-offs and landings, operating conditions, the time of day those aircraft operations occur, the runways that are used, weather conditions, and airport-specific flight procedures that affect the noise produced.

3.2.3 In light of the many factors contributing to the noise situation at a particular airport and in addition to measuring the noise from individual aircraft events in particular locations, it is customary in airport noise studies to model

“noise contours” that are averaged over long periods of time. The contours are typically based on the “average day” during a particular year, but can also be established for particular subdivisions of the day (e.g. the night period) or averaging periods shorter than a year. These parameters can be chosen in accordance with the identified noise measure in order to obtain meaningful results.

3.2.4 A noise contour is a line of constant value of aircraft noise exposure averaged over a given period of time (typically one year) for a traffic mix of aircraft under typical operating conditions. Generally, airport noise contours have been plotted at noise index intervals to assist in defining the “most affected” versus the “least affected” zones surrounding the airport.

3.2.5 A noise index is a parameter that is associated with noise exposure over a period of time. Its value is considered to be a predictor of noise effects on people. The noise index may take some account of factors in addition to the magnitude of sound (especially time of day). An example is day-night average sound level (L_{dn}). Alternatively, in the case of assessment under the Balanced Approach, other quantities can be used to describe the noise situation around the airport such as the number of events above a given noise level.

3.2.6 Because the noise contour is based on a specific traffic forecast, the variation of the traffic situation over time will influence its shape. For example, a 65- L_{dn} noise contour calculated based on next year’s scenario (incorporating input such as traffic mix and plans) may be different from today’s 65- L_{dn} contour.

3.2.7 In the same way, if an authority wishes to assess the possible options for mitigating a noise problem during a specific time of day, e.g. from 1400 to 2000 hours, the noise contours should account for the average effect of the expected traffic during that time of day over the time period, typically one year.

3.2.8 Circular 205 — *Recommended Methods for Computing Noise Contours around Airports* describes the major aspects of the calculation of noise contours of constant value of noise exposure for air traffic at an airport and presents several methods for calculating contours that some ICAO Contracting States have adopted. Circular 205 also shows a contour as a line of a noise exposure mapping corresponding to a given value of a “noise index”, which is a parameter that quantifies the noise exposure.

3.2.9 A lower noise index value will define a larger noise contour, and a higher noise index value will define a smaller noise contour. For example, a 75- L_{dn} noise contour will encompass a smaller physical area than a 65- L_{dn} noise contour.

3.2.10 There is no direct correlation between the size of the noise contour and the number of people who are within its boundaries at a given time. The number of people within the contour area will be wholly dependent on the specific circumstances of the airport and development of the surrounding community.

3.2.11 A projected contour should normally take into account future operations in order to reasonably accommodate future aviation traffic growth without an increase in the number of people affected by noise.

3.2.12 The ICAO Assembly urges that noise surrounding an airport be assessed based on objective and measurable criteria for the purposes of the Balanced Approach. A common metric for such criteria is the number of people encompassed within a noise contour established under a specified noise index (such as 65- L_{dn}). In some circumstances, a reduction in the number of persons within a specific contour can indicate noise benefits for all – for example, this would occur if a common aircraft type operating into an airport were replaced by a quieter aircraft type. On the other hand, reductions in the number of persons within a specified noise contour might be achieved simply by concentrating more noise on a smaller number of people. In such a case, some people might benefit at the expense of others, and such potential effects should be taken into account.

3.3 SUPPLEMENTAL FLIGHT PATH BASED INFORMATION

3.3.1 Aircraft noise can also be described in terms of flight path based concepts, such as the location of aircraft flight paths, the number of flights and the time distribution of aircraft movements on the flight paths; these flight path based concepts can be used to demonstrate to decision-makers and non-experts changes in noise exposure patterns introduced by the implementation of noise control measures.

3.3.2 These concepts can be helpful in providing information that goes beyond the average day. Information can be obtained on noise exposure at sensitive times and on both short- and long-term temporal variations in aircraft noise. Flight path based analyses are useful in revealing changes in noise exposure which may not be evident when using the average day noise contours. For example, they can be helpful in examining the impacts of introducing a small number of aircraft movements.

3.4 BASELINE

3.4.1 It is typical for the authority conducting the assessment to identify the “baseline” noise situation. The main component of the baseline is the noise situation around the airport as it currently exists, taking into account existing noise controls and current operating and land-use regulations. The “baseline” noise situation is not only the current situation; it is also referred to as the “no further action scenario,” because it is the noise scenario that is expected to occur based on existing plans with no additional action.

3.4.2 The baseline noise situation should be assessed over a projected time period taking into account what is known about the fleet mix and fleet noise performance over that time period, traffic, operational procedures, existing management plans, agreed future noise controls, exemptions, agreed cut-off dates, and noise mitigation actions. In such a case, the “baseline” noise situation is that which currently exists and that which is expected to exist at a given point in the future taking into account all noise mitigation actions that are already planned. Any additional noise mitigation measure that has not been agreed would be outside the baseline.

3.4.3 The length of time over which the noise situation is projected should be sufficiently long to take into account changes in the fleet mix, the longer-term nature of airport planning and other factors. It should be usual to establish a baseline noise assessment that examines noise in the present and into the future at a period of time established by the authority (e.g. five-year and ten-year intervals). To get a sense of the noise situation as it has evolved, the authority might also want to assess the noise situation at intervals in the recent past as well.

3.5 ASSESSMENT METHODOLOGY

3.5.1 Once the baseline noise situation has been determined, it should be compared with whatever noise objective has been established for the airport in question. If the baseline noise situation does not meet the noise objective, measures may need to be taken. A comparison of the baseline noise situation with the noise situation that is projected to occur if a particular noise control measure is put in place (often referred to as the “action scenario”) can show what change in noise exposure and what change in the number of inhabitants within the specified noise contours will result from the particular measure.

3.5.2 The comparison for assessing available noise control measures under a Balanced Approach is addressed in greater detail in Chapter 8. The evolution of the noise situation is dependent on the way in which the use of land surrounding an airport is planned and managed, the configuration of the infrastructures of the airport, and the fleet composition and the way in which it is operated. Future growth and development may be constrained by inappropriate land use near airports.

3.5.3 Under the Balanced Approach, the noise index (referred to as the “BA-noise index”) used to establish the noise contour to identify the number of people affected by aircraft noise should be consistent with the noise index used to establish the contour to control land use.

3.5.4 Authorities may establish noise contours by statute or regulation which imposes specific land-use management requirements. Such statutory or regulatory noise contours may not reflect the full extent of the aircraft noise effect around an airport. Many people consider themselves to be adversely affected by aircraft noise in areas some distance from the regulated zone. In cases where an authority has determined that aircraft noise outside already specified contours is of concern, the aircraft noise assessment could include examination of noise exposure over areas extending beyond the regulated zone.

3.6 CONSIDERATION OF THE BA-NOISE INDEX VALUES

3.6.1 The results of the assessment of the various scenarios depicting the possible evolution of the noise situation at an airport depend directly upon the BA-noise index. Measures available for management of the noise situation will vary depending on the unique circumstances of the airport.

3.6.2 In most instances, the noise index values used to define, at a certain date, the contour boundaries of the noise zone (referred to as the regulated zone) surrounding an airport have been already determined and imposed by the authority. There are usually multiple contours of decreasing exposure, with different building control and mitigation measures permitted in each.

3.6.3 The authority may discover that the future contours identified for the end of the assessment period corresponding to the selected BA-noise index value and the regulated zone are of a different size and shape. Depending on the position of these contours relative to the regulated zone, there may be two different situations:

- A higher BA index results in a smaller BA contour which may remain inside the regulated zone. This allows the authority to take advantage of the already existing urbanization control. However, it may exclude a number of people who may be affected by noise, which may limit the ability of the authority to achieve its noise objective.
- A lower BA index results in a larger BA contour which may go beyond the regulated zone. This may result in having more people who may be affected by noise being eligible for the benefits from programmes designed to achieve the authority’s noise objective. However, it may require expansion of the land-use regulated zone by the appropriate authorities in order to extend urbanization control to the BA contour. If not, it may limit the ability of the authority to achieve its noise objective.

3.7 MANAGEMENT PLANS

3.7.1 When identifying the baseline noise situation, if an airport has an existing management or master plan, it can be a valuable tool to help estimate future noise levels. Existing management plans often include information about air traffic, for example, the number of landings and take-offs per aircraft type and runway direction, at present and for a planned period into the future.

3.7.2 Management plans also tend to include information on the number of people affected by aircraft noise, or other environmental indicators within certain zones surrounding the airport, and any land-use restrictions already in place within those zones.

3.7.3 They may also include housing requirements and restrictions and, more importantly, noise contours for current and planned traffic corresponding to the noise index used for establishing the above-mentioned housing restrictions.

3.7.4 In addition to any information that may be available in an existing management plan, other current and agreed-to noise mitigation measures should be taken into account in establishing the baseline. These would include measures such as noise abatement operational procedures and existing operating restrictions. They may also include noise reductions at source based on expected noise performance improvements to an operator's fleet as a result of technology developments and fleet renewal.

3.7.5 Noise management plans could also consider trade-offs (see Chapter 8).

Chapter 4

REDUCTION OF NOISE AT SOURCE

4.1 GENERAL

4.1.1 Research and development aimed at reducing the impact of aircraft noise through aircraft technology improvements are ongoing activities, and ICAO continuously reflects state-of-the-art technology in its standards. It is important for States to consider the current and future benefits of new technology, as reflected in ICAO standards, as well as future aviation growth when assessing a noise problem and when deciding whether or not additional measures are warranted.

4.1.2 Reduction of noise at source, as used in the context of the Balanced Approach and as described by ICAO's Committee on Aviation Environmental Protection (CAEP), refers to the review of aircraft noise standards to ensure that they reflect the current state of aircraft technology — thus, noise reduction achieved through the adoption and implementation of the noise certification standards in Annex 16, Volume I, to the Chicago Convention (ref.: Committee on Environmental Protection, Report of the Fifth Meeting (Doc 9777), page 3.22, paragraph 3.8.3 a)).

4.1.3 There are means other than the use of certification standards to affect noise at source (i.e. aircraft level). For example, putting a noise-related restriction on an aircraft or using a certain noise abatement operational procedure affects the perceived noise from an aircraft. However, as defined by ICAO under the Balanced Approach, “reduction of noise at source” is limited to noise reduction through the adoption and implementation of noise certification standards. Other aircraft-related measures such as operating restrictions and noise abatement operational procedures fall under separate principal elements of the Balanced Approach.

4.1.4 Because reduction of noise at source is limited to the adoption and implementation of certification standards, this element of the Balanced Approach is not within the control of individual airports. However, to ensure that noise standards reflect current technology and that airport communities can benefit from the introduction of new technology, the ICAO Assembly encourages States to promote and support studies, research and technology programmes aimed at reducing noise at source (or by other means).

4.1.5 Adoption and implementation of certification standards are within the authority of ICAO Contracting States that generally apply the certification standards specified in Annex 16 to the Convention on International Civil Aviation. Accordingly, reduction of noise at source is basically a noise measure available to ICAO Contracting States consistent with Annex 16.

4.1.6 However, reduction of noise at source is not limited to the development of new, more stringent standards or new, quieter aircraft types. It also results from constant technology improvements throughout the life cycle of an aircraft type. Such technology improvements are progressively integrated into the fleet mix, thus improving its overall noise performance. Therefore, when assessing the future noise situation at an airport, the noise performance trend of the fleet mix operating at that airport should be considered.

4.2 REDUCTION OF NOISE AT SOURCE UNDER THE BALANCED APPROACH

4.2.1 When assessing the noise situation at an airport, consideration should be given to:

- integration into aircraft fleets, over time, of technology improvements meeting the latest standards;
- specific fleet modernization plans of airlines operating at an airport;
- national plans to adopt the latest noise standard;
- adoption by Contracting States of the latest ICAO noise recommendations.

4.2.2 In conducting this assessment, it is also necessary to consider the noise performance of aircraft certified and/or re-certified consistent with Annex 16. Noise levels for originally certified and/or re-certified aircraft types can be obtained from the ICAO Noise Data Bank and other recognized sources.

4.2.3 Further noise reduction at source and its potential introduction into the fleet is dependent upon several factors including technology, economic factors and market forces. It may be appropriate in a global system approach to consider the potential for further noise reduction at source in conjunction with other factors like fleet and traffic evolution, noise abatement operational procedures, air traffic management (ATM) and airport infrastructure, operating restrictions and economic instruments. The objective should be to identify the most cost-effective measure or combination of measures in this broader perspective to resolve the noise problem at the airport concerned.

4.2.4 It should be recognized that the level of uncertainty associated with projected noise reduction at source is generally high due to the combined effects of underlying factors difficult to predict (technology, the economy, the market, traffic, and fleet developments). To be in a position to make noise reduction projections, it is however desirable to have some realistic view of what the future airport noise situation might be and to assess what further noise reduction at source may compensate for the predicted traffic increase.

4.2.5 Communication between stakeholders (research centres, manufacturers, operators, authorities, airports, air traffic service providers, neighbour associations), in particular regarding noise reduction technology developments and prospects, should be maximized. This would improve transparency and the understanding of the potential future evolution of the noise situation at an airport and permit a better anticipation of noise problems and an improved decision-making process concerning potential solutions.

Chapter 5

LAND-USE PLANNING AND MANAGEMENT

5.1 GENERAL

5.1.1 The objective of compatible land-use planning in this context is to direct incompatible land use (such as houses and schools) away from the airport environs and to encourage compatible land use (such as industrial and commercial use) to locate around airport facilities. While not the only compatibility issue, aircraft noise has been the main issue of airport land-use compatibility conflicts.

5.1.2 The ICAO Assembly stated, “the number of people affected by aircraft noise is dependent on the way in which the use of land surrounding an airport is planned and managed, and in particular the extent to which residential development and other noise-sensitive activities are controlled.”

5.1.3 Because in many instances the implementation of compatible land-use measures and the realization of the resulting benefits may be long-range, effective land-use measures should be identified early in order to have the most significant and lasting benefits over the long term.

5.1.4 This is particularly appropriate to land-use planning at existing airports where it is recognized that the ability to make immediate land-use changes is limited, but where it is also important to prevent additional encroachment of incompatible land use as aircraft source noise decreases and noise contours retreat closer to the airport boundary.

5.1.5 It is recognized that in some situations such as at locations lacking available land, the opportunity to incorporate some or all of the following principles may not be available. However, as stated by the ICAO Assembly, ICAO Contracting States are urged, where the opportunity still exists, to minimize aircraft noise problems through preventive measures such as:

- locating new airports in an appropriate place, such as away from noise-sensitive areas;
- taking the appropriate measures so that land-use planning is taken fully into account at the initial stage of any new airport or of development at an existing airport;
- defining and updating zones around airports associated with different noise levels taking into account population levels and growth as well as forecasts of traffic growth and establishing criteria for the appropriate use of such land, taking account of ICAO guidance;
- enacting legislation, establishing guidance or using other appropriate means to achieve compliance with those land-use criteria; and
- ensuring that reader-friendly information on aircraft operations and their environmental effects are available to communities near airports.

5.1.6 Land-use planning and management around airports is one of the principal elements of the Balanced Approach. Local or regional authorities are typically responsible for the land-use planning and management functions necessary to implement urbanization control measures around an airport. The airport authority should work closely with those authorities responsible for land-use management to educate them regarding the noise impact of aviation operations

and encourage these authorities to develop and implement land-use planning and control measures in affected areas surrounding the airport. ICAO Contracting States should provide a leadership role by encouraging local and regional authorities to implement land-use planning and management around airports through appropriate early action and cooperative mechanisms between interested stakeholders, such as coordination committees.

5.2 TYPES OF LAND-USE PLANNING AND MANAGEMENT MEASURES

5.2.1 Land-use planning and management measures can be categorized as:

- **Planning instruments:** comprehensive planning, noise zoning, subdivision regulations, transfer of development rights, and easement acquisition.
- **Mitigating instruments:** building codes, noise insulation programmes, land acquisition and relocation, transaction assistance, real estate disclosure, and noise barriers.
- **Financial instruments:** capital improvements, tax incentives, and noise-related airport charges for revenue generation to assist in funding noise mitigation efforts.

5.2.2 The following section describes a wide variety of possible land-use planning and management measures under each category as they relate to compatible land-use planning efforts. For additional information on land-use planning and more specific details on these measures, refer to the *Airport Planning Manual, Part 2 — Land Use and Environmental Control* (Doc 9184).

5.3 EXAMPLES OF LAND-USE PLANNING AND MANAGEMENT MEASURES

5.3.1 Various measures are available for managing the use of land around airports. The effectiveness of these measures for both existing and new airports should be considered for each particular situation.

5.3.2 The selection of a particular measure or combination of measures over others and the precise manner in which any measure or combination of measures is formulated, applied and financed depend to a great extent on specific national and local circumstances.

Planning Instruments

5.3.3 **Comprehensive planning.** Comprehensive planning takes into account existing development and coordinates future development to be compatible with various community goals. Land-use planning and control authority rests in most countries with local governmental bodies, which may be obliged or advised to take into account aviation noise measures.

5.3.4 **Noise zoning.** Noise zoning is the exercise of the legal powers of a national or local government that enables it to designate the uses that are permitted for each parcel of land, depending on the noise exposure. It normally consists of a zoning ordinance that specifies land development and use constraints, based on certain noise exposure levels. The noise contours extending outward from the airport delineate areas affected by different ranges of noise exposure. Generally, no additional noise-sensitive land uses should be permitted in an area subjected to levels of noise higher than considered acceptable for that use.

5.3.5 **Subdivision regulation.** Noise zoning ordinances may include subdivision regulations to guide development in noise-impacted areas. These regulations may be useful in minimizing noise impacts on new development, but would not affect existing development. Subdivision regulations may include reduction in building exposure through site orientation, density transfer and open-space requirements. Subdivision regulation may also include the requirement for a restrictive covenant that requires prospective owners to be legally notified that the property is subject to noise from aircraft operations, or a covenant that requires buildings to be designed and constructed to minimize interior sound levels derived from exterior noise sources.

5.3.6 **Transfer of development rights.** Under this concept, some of a property's development rights can be transferred to another property that is remote from the airport where the rights may be used to intensify the amount of allowable development. Landowners could be compensated for the transferred rights by their sale at new locations or the airport could purchase the rights. Depending upon the market conditions and/or legal requirements, the airport could either hold or resell the rights.

5.3.7 **Easement acquisition.** An easement confers the right to make use of a landowner's property for a limited purpose in exchange for an agreed-upon value. In the context of airport noise compatibility planning, two general types of easements are available: those which permit noise to affect the property and those which prevent the establishment or continuation of noise-sensitive uses on the property.

Mitigating instruments

5.3.8 **Building codes.** Minimum structural construction techniques and material standards often determine whether changes in current standards or adoption of new standards can increase the interior noise reduction levels of typical residential or commercial structures in noise-impacted areas. Building codes are essentially a legal means of requiring adequate sound insulation to be incorporated in new construction. While there may be difficulties in getting sound insulation requirements incorporated in building codes for new construction, these are slight compared with the problems of effective soundproofing for existing buildings, particularly housing.

5.3.9 **Noise insulation programmes.** Noise insulation can lower interior noise levels for residential structures that cannot reasonably be removed from noise-exposed areas. Noise insulation is particularly effective for commercial buildings, including offices and hotels. However, it is much more desirable to control insulation requirements for such buildings from the outset, if they must indeed be constructed in such areas.

5.3.10 **Land acquisition and relocation.** This strategy involves the acquisition of land through purchase by the airport operator (or planning authority in case of new developments) and the relocation from the acquired land of residences and businesses that are not compatible with airport-generated noise levels. Land acquisition and relocation absolutely assure the airport of long-term land-use compatibility. Acquired land can be cleared, retained as a buffer, sold with easements (to control future development) or redeveloped for compatible land uses.

5.3.11 **Transaction assistance.** Transaction assistance involves some level of financial and technical assistance to a homeowner who is trying to sell a noise-impacted property. It may involve paying realtors' fees. At the extreme end, an airport actually buys properties that have been on the market for an extended time and then resells them. In order to become compatible with noise levels, the properties are noise-insulated prior to resale and usually resold with an easement.

5.3.12 **Real estate disclosure.** When environmental regulations and issues affect development, real estate disclosure notices can be prepared. In order to be effective, these notices ideally need to describe aircraft noise in a

non-technical way that is comprehensible to the prospective resident. Identification of the aviation noise impact on real estate may foster an awareness of airport/community relationships and serve notice to prospective buyers of potential disturbances due to aircraft noise. Existing property owners and realtors often oppose real estate disclosure because it may make it more difficult to sell noise-impacted property. However, disclosure may deter buyers who are the most sensitive to noise or satisfactorily inform those who still wish to purchase a noise-impacted property to the extent they do not become noise complainants or noise litigants in the future.

5.3.13 **Noise barriers.** These consist of barriers on the ground such as earthen berms, vegetation or other barriers, usually man-made, which are located between sources of ground-level noise on the airport and very close-in noise-sensitive receptors. Noise barriers are of limited use at airports except for ground running operations, etc. They do not mitigate in-flight noise. Noise barriers must be both structured and positioned accurately to provide any meaningful relief. It has been particularly beneficial to attractively landscape earthen berms for visual appeal. A proper positioning of airport buildings can also function as a noise screen for adjacent communities against certain airport activities.

Financial instruments

5.3.14 **Capital improvements planning.** Development can be stimulated or discouraged by the presence or absence of an infrastructure network, which typically includes roads and utilities (power, gas, water and sewer). Other community facilities and services, such as schools and police and fire service also tend to promote development. Capital improvements can be programmed to include the placement of an infrastructure to support industrial and commercial uses in areas where such growth would be compatible. This strategy can also discourage certain types of growth, such as residential development, from areas that are considered incompatible for such use. Similarly, the capital improvements programme can be developed to encourage noise-tolerant land use with the appropriate type, size and location of infrastructure in the noise-impacted areas.

5.3.15 **Economic incentives.** Economic incentive programmes are typically related to promoting noise insulation improvements. The strategy is to provide economic incentives to existing incompatible uses in order to encourage structural improvements that serve to reduce interior noise levels. Governmental bodies may institute additional economic incentive programmes as a means of redeveloping specific areas for more noise compatible uses. Various tax incentives, such as reduction or elimination of property taxes, may also be effective in relocating or expanding industry to a compatible zone.

5.3.16 **Noise-related airport charges.** Noise-related airport charges may be levied by national governments, local governments or the airport authority at airports experiencing noise problems to recover the costs applied to the alleviation or prevention of noise impacts on the surrounding community. The application of noise-related charges should follow the principles on such charges developed by ICAO and contained in the Statements by the Council to Contracting States in *ICAO's Policies on Charges for Airports and Air Navigation Services* (Doc 9082). Generally, the guidance provides the following principles related to charges:

- Noise-related charges should be levied only at airports experiencing noise problems and should be designed to recover no more than the costs applied to their alleviation or prevention.
- Any noise-related charges should be associated with the landing fee, possibly by means of surcharges or rebates, and should take into account the noise certification provisions of Annex 16 to the Convention.
- Noise-related charges should be non-discriminatory between users and should not be established at such levels as to be prohibitively high for the operation of certain aircraft.

5.3.17 There are various systems of noise-related airport charges. One system divides all aircraft into several categories according to noise performance and determines the airport charge generally to fund insulation. Another system

returns part of the landing fee if the aircraft meets certain noise criteria thus allowing for a global revenue neutral charging system. A third system levies extra noise charges on top of the normal landing fee based on the noise performance of the aircraft. In some countries, extra charges are levied on night operations because of the extra annoyance during night hours.

5.4 LAND-USE ZONES AROUND AN AIRPORT

5.4.1 Land-use management can be applied differently (in several zones), allowing for urbanization control or management to be less restricted the farther away it takes place from the airport. This can be illustrated by the following criteria for the possible various zones surrounding the airport:

- All housing is forbidden — occurs very often within the actual airport perimeter and in areas of highest noise exposure.
- New housing is forbidden — no additional housing is allowed in this area.
- Limited and regulated housing growth — all new housing is regulated and required to be soundproofed, and all existing housing, prior to regulations, has benefited or will benefit from financial aid for soundproofing as defined within the noise mitigation programme.
- Regulated housing growth — all new housing is regulated and soundproofed, but all existing housing, prior to regulations, does not benefit from financial aid for soundproofing as defined within the noise mitigation programme.
- Unregulated housing growth — outside these areas, housing is no longer constrained for aircraft noise reasons.

5.4.2 Some of the above-mentioned areas might not exist around a particular airport, depending on the progressive nature of current regulations. Any creation or extension of such areas, however, should be based on the defined index that is used to model the noise-exposure contour enabling the tracing of the corresponding boundaries around the airport. Any creation or extension of areas in which new housing is forbidden reduces the potential number of people to be affected in the future.

5.4.3 Any increase in the severity of restrictions governing the building of new housing contributes to reducing the number of people affected by noise, for example, dispersed individual housing as opposed to collective housing, or the freezing of building land for housing. The same applies to the extension of areas in which all new housing is regulated.

5.4.4 Depending on the way the impact of aircraft noise on people with soundproofed houses is assessed, any creation or extension of areas in which new or pre-existing housing is soundproofed can reduce the number of people affected. The same applies when the noise attenuation standard specified to be achieved via soundproofing programmes is increased.

5.4.5 Urbanization will normally occur around airports unless a regulatory constraint is issued limiting the development of the land. Local and regional authorities should ensure that mechanisms are in place to promote compatible development such as industrial and commercial uses. The land value, the type of possible development and the specific location of the development will, however, be a reflection of the real estate market, the overall availability of land for specific uses and the current zoning conditions.

5.4.6 Noise mitigation measures for residential development should take into account the timing of such development. Residential development within the noise-sensitive area should be eligible for mitigation measures only if

built prior to the development of a new or modified airport or use thereof. Precedence for such mitigation measures should be given to houses exposed to higher noise levels. Local building codes can provide a mechanism for the required acoustic treatment of all houses in a noise-sensitive area built after the development of a new or modified airport or use thereof.

5.5 ENCROACHMENT ANALYSIS

5.5.1 The Assembly, in Resolution A37-18, Appendix C recognized the importance of protecting improvements in the noise climate achieved at airports. For example, it considered “that the improvements in the noise climate achieved at many airports through the replacement of Chapter 2 compliant aircraft ... by quieter aircraft should be safeguarded ... and should not be eroded by incompatible urban encroachment around airports.” In the same Appendix, when discussing policies based on the Balanced Approach to noise management, it “Encourages States to apply land-use planning and management policies to limit the encroachment of incompatible development into noise-sensitive areas ...”

5.5.2 In order to better evaluate the appropriateness of measures to prevent additional encroachment of incompatible land use around airports, it is suggested to calculate the degree and rate of encroachment and also the effectiveness of land-use planning and management measures adopted over time. Assessment of the rate of encroachment aims to safeguard improvements in the noise climate achieved at airports.

5.5.3 An important step in land-use planning and management is to have a methodology to evaluate the effectiveness of the land-use planning and management measures adopted. In this context, it may be appropriate to develop an encroachment analysis for each specific international airport. An encroachment analysis is an evaluation over a time frame, usually ten to twenty years, of the percentage of change in population/households within the airport noise-regulated area where land-use planning is applicable as defined by the authority.

5.5.4 Appendix 1 describes the findings of a limited number of States relative to assessments of population growth and encroachment around airports. It indicates that encroachment has occurred and points to how the problem might be described and assessed in a systematic way. Assessing and quantifying encroachment requires that an airport maintain historical population and housing information. The information in Appendix 1 illustrates possible means of quantifying encroachment, given the appropriate historical data.

Chapter 6

NOISE ABATEMENT OPERATIONAL PROCEDURES

6.1 GENERAL

6.1.1 The size and shape of noise contours around an airport resulting from aircraft operations can be influenced by both in-flight and ground-based operational procedures. Implementation of these noise abatement operational procedures can minimize the number of people affected by reducing the level of noise perceived at particular locations. Such measures can address particular noise problems around an airport.

6.1.2 Safety remains the highest priority in aviation, and the safety of air traffic continues to be the most important consideration in the development and implementation of noise abatement operational procedures. The use of approved noise abatement operational procedures must ensure that the necessary safety of flight is maintained by considering all factors that might affect a particular operation. These include, but are not limited to, current and forecast weather, runway conditions and available navigation aids.

6.1.3 Noise abatement operational procedures should not be introduced unless a noise problem is demonstrated to exist or is anticipated in the future based on appropriate studies and consultation (see *Procedures for Air Navigation Services, Aircraft Operations, Volume I — Flight Procedures, Part V (PANS-OPS, Doc 8168)*).

6.1.4 Doc 9888 — *Noise Abatement Procedures: Review of Research, Development and Implementation Projects* contains the results of surveys which were carried out to compile the latest information on such projects.

6.2 PROCEDURES

6.2.1 Possible procedures for noise abatement when a problem has been confirmed may include one or more of the following, consistent with the advice in PANS-OPS, Volume I, as appropriate:

- the use of noise preferential runways to direct the initial and final flight paths of aircraft away from noise-sensitive areas;
- the use of noise preferential routes to assist aircraft in avoiding noise-sensitive areas on departure and arrival, including the use of turns to direct aircraft away from noise-sensitive areas located under or adjacent to the usual take-off flight paths;
- the use of noise abatement take-off or approach procedures designed to optimize the distribution of noise on the ground while maintaining the required level of safety.

6.2.2 In selecting noise abatement take-off procedures, it should be noted that noise benefits will vary depending on the type of take-off procedure chosen. Since the procedures employ variations in the schedule of engine thrust levels and aircraft high-lift device management, the resulting noise levels will vary along the take-off flight path. The selection process should include an understanding of the selected noise benefits and can be used in conjunction with preferential noise flight tracks.

6.2.3 Noise abatement operational procedures in principle shall not contain a prohibition on the use of reverse thrust during landing (see Doc 8168). The use of reverse thrust may however be limited without restricting aircraft access where it can be demonstrated that the airport characteristics, such as runway length, and the aircraft performance characteristics maintain the required level of flight safety.

6.2.4 The implementation of noise abatement operational flight procedures may generate new problems elsewhere around the airport according to the measures taken and the associated changes in the noise contours. Attention should be paid to these potential pitfalls wherever possible, recognizing that appropriate benefits may be lost unless complementary measures are taken (see Chapter 8).

6.2.5 The application of noise abatement operational procedures and their impact are aircraft type and operator specific. Operators develop the required procedures in conjunction with the airframe manufacturer and their regulatory authority. In developing noise abatement take-off procedures, operators, for safety and training issues, limit their operation to no more than two procedures.

6.2.6 Noise abatement operational procedures at some airports have the potential to provide relief, and such procedures can be enhanced by the capability and use of aircraft flight management and ground automation systems. As these systems are developed and their capabilities increase, new advanced procedures are likely to become available, potentially bringing further noise benefits in the future.

6.2.7 Flight management is the responsibility of each aircraft operator. This allows the airport operator to modify the track definition in the horizontal plane insofar as ICAO operational standards are complied with.

6.2.8 The implementation of descent and approach procedures, continuous descent approach (CDA) in particular, will require a number of issues to be addressed related to: traffic capacity; operational and air traffic control (ATC) constraints; weather conditions; airport constraints; crew workload, awareness, training and experience; aircraft and engine characteristics; regulations; and safety requirements. Successful implementation will depend on close collaboration between all parties (operators and pilots, airframe manufacturers, air traffic control service providers, airports and authorities, and research organizations).

6.2.9 Utilizing descent profiles, reduced power/ reduced drag techniques or CDA (or any combination thereof) can be effective and operationally acceptable based on experience.

6.2.10 A noise abatement operational procedure may limit the access of an aircraft that does not have the particular performance characteristics to comply with the procedure (see Chapter 8).

6.3 EXAMPLES OF NOISE ABATEMENT OPERATIONAL PROCEDURES

Use of flight departure and approach routings

6.3.1 **Noise preferential routes.** Also known as minimum noise routes, these routes may be established to ensure that departing and arriving aircraft avoid overflying noise-sensitive areas in the vicinity of the airport, taking into account specific constraints such as terrain.

6.3.2 **SID/STAR procedures.** All aircraft should operate to and from airports using standard instrument departure (SID) and, if appropriate, standard terminal arrival (STAR) procedures. The main purpose of these procedures is to provide obstacle clearance protection to the aircraft; however, they also enable the development and implementation of noise abatement flight tracks for aircraft. Each runway should have its own specific SID and STAR.

6.3.3 **Dispersed flight tracks.** Successive departing aircraft may be dispersed on different flight tracks over wide-ranging areas. Dispersing flight tracks in this way tends to decrease the length of the noise exposure areas and to increase the width.

6.3.4 **Automated arrival and departure procedures.** Automated arrival and departure procedures based on area navigation (RNAV) procedures and systems using on-board flight management systems (FMS)/RNAV systems provide improved accuracy and control when operating SIDs, STARs and reduced power/reduced drag techniques (see paragraphs 6.3.8 to 6.3.10) therefore minimizing the width of the noise exposed area and increasing its length.

Use of runways

6.3.5 **Noise preferential runways.** Noise preferential runways provide preferred runway directions for take-off or landing, appropriate to the operation. They are selected for noise abatement purposes, the intent being to utilize whenever possible those runways which enable aircraft to avoid noise-sensitive areas during the initial departure and final approach phases of flight. Flight safety should be the determining factor in runway selection when implementing noise abatement operational measures. Runways selected for preferential use should be equipped with suitable navigation aids (see Doc 8168). The use of a preferred runway according to quantity of traffic or aircraft performance criteria transfers the traffic from one direction to another. It reduces the length of the noise exposure contour in the first direction but then extends it in the second, thus re-shaping the noise contour, potentially resulting in a reduction in the number of people affected.

6.3.6 **Displaced thresholds.** Reduction of noise can be achieved by displacing the commencement of the take-off and the landing threshold.

Use of departure procedures

6.3.7 **Noise abatement departure procedures.** These procedures are designed by the operator in consultation with the airframe manufacturer, implemented in line with local airport practices and approved by the regulatory authority of the operator. Their objective is to optimize the distribution of the exposure to noise at a particular location on the ground while maintaining the required levels of flight safety.

Use of approach procedures

6.3.8 **Descent profiles.** Descent profiles may reduce the noise exposure of an aircraft by maintaining higher than normal approach altitudes/angles and instrument landing system (ILS) glide slope interception from a higher altitude.

6.3.9 **Reduced power/reduced drag techniques.** Their principle consists in delaying as much as possible wing flap extension and landing gear deployment, consistent with air traffic control (ATC) speed, height clearance and safe operation. These techniques involve changes in engine power associated with changes in aircraft configuration.

6.3.10 **Continuous descent approach (CDA).** Commonly referring to the initial approach phase between 6 000 ft and the interception of the glide slope, CDA ideally allows an uninterrupted descent from cruising altitude; in practice, it is usually defined as a descent with no segment of level flight exceeding 2 or 2.5 NM. CDA reduces the noise experienced on the ground by reducing the overall thrust required during initial descent and keeping the aircraft higher for longer. In addition to noise reduction, CDA can provide emission benefits.

Use of reverse thrust

6.3.11 Reverse thrust is an effective complementary way of braking an aircraft, especially on contaminated runways and serves to significantly reduce the required runway length on landing or in the case of an aborted take-off. In some cases, in order to minimize ground noise, the use of reverse thrust for jet or propeller engines can be limited to reverse idle. The use of reverse thrust above reverse idle may be prohibited during a specified period, especially during night hours; such a limitation would only apply when safety allows it (see Chapter 8).

Use of ground-based operational procedures

6.3.12 There are several operational measures used on the ground at airports with a view to reducing noise pollution. These measures can be considered as noise abatement operational procedures and they may include limiting aircraft engine ground running. In most cases, engine ground runs take place under idle rather than high power conditions. Operational measures may be introduced, however, only permitting high power engine runs in designated areas, by time of day, and/or in specially constructed noise isolating engine testing pens away from noise-sensitive airport areas. Such procedures will limit engine ground running which is required in order to confirm maintenance action and more importantly carry out checks critical to flight safety.

6.3.13 Auxiliary power unit (APU) operation is required in order to provide aircraft system power and air conditioning for aircraft maintenance, pre-flight preparation and, more importantly, engine start at departure. Operational measures may be introduced to reduce noise in the vicinity of the parked aircraft and minimize operation providing alternative sources are available such as ground support equipment (GSE) and/or terminal bridge services.

6.3.14 Operational measures may be introduced in order to reduce taxiing time and distance.

Chapter 7

OPERATING RESTRICTIONS

7.1 GENERAL

7.1.1 Under the Balanced Approach, an operating restriction is defined as “any noise-related action that limits or reduces an aircraft’s access to an airport.” Operating restrictions can improve the noise climate by limiting or prohibiting movements of the noisiest aircraft at an airport, enabling the airport to contain or shrink the noise contours around the airport.

7.1.2 Operating restrictions that are implemented at airports for reasons other than noise control are not considered in this guidance material. An example of such a restriction might be a restriction on total airport capacity implemented for safety reasons such as traffic separation issues.

7.1.3 According to the identified noise problem at an airport, operating restrictions may be part of the set of measures to be implemented to alleviate the noise problem. However, ICAO encourages States not to apply operating restrictions as a first resort, but only after consideration of the benefits to be gained from the other three principal elements of the Balanced Approach.

7.1.4 The ICAO Assembly recognized in particular that States have legal obligations, laws, existing arrangements and established policies that may govern the management of noise problems at their airports and could affect the implementation of local noise-related operating restrictions. The Assembly also observed that at many airports land-use planning and management and noise abatement operational procedures are already being used and other noise mitigation measures are in place, although urban encroachment continues in certain areas.

7.1.5 As stated by the ICAO Assembly, “The Assembly urges States not to introduce any operating restrictions at any airport on aircraft that comply with Volume I, Chapter 3 of Annex 16 before:

- completing the phase-out of aircraft which exceed the noise levels in Volume I, Chapter 3 of Annex 16, at the airport concerned; and
- fully assessing available measures to address the noise problem at the airport concerned in accordance with the Balanced Approach ...”

7.1.6 The ICAO Assembly also urges ICAO Contracting States not to permit the introduction of any operating restrictions aimed at the withdrawal of aircraft that comply, through either original certification or re-certification, with the noise standards in Volume I, Chapter 4 of Annex 16.

7.1.7 The ICAO Assembly further urges States to ensure that any operating restrictions be adopted only where such action is supported by a prior assessment of anticipated benefits and of possible adverse impacts.

7.1.8 In addition, ICAO Resolution A37-18 urges Contracting States that permit the introduction of operating restrictions of aircraft which comply, either through original certification or recertification, with Volume I, Chapter 3 of Annex 16, to:

- base such restrictions on the noise performance of the aircraft, as determined by the certification procedure conducted consistent with Annex 16, Volume I;

- tailor such restrictions to the noise problem of the airport concerned in accordance with the Balanced Approach;
- limit such restrictions to those of a partial nature wherever possible, rather than the complete withdrawal of operations at an airport;
- take into account possible consequences for air transport services for which there are no suitable alternatives (for example, long-haul services);
- consider the special circumstances of operators from developing countries in order to avoid undue economic hardship for such operators, by granting exemptions;
- introduce such restrictions gradually over time, where possible, in order to take into account the economic impact on operators of the affected aircraft;
- give operators a reasonable period of advance notice;
- take account of the economic and environmental impact of recent events on civil aviation in the near term; and
- inform ICAO, as well as the other States concerned, of all such restrictions imposed.

7.1.9 When considering operating restrictions, minimum aircraft noise performance required for access to an airport may be defined according to:

- the chapter of Annex 16, Volume I, to which an aircraft has been certificated;
- aircraft certified noise levels in accordance with Annex 16, Volume I, Part II;
- the margin with respect to the permissible limits defined in Chapter 3 of Annex 16, Volume I, Part II; and
- the cumulative margin with respect to the permissible limits defined in Chapter 3 of Annex 16, Volume I, Part II.

7.1.10 As for other measures, available operating restrictions should be explored in a coherent and objective manner with respect to the basic principles of transparency, cost-effectiveness, non-discrimination, and with due consideration of possible market distortion, traffic demand, and long-term predictability required for fleet planning.

7.2 TYPES OF OPERATING RESTRICTIONS

7.2.1 Operating restrictions typically fall into the following four categories or any combination thereof. They can be global, aircraft-specific, partial and/or progressive. (Note: This guidance document does not consider whether the following restrictions can be selected without generating competitive distortions.)

- **Global restrictions.** Apply to all traffic at an airport based on total fleet noise performance.
- **Aircraft-specific restrictions.** Apply to a specific aircraft or a group of aircraft based on individual noise performance.
- **Partial restrictions.** Apply for an identified time period during the day, on specific days of the week, or only for certain runways at the airport.

- **Progressive restrictions.** Provide for a gradual decrease in the maximum level of traffic or noise energy used to define a limit over a period of time. This period is typically defined as a number of years before reaching a final level.

7.2.2 Operating restrictions can be implemented in different ways:

- number of movements per period of the day and/or year for the airport or per runway direction, for example, a maximum annual number of movements at the airport;
- quotas expressed as a combination of movements and aircraft acoustic characteristics or a fixed contour. Consequences of quotas may be a restriction on available slots or the closure of certain runway directions during a certain period.

7.3 EXAMPLES OF OPERATING RESTRICTIONS

7.3.1 Following are specific examples of operating restrictions. Any one of them may fall into one or more of the four categories of the above-described operating restrictions depending on how they are applied.

7.3.2 **Cap rules.** These global measures define the maximum number of operations not to be exceeded at an airport often for a given time period of the year. They can be partial, i.e. applicable to all operations of all aircraft during an identified period of the day on specific runways or on all runways of an airport. Sometimes the operations are weighted per period of the day or according to the noise (certified characteristics) of the aircraft (e.g. certified level, certified margin, cumulative margin).

7.3.3 **Noise quotas.** A noise quota (sometimes expressed as a “noise budget”) is generally used to cap the total noise level from aircraft operations within a given area over or around the airport to some established total value over a given period of time (six months, one year, etc.). This may be expressed as an established noise energy over a period of time or the allocation of a maximum number of operations weighted by noise certification levels of the aircraft over a period of time. Noise quotas may be based on an historic noise level at the airport or on a future noise goal for the airport. They may be implemented to maintain a certain total noise level or to decrease the total noise level over a period of time. In the former case, as operators begin to use quieter aircraft, more slots could conceivably be available. Under the latter system, the use of quieter aircraft becomes necessary just to maintain a given number of slots.

7.3.4 **Non-addition rules.** Non-addition rules are measures of aircraft-specific restrictions aimed at prohibiting the new operation of specific aircraft or the operation of new (additional) aircraft based on noise performance using noise certification levels. These restrictions may apply to all runways of an airport or to specified runway directions.

7.3.5 **Nature of flights.** The nature of flights may be used as the criteria for partial operating restrictions in order to limit access to an airport. This kind of restriction often applies to non-scheduled flights and/or non-maintenance-based flights, check flights and training flights. These flights may be forbidden, or not permitted during a specified period of the day, for instance during night hours and/or on specific days of the week.

7.3.6 **Night-time restrictions.** Due to the particular importance of the night for sleep, restrictions during night-time are of special concern. The operating restrictions described in this chapter may be applicable during the day and/or night, but due to the demand of people for undisturbed sleep, the measures introduced at the airport may be enhanced at night.

7.3.7 **Curfews.** Airport curfews are global or aircraft-specific partial operating restrictions that prohibit take-off and/or landing during an identified time period. Curfews might be tightened from the evening to the night and softened from the night to the morning as well. Curfews might be applied to specific runways.

Chapter 8

RELATIONSHIP BETWEEN THE PRINCIPAL ELEMENTS AND MEASURES OF THE BALANCED APPROACH

8.1 GENERAL

8.1.1 This chapter addresses the relationship or interdependency between the different principal elements of the Balanced Approach, the complementary use of the different principal elements and the measures they involve, the consideration of trade-offs between aircraft noise and engine emissions when selecting various measures and the possibility of certain mitigation measures or of certain economic instruments becoming operating restrictions in specific cases.

8.1.2 This chapter explores how a combination of measures could be used to reach the airport's noise goal or objective and how to combine noise mitigation measures with preventative or protective measures. All measures, whether used to directly mitigate noise or as complementary measures to prevent the degradation of the noise reduction benefit, should be considered under the Balanced Approach.

8.1.3 This chapter demonstrates that action taken under one principal element of the Balanced Approach may have an impact on areas addressed by the other principal elements. It explores using the principal elements in a complementary manner to leverage the potential benefits available in the longer term and protect the gains achieved.

8.2 CONTRIBUTION OF EACH OF THE PRINCIPAL ELEMENTS AND THE INTERRELATIONSHIP BETWEEN MEASURES UNDER CONSIDERATION

8.2.1 In accordance with Assembly Resolution A37-18, "... improvements in the noise climate achieved at many airports through the replacement of Chapter 2 compliant aircraft ... by quieter aircraft should be safeguarded by taking account of the sustainability of future growth and should not be eroded by incompatible urban encroachment around airports." When developing measures in accordance with the Balanced Approach, resulting benefits should be protected whenever possible.

8.2.2 Consistent with the above, the authority should consider that once a measure has been taken under one of the principal elements of the Balanced Approach, there may be a need to protect the resulting reduction in the number of activities affected by noise exposure. For example, if actions taken under the Balanced Approach result in reduced planned noise exposure contours around an airport, other steps might need to be taken to prevent encroachment into these now quieter areas thereby ensuring the protection of the gains achieved and accounting for future growth. Otherwise, the benefits of measures implemented under the Balanced Approach may be lost.

8.2.3 A combination of the principal elements may be necessary to improve the noise climate around an airport and preserve the potential long-term benefits. For example, noise abatement operational procedures or operating restrictions may improve the noise climate around an airport in the first instance. Without complementary land-use measures, the anticipated benefits over the long term will not be achieved and, consequently, the return on their costs may be lost.

8.2.4 Noise reduction benefits may result from different actions such as improvements in technology, noise abatement operational procedures and operating restrictions. The measures under consideration should be contemplated in combination with each other and defined within the framework of the Balanced Approach. The section below recalls how each principal element contributes to the improvement of the noise situation and how those elements interrelate.

8.3 REDUCTION OF NOISE AT SOURCE

8.3.1 States and local authorities need to consider the effect of normal attrition, the renewal of the fleet and introduction of ICAO standards before considering the need for additional measures to be taken under the other elements of the Balanced Approach. Although these factors may provide global benefits, they may not address the needs of airports unless supported by complementary measures.

8.3.2 The future composition of traffic is a major factor in the changing noise environment. Therefore, the projected upgrading of fleets may serve as a reference point in the absence of local action for noise reduction at source.

8.4 LAND-USE PLANNING AND MANAGEMENT

8.4.1 Land-use planning and management measures such as land acquisition, relocation of incompatible development, noise mitigation programmes and urban zoning (see Chapter 5) may be effective in reducing the number of people affected by noise. The airport authority should work closely with those authorities responsible for land-use management to educate them regarding the noise impacts of aviation operations and encourage them to develop and implement land-use planning and management measures in affected areas surrounding the airport.

8.4.2 Certain measures for the reduction of noise, such as the introduction of quieter fleets, the application of noise abatement operational procedures and the use of operating restrictions, may provide the benefit of a reduction or a modification in the noise-affected area surrounding an airport. Any beneficial effects that may be achieved by the use of these measures should be preserved whenever possible through the application of complementary measures relative to land-use planning and management.

8.4.3 In order to preserve the already foreseen reduction in the number of people affected and the opportunity to provide a cushion for future aviation traffic growth, the authority should consider the implementation of complementary measures, such as land-use planning and management, by the authorities responsible for land-use plans and regulations to prevent encroachment of incompatible land use surrounding an airport.

8.4.4 The authority should ensure that the land-use planning and management policies and procedures needed to assist in minimizing further incompatible urban development within the previously noise-affected area surrounding an airport are reassessed and revised. In implementing an action plan consistent with the Balanced Approach, the airport authority should work with the authorities responsible for land-use management to achieve the revision of land-use plans and regulations.

8.5 NOISE ABATEMENT OPERATIONAL PROCEDURES

8.5.1 Noise abatement operational procedures may be effective in reducing the size or modifying the shape of the noise contour, thereby possibly improving the noise situation around an airport. There may be a reduction in the number of people affected by noise if the contour shrinks in areas that have already experienced urban development.

8.5.2 Particular attention should be paid to the risk that noise abatement operational procedures might generate an increase in noise exposure in other areas when noise is shifted. Prior to implementation, the impact of specific noise abatement operational procedures should be carefully assessed to confirm that overall improvements to the noise situation at an airport will be achieved.

8.5.3 Any beneficial effects that may be achieved by the use of these measures should be preserved whenever possible through the application of complementary measures relative to land-use planning and management.

8.6 OPERATING RESTRICTIONS

8.6.1 Operating restrictions such as a ban on noisy aircraft or the introduction of partial curfews may improve the noise situation around an airport and reduce the number of people affected by aircraft noise.

8.6.2 Operating restrictions at a specific airport may result in the further reduction of noise at source above the current international ICAO standard. Such restrictions may improve the noise situation around airports. However, without the consideration of complementary measures, particularly land-use planning and management, to protect the improvements that have been achieved, the benefits may be lost and the further proliferation of costly operating restrictions may result.

8.7 ASSESSING THE EFFECTS OF COMBINED ELEMENTS AND/OR MEASURES

8.7.1 This section briefly introduces the factors that should be considered when assessing the environmental benefits and cost of the combined principal elements and/or measures. Chapter 9 discusses the factors and provides a methodology that might be used to assess the relative cost and benefits of the measures available to the authority.

8.7.2 The difficulty quantifying the impact of a number of relevant factors such as political, social and legal factors may affect the outcome of the assessment since there may be an element of uncertainty in the comparison of some measures. Planning decisions will therefore require the exercise of careful judgement as well as the support of economic analysis.

Noise benefits

8.7.3 The typical baseline represents the changes in the noise situation taking into account any new ICAO recommendations with no additional measures. Once the actions have been identified and judged possible by the authority, it is appropriate to assess the changes according to the realistic combination of measures.

8.7.4 One way of assessing the noise benefit associated with each combination is to express it as a reduction in the total number of people who will be affected, or the degree to which they will be affected, at the same time as that used at the end of the baseline situation. Any combination that does not provide the required benefits should be abandoned, which would eventually also enable the authority to decide which of the current measures could possibly be abrogated.

8.7.5 The benefits are accounted for, for example, by the reduction in the total number of people exposed; they can be accounted for by the reduction in the weighted number of people, insofar as the State introduces a system of weighting to allow for the number of people exposed living in soundproofed housing, compared with those living in non-insulated houses. Instead of a weighted number of people, a weighted number of houses may be easier to use and considered as representative.

8.7.6 Weighting can also be used to take into account those people exposed to high levels of noise energy and those exposed to low levels of noise energy, or for those people exposed during certain periods of the day and those exposed during other periods.

Cost of the available measures

8.7.7 The cost of each combination of measures which provides environmental benefits and which meets the objective should be assessed. The potential cost per activity no longer affected or less affected will be a major factor in the final decision on the choice of the combination of measures to be adopted.

8.7.8 Costs can come from very different sources. In the case of worldwide measures, costs are generally borne by the operator and subsequently transferred directly to the air transport customer.

8.7.9 Costs could be borne by operators in terms of fleet renewal or depreciation, loss of revenue subsequent to a reduction in the operation of their fleet and the increase in operating costs. They can also be borne by the operator through the modification of airport facilities or their use (infrastructure or underuse) or diversification of their operations. In the case of relocation, it is necessary to take into account the environmental deterioration and other costs/ profits relative to operations relocated to other facilities.

8.7.10 Costs may be borne directly or indirectly by air transport customers in terms of an increase in transport costs or routing times or substituted purchases. They may also be borne by air transport suppliers in terms of a drop in activity or depreciation of a product where demand has dropped. Costs can affect the owners of land in the vicinity of the airport insofar as they depreciate or raise the value of their property, depending on the reinforcement or reduction of land-use constraints relative to airport activity and the changing pressure for land use according to the economic activity around the airport. They also affect residents concerned about the soundproofing of their houses according to the measures advocated by the authority.

8.7.11 Finally, costs can be borne by States, citizens or airport management companies if they decide not to recover them by a fee or tax levied on the operators or air transport customers when they finance measures such as the buying back of land or the building of new facilities.

8.8 ECONOMIC INSTRUMENTS AND THEIR POTENTIAL IMPACTS

Existing ICAO guidance identifies the principle that noise-related charges should be non-discriminatory between users and should not be established at such levels as to be prohibitively high for the operation of certain aircraft. However, a noise-related economic instrument, depending on application, could have an unexpected and unintended effect on operators or a specific operator at an airport by limiting access to that airport. Whether or not an economic instrument imposes a restriction on an operation at an airport, its impact would be determined by an assessment of the situation at the airport in consultation with the authority and the stakeholders, consistent with the Balanced Approach.

8.9 NOISE ABATEMENT OPERATIONAL PROCEDURES AND THEIR POTENTIAL IMPACTS

8.9.1 Any measure taken under the Balanced Approach, depending on its application and effect, if not accounted for in the initial assessment and planning, could have an unexpected and unintended effect on the noise situation, the aircraft fleet operating at the airport, and the surrounding community.

8.9.2 Any mandatory noise abatement operational procedure has the potential in specific instances to limit the access to an airport of an aircraft that does not have the particular performance characteristics to comply with the procedure. Some examples are:

- a noise abatement operational procedure that prohibits the operation of at least one type of aircraft in all available runway directions over a specified time period;
- the requirement of a specific profile (minimum climb gradient) in the direction of a runway in service as long as no other runway direction is also in service at the same time without climb gradient limitation;
- the requirement for a minimum navigational capability, or limitation on the use of reverse thrust above idle, when such use is assumed in the certified runway limitations for the aircraft concerned (e.g. contaminated runway). Any of these examples may exclude access to that airport.

8.10 TRADE-OFF CONSIDERATIONS BETWEEN NOISE AND EMISSIONS

8.10.1 Although emissions are not a part of the Balanced Approach, this section provides general background information and suggested considerations to be given in relation to the inherent complex and evolving interdependence between environmental factors. It is meant to help ICAO Contracting States decide on possible alternative measures that should be evaluated when initiating actions to improve the noise situation at airports, under the Balanced Approach.

8.10.2 Historically the introduction into the fleet of quieter aircraft has had a positive effect on emissions (excluding total compensation of traffic growth effect). This is because the new aircraft/engine combinations also have better fuel burn and sometimes better combustor characteristics with the positive effects of improved features outweighing the negative impacts of trade-offs.

8.10.3 With the advent of more stringent noise certification requirements, combined with increasingly challenging technical improvements, the situation may change, and the fleet could experience some emission impacts — or reduced emission benefits — as a result of future trade-offs (independently from the traffic growth effect). These impacts could be amplified by trade-offs performed downstream of the product design process, for instance, in the case of the use of noise attenuation add-on features.

8.10.4 Strong interrelationships link aircraft environmental needs (noise and emissions) at different stages: technology orientations, design requirements, product development and optimization, and the balancing of measures to address the various issues. Trade-offs can apply between noise and CO₂, noise and NO_x, noise and other emissions, and also between gaseous emissions.

8.10.5 Because emission issues (as well as noise issues) are growing (particularly concerning interference with climate), the question of trade-offs is becoming increasingly important at each stage. When dealing with trade-offs between noise and emissions, various underlying issues need to be understood, such as:

- the direct effects of some emissions, both local (air quality) and global (interference with climate), are still uncertain in the scientific communities;
- research, technology development and design activities are expected to follow multiple paths (to reduce noise and the local and global impact of emissions) that will influence the environmental signature of aviation. As criteria emerge from scientific work, they should drive the intensity of efforts dedicated to each path.

8.10.6 The effects of trade-offs quantitatively depend on:

- the objective being pursued and the priorities selected;
- the type of technology and design features involved in reducing noise and emissions (sources, means used and components affected); and
- the type of engine, the type of aircraft and the phase when they are applied.

8.10.7 It should be noted that noise mitigation actions might have an influence on some emissions that are considered for their global effects such as CO₂.

8.10.8 Noise abatement operational procedures are aimed at providing benefits to the community surrounding an airport but may have an impact on aircraft emissions. Such an impact should be balanced against the benefits to the community in the form of reduced noise levels. Noise abatement operational procedures should not be disregarded unless it can be substantiated that the emission requirements override the noise benefits of these procedures.

Chapter 9

ANALYSIS AND SELECTION OF MEASURES

9.1 GENERAL

9.1.1 The purpose of this chapter is to provide guidance on the analytical and methodological tools that may be used by Contracting States or their delegated authorities to address the request contained in Assembly Resolution A37-18 regarding the “evaluation of the likely costs and benefits of the various measures available and, based on that evaluation, selection of measures with the goal to achieve maximum environmental benefit most cost-effectively.”

9.1.2 In practice, this means that Contracting States should identify the various measures available to achieve a stated environmental objective, select a ranking criterion, rank the measures accordingly and select the most cost beneficial or cost-effective measure. Since an environmental objective is typically stated in terms of benefits, the measures available would normally have the same benefits and the associated costs could be used as the ranking criterion.

9.2 GUIDANCE ON ECONOMIC ANALYSIS

9.2.1 The guidance on economic analysis in Appendix 2 provides evaluation techniques and analytical methods that may be used to evaluate the likely costs and benefits associated with the various noise-related measures under consideration. The guidance is intended to illustrate good practices in the conduct of economic analysis that can be used by States or airport authorities to achieve the goals of Assembly Resolution A37-18. It describes how to identify, estimate and aggregate the incremental costs and benefits. By doing so, an objective comparison of various alternatives to achieve the stated environmental objective can be made.

9.2.2 Appendix 2 also describes how to use this information to draw conclusions about the expected economic impact on and resulting benefits for stakeholders from alternative options or scenarios. It also assists in the identification of the most cost-effective, environmentally beneficial measure. It will become clear that there is a large element of uncertainty in such comparisons because of the difficulty quantifying the impact of a number of assumptions and relevant factors that will affect the actual economic outcome. Planning decisions will therefore require the exercise of careful judgement as well as economic analysis based on the techniques described in Appendix 2.

9.2.3 Appendix 2 is presented in two parts. The first part (sections 2 through 4) discusses various approaches to economic analysis as well as evaluation methods such as cost-benefit analysis (CBA), cost-effectiveness analysis (CEA) and the use of sensitivity analysis to evaluate the impact of uncertainty in an economic analysis. The evaluation procedures described are the discounted cash flow analysis technique, the snapshot approach and the person-years method.

9.2.4 Since the Balanced Approach calls for an airport-by-airport analysis, the second part (section 5) describes the evaluation process covering the potential types of costs and benefits and discusses the application of these economic methodologies to the Balanced Approach framework. The second part identifies the types of costs and benefits that should be assessed for each element of the Balanced Approach: reduction of noise at source, land-use planning, noise abatement operational procedures and operating restrictions on aircraft. However, in implementing the Balanced Approach on an airport-by-airport basis, unique situations are surely to arise. Therefore, the types of costs or benefits to be evaluated may differ from the types identified in Appendix 2.

9.2.5 The second part also considers the choice of the most cost-effective measure or combination of measures. The likely costs and benefits resulting from implementing the Balanced Approach at a particular airport would depend largely upon the choice of options from the elements under the Balanced Approach that offer a potential solution to meet the stated environmental objective. However, of the possible options, the most cost-effective option would be the one having the best benefit-to-cost ratio, or the least cost for equivalent environmental benefit, that would meet the objective.

9.2.6 Stakeholders that would be affected by the implementation of policy options at airports include: air carriers, airport authorities, States, nearby residential and business communities, private and commercial entities that rely upon air transport, etc. In conducting an economic analysis, it is important to ensure that all affected parties are identified and the relevant costs and benefits to each and every affected stakeholder are identified and assessed.

9.2.7 Analysis of the costs, benefits and uncertainty associated with a project or policy action must be guided by the principle of transparency and full disclosure within current laws and practices. Data, models, inferences and assumptions should be identified and evaluated explicitly, along with adequate justification for the choices made, and assessments of the effects of these choices on the analysis. The choice of analytical method is dependent upon the availability of data and can have a significant effect on the outcome.

9.2.8 The outcome of an economic analysis depends upon numerous assumptions, estimates and forecasts chosen to model and project the future under a base case, and several policy option scenarios. Each choice of values for the assumptions and forecasts can introduce uncertainty into the economic analysis results depending upon the level of confidence in the choice of assumptions. Uncertainty should be made as transparent as possible. Data, models and their implications for risk assessment should be identified. Assumptions and methods used should be well-documented and accompanied by a sensitivity analysis.

9.3 SELECTING MEASURES

Based on the results of the cost-effectiveness analysis, appropriate measure(s) would be selected. The goal is to achieve maximum environmental benefit in the most cost-effective manner. The selected measure(s) would be tailored to the noise problem of the airport concerned, consistent with the cost-effectiveness analyses.

Appendix 1 to Part I

POPULATION/HOUSING ENCROACHMENT IN THE VICINITY OF AIRPORTS

1. INTRODUCTION

1.1 As stated in Chapter 1, 1.1.6, the concept of the balanced approach is based in particular on the need to preserve the benefits gained from aircraft-related measures that may be lost if the population subsequently grows on land near airports that has been relieved. Further development of that land, if not coordinated with the expansion plans of an airport, can affect noise exposure at given traffic conditions and can lead to additional costs both to the community and to aviation.

1.2 Items 1 and 2 of Appendix F of Assembly Resolution A37-18 specifically relate to the issue of encroachment, wherein the Assembly:

- a) "Urges States that have phased out operations of Chapter 2 aircraft at their airports as provided for in Appendix D to this Resolution, whilst preserving the benefits for local communities to the greatest extent practicable to avoid inappropriate land-use encroachment whenever possible in areas where reduction in noise levels have been achieved"; and
- b) "Urges States to ensure that the potential reductions in noise levels to be gained from the introduction of quieter aircraft, particularly those complying with the new Chapter 4 standard, are also not avoidably compromised by inappropriate land-use or encroachment".

1.3 In response, the following terms of reference were proposed for examining population growth around airports:

- a) assess population growth around the world's jet airports, identifying and monitoring cases where the problem is most severe, elaborating historical and up-to-date analysis of these airports and reporting all measures taken to deal with noise; and
- b) conduct a study of the land-use around representative airports of the world having larger numbers of impacted persons to include determination of the rate at which encroachment is or is not occurring, tying encroachment to land-use management policy and enforcement.

1.4 This appendix describes the findings of a limited number of States relative to assessments of population growth and encroachment around airports. It indicates that encroachment has occurred and points to how the problem might be described and assessed in a systematic way. Assessing and quantifying encroachment requires that an airport maintain historical population and housing information. This appendix illustrates possible means of quantifying encroachment, given the appropriate historical data.

2. APPROACH

2.1 Assessing development around airports requires that historical trend information be collected for both housing and population. Collecting data of this nature is a new type of process. Rather than an exhaustive inventory of

airport data that would encompass the full scope of a global noise exposure model analysis, the approach followed consisted of collecting data from some airports in some States where information could be obtained in support of the study. This would then be used as the prototype for the requirements of a more broad-scale analysis should it be required subsequently. Those able to contribute were free to submit data in any available form that could be used to assess encroachment. The example cases presented are based on the best historical population data that States were able to obtain within the given scope.

2.2 The term “encroachment” is used to describe growth of residential development in areas that are incompatible or potentially incompatible with aircraft noise. Incompatibility is defined in terms of noise exposure criteria; generally these are established locally or nationally. The analysis is straightforward when the boundary of a protected zone is demarcated to allow for future airport growth, for example, within which development would be incompatible when aircraft noise exposure reaches its forecast maximum (perhaps when traffic reaches the planned ultimate capacity of the airport).

2.3 Quantifying encroachment requires definition of an incompatibility zone. Such zones are usually established by defining noise exposure contours around an airport using a noise exposure metric known to correlate with the health and welfare of people and a traffic forecast that anticipates some future growth scenario. In an ideal situation, the boundary might be developed to reflect the planned ultimate capacity of the airport. However, the reality is that forecast capacity can change over time making the tracking of encroachment in these terms difficult.

2.4 The establishment of noise zones and limiting development in the vicinity of the airport are discussed in the *Airport Planning Manual* (Doc 9184), Part 2, *Land Use and Environmental Control*, Chapter 5 — *Land-use Planning*. Examples from seven States are reported, and in general there appear to be two concepts:

- a) establish a reference contour or noise zone based on the planned ultimate capacity of the airport; and
- b) establish a reference contour or noise zone based on a reasonable baseline year of traffic that could serve as a conservative estimate of future growth.

In the latter, it is recognized that growth will occur, but it is difficult to predict exactly how that growth will shape future contours because capacity enhancement plans can change over time.

2.5 States participating in the study addressed the following questions:

- a) Does your State use a noise protection zone concept?
- b) What authority, if any, in your State has responsibility for seeing that the noise protection zone is enforced?
- c) Are there historical data that can track growth in this noise protection zone over time? If yes, can this be illustrated with an example? Can data be made available to ICAO/CAEP showing the noise protection zone and changes in population/housing in the zone over time?

2.6 Examples of answers to the above questions were collected from five States with the results of an examination of historical noise data provided from four States: Brazil, Japan, the United Kingdom and the United States. For this appendix, the airports are labelled “Sample airports”.

3. SUMMARY OF DATA AND ISSUES

3.1 Brazil, Japan, the United Kingdom and the United States provided examples that track population/housing growth over time. Brazil and Japan presented their information as tracked against a formal noise zone as described in Doc 9184. The United Kingdom and the United States presented population changes over time as tracked against changing contours over time, which in general were receding.

3.2 The example studies presented using reference contours may not represent what all parties consider to be “encroachment” because there will be some debate on the reference baseline contour against which population growth should be tracked. However, the airport examples collected may be used to demonstrate trends that exist at airports. Where reference contours were used, the baseline year may or may not represent a reasonable noise protection zone for an airport. Determining this for each airport was outside the scope at the time. However, the years chosen in these studies represent the shrinking contour trends seen during the transition to Chapter 3 aircraft and arguably can be used to demonstrate the opportunity gained or lost by not limiting residential development in areas close to the airport.

3.3 These studies also tracked population and housing trends separately. In some instances, population had gone down, yet the number of housing units had increased. This may be the result of a declining density per household. However, the financial obligation on aviation will most likely involve the insulation or purchase of housing units. For this reason, it may be better to define encroachment by tracking the housing counts.

4. ENCROACHMENT ASSESSMENT METHODOLOGY

4.1 Attachment A contains examples from States that have a formal definition of a noise protection zone as given in Appendix 1 of Doc 9184, Part 2. This is the most straightforward case since these States have formally identified a zone that stays fixed for a long period of time. In some cases, States have national legislation that dwellings are not permitted within these zones. Enforcement, however, at the local level did not occur, and the results are indicative of what a State could gain if the nationally developed noise zone was enforced at the local level.

4.2 Attachment B contains examples of changes in population tracked against two contour bands that were developed for two different reference years. For this analysis, the State was able to provide historical data that allowed for an examination of both population/housing and contour changes over time.

4.3 Table I-A1-1 summarizes different methods of looking at population and housing growth over time and how this growth tracks against a contour that changes over time.

- a) The areas shaded medium grey show the results of keeping one parameter fixed (contour or population) and changing a second parameter (contour or population). For example, the cell labelled “Noise change” shows the overall change in baseline population exposed to noise due to a change in contours.
- b) The area shaded dark grey and labelled “Noise and population change” shows the combined effects of population and contours changing over time. Receding contours over time will normally result in negative numbers in these cells as long as the distribution is not too sensitive to a change in contour shape. It is these numbers that are usually reported in airport planning projects, and they usually demonstrate declining numbers of people exposed due to receding contours.
- c) The cells labelled “Population change” show the population/housing changes relative to a fixed contour level, either the “before” contour or the “after” contour. These numbers may be considered indicative of encroachment.

4.4 Both the population change (before) and population change (after) will give a measure of population encroachment. Where the zoning remains fixed over time and covers both the smaller and larger noise contour, and provided the zoning restrictions are applied consistently, encroachment findings should be similar in both the “before” and “after” cases.

Table I-A1-1. Methods of looking at population and housing growth over time

Scenarios		Census data	
		Before	After
Contour set	Before	Base case	Population change (before)
	After	Noise change	Population change (after)
			Noise and population change

4.5 However, where zoning is directly linked to a noise contour, the zoned area will shrink or grow over time, depending on whether noise contours are also shrinking or growing. In the case of shrinking contours, only populations still contained inside the smaller contour will have been in the “zoned region” across the two census periods. In the case of growing contours, although a zone will have expanded to encompass the larger noise contour, only the region within the smaller contour will have been zoned throughout the time period between the two censuses.

4.6 This differentiation is particularly important since census intervals are typically quite long, e.g. ten years, and noise contours may change in size considerably during this period. Moreover, population changes may not be uniform during the period between two censuses. Thus in the case of shrinking contours, population (after) is the most relevant result for illustrating population encroachment. In the case of expanding contours, population (before) is the most relevant result for illustrating population encroachment.

4.7 Population is rarely distributed uniformly around an airport, and the above analysis is valid only if the smaller noise contour is completely contained within the larger contour. Contour shapes may change over time for a variety of reasons including capacity enhancements that affect the distribution of runway/flight track utilization. Where the contour shapes change considerably, additional analysis will be required to assess encroachment only within the zoned area; otherwise there is a risk of reporting the effects of population changes beyond the zoned area.

4.8 Table 1 in Attachment B reports totals and per cent changes for population and number of households over time. Results are reported for several noise bands in order to track growth at increasing distances from the airport. However, it should be noted that not all noise bands are considered significant by the State reporting the results.

4.9 The results presented in Attachment B are representative of data that were collected, although not every sample airport shows the same trend. In general, the data provide examples that may be considered indicative of encroachment.

4.10 It should be noted that the population for some of the reference years are the best estimates that were available to the task group. Although the data are the best available, there are some uncertainties that should be further researched. One State reported that the future reference year would be updated once new national numbers were officially reported. Another State used national census estimates and is continuing to research planning authorities that would track population and housing over time and report these numbers officially for their region.

4.11 Attachment C includes additional studies from various States (Brazil, Italy, New Zealand, United States) that have been conducted concerning population encroachment near airports.

5. CONCLUSIONS

5.1 This study on encroachment expands on the details on the development of noise zones provided in Doc 9184. Section 4 of this appendix presents methods of quantifying encroachment against a defined noise zone or against reference contours that may change over time.

5.2 Major elements necessary for assessing encroachment include:

- a) agreement at the local level on a reasonable reference contour or noise zone (see 3.2);
- b) if considering the planned ultimate capacity of the airport, addressing capacity enhancements that can change over time (see 2.3); and
- c) obtaining historical population and housing data that track growth over time.

Attachment A to Appendix 1

ENCROACHMENT ON FORMAL NOISE PROTECTION ZONES

Table 1 shows the overall changes for a single noise zone. Population and housing estimated to increase indicates that encroachment is occurring. Table 2 shows changes in the number of households for 12 different zones that have varying degrees of restrictions concerning housing. For Zone 4 and Zones 8 to 12, it is recommended that new housing be prohibited. However, analysis using national housing counts indicates local authorities are allowing growth to occur.

Table 1. Sample airports with a single noise protection zone

Year	Airport 1		Airport 2	
	Population	Households	Population	Households
1995 census data	149 534	63 778	110 874	48 910
2000 census data	145 715	65 810	116 954	53 166
Difference	-3 819	2 032	6 080	4 256
% based on 1995	-2.6	3.2	5.5	8.7

Table 2. Sample airport with multiple noise protection zones

Airport zone	Contour band	Homes		Change		Encroachment
		1992	2002	Number of homes	Annual average	
Zone-1	$65 \leq L < 75$	2 147	2 735	588	2.5%	27.4%
Zone-2	$65 \leq L < 75$	6 192	6 203	11	0.0%	0.2%
Zone-3	$65 \leq L < 75$	1 583	1 282	-301	-2.1%	-19.0%
Zone-4	$65 \leq L < 75$	154	327	173	7.8%	112.3%
Zone-5	$65 \leq L < 75$	2 282	3 506	1 224	4.4%	53.6%
Zone-6	$65 \leq L < 75$	927	1 875	948	7.3%	102.3%
Zone-7	$65 \leq L < 75$	4 951	5 240	289	0.6%	5.8%
Zone-8	$65 \leq L < 75$	181	277	96	4.3%	53.0%
Zone-9	$65 \leq L < 75$	908	2 499	1 591	10.7%	175.2%
Zone-10	$65 \leq L < 75$	149	281	132	6.5%	88.6%
Zone-11	$75 \leq L$	1 441	2 039	598	3.5%	41.5%
Zone-12	$75 \leq L$	2 632	4 808	2 176	6.2%	82.7%
Total		23 547	31 072	7 525	2.8%	32.0%

Attachment B to Appendix 1

EXAMINATION OF POPULATION/HOUSING AND CONTOUR CHANGES OVER TIME

Table 1. Sample data for seven airports against historical reference contours

		1991 census data				2001 census data			
		Base case				Population change (before)			
		Population		Households		Population	Change	Households	Change
1991 contours	57-60	313 390		128 448		340 009	+8%	147 028	+14%
	60-63	154 519		62 665		164 892	+7%	70 369	+12%
	63-66	74 820		29 269		80 852	+8%	33 406	+14%
	66-69	44 973		17 128		45 896	+2%	18 703	+9%
	69-72	17 847		6 982		20 031	+12%	8 378	+20%
	>72	12 394		4 869		11 413	-8%	4 698	-4%
		Noise change (using 1991 census)				Population change (after)			
		Population	Change	Households	Change	Population	Change	Households	Change
2001 contours	57-60	165 430	-47%	69 048	-46%	180 221	+9%	79 150	+15%
	60-63	73 675	-52%	29 368	-53%	80 648	+9%	33 721	+15%
	63-66	43 848	-41%	16 608	-43%	44 081	+1%	17 929	+8%
	66-69	18 045	-60%	6 577	-62%	19 045	+6%	7 496	+14%
	69-72	5 217	-71%	1 879	-73%	4 639	-11%	1 741	-7%
	>72	1 119	-91%	461	-91%	946	-15%	443	-4%
		Noise and population change							
	57-60	180 221	-42%	79 150	-38%				
	60-63	80 648	-48%	33 721	-46%				
	63-66	44 081	-41%	17 929	-39%				
	66-69	19 045	-58%	7 496	-56%				
	69-72	4 639	-74%	1 741	-75%				
	>72	946	-92%	443	-91%				

- Increases in population from 1991 to 2001 with respect to the 2001 contours are indicative of encroachment.
- Decreases in population from 1991 to 2001 with respect to the 1991 census are indicative of receding contours.
- Overall decreases in population from 1991 to 2001 with respect to the 2001 contours show the receding contours have a larger effect on reduction in population than the encroachment reported in 1.

Attachment C

ADDITIONAL STUDIES CONCERNING POPULATION ENCROACHMENT NEAR AIRPORTS

BRAZIL

Changes in residential and population noise exposure in the vicinity of a busy international airport were analysed. The data used in the analysis included population/households within the areas limited by the airport noise zoning plan, which is a noise compatibility plan, for the years 1991 and 2000. The population and household data are from the census undertaken in those years. The several planning zones that make up the airport noise zoning plan were established in accordance with contour bands relative to 65 to 75 L_{dn} and above and also the areas limited by the local land-use and zoning plan. It is important to point out that the planning zones of this airport have not changed since 1991.

Table 1 presents the population and household changes for six zones included within the $65 \leq L < 75$ contour band and for the above 75 L_{dn} band.

Table 1. Airport population and household changes

ZN (Zones)	Contour band	Census data					
		1991		2000		Change (%)	
		Population	Household	Population	Household	Population	Household
ZN-1	$65 \leq L < 75$	35 364	8 569	38 549	10 460	9.01%	22.07%
ZN-2	$65 \leq L < 75$	733	174	1 297	351	76.96%	102.00%
ZN-3	$65 \leq L < 75$	14 536	3 420	22 150	5 861	52.37%	71.37%
ZN-4	$65 \leq L < 75$	18 474	4 739	20 307	5 756	9.92%	21.46%
ZN-5	$65 \leq L < 75$	7 332	1 718	11 440	2 929	56.02%	70.49%
ZN-6	$L \geq 75$	17 168	4 048	24 355	6 515	41.86%	60.96%
Total		93 607	22 668	118 097	31 872	26.16%	40.61%
ZN-(X)*	$65 \leq L < 75$	76 439	18 620	93 742	25 357	22.64%	36.18%
ZN-6	$L \geq 75$	17 168	4 048	24 355	6 515	41.86%	60.96%

*Zone defined as the aggregate of zones included within the contour band ranging from 65 to 75 L_{dn} .

Table 2 presents the restrictions within planning zones. According to the data in Table 2, the zones that showed the smallest increase in households were the ones where dwellings are permitted (ZN-1 and ZN-4). Among the zones where dwellings are allowed, the one with the largest increase was ZN-3 in which only single-family dwellings are allowed.

On the other hand, all the zones in which households are prohibited presented a significant increase in the number of homes (ZN-2, ZN-5 and ZN-6). Note the case of ZN-2, which had the greatest increase in households (102%) among all the zones analysed.

Table 2. Restrictions within planning zones

ZN (Zones)	Contour band	Restrictions	Encroachment	
			Population	Household
ZN-1	$65 \leq L < 75$	Single-family dwellings allowed	9.01%	22.07%
ZN-2	$65 \leq L < 75$	Dwellings prohibited	76.96%	102.00%
ZN-3	$65 \leq L < 75$	Single-family dwellings allowed	52.37%	71.37%
ZN-4	$65 \leq L < 75$	Multi-family dwellings allowed	9.92%	21.46%
ZN-5	$65 \leq L < 75$	Dwellings prohibited	56.02%	70.49%
ZN-6	$L \geq 75$	Dwellings prohibited	41.86%	60.96%

In spite of the fact that the surrounding areas affected by airport noise are, in principle, subject to control by an airport noise zoning plan, the data showed that the zone where the noise level is above 75 L_{dn} (ZN-6) presented a greater encroachment than the total remaining zones within the 65 to 75 L_{dn} band, although residential buildings are not permitted in that area. In fact, in less than a decade, population doubled and the number of houses increased by almost 61 per cent. It is important to point out that this zone is mainly occupied by a low-income population and also has slum areas, which have grown without local authority control.

The results of this analysis indicate that the land-use restrictions specified in the noise zoning plan are not being adequately followed. This most surely is due to the lack of commitment of the local authority responsible for the approval of buildings according to the plan.

Therefore, this fact reinforces the need to improve not only the methodologies used in Brazil that allow for a better understanding of the dynamics of land occupation in these areas, but also the instruments to control and monitor land use.

ITALY

To guarantee agreement at the local level on a noise zone and the correct land-use management from the local authorities, the national regulation requires the Italian Civil Aviation Authority (ENAC) to set up a noise airport committee at each airport, chaired by the airport director (ENAC) and composed of representatives from the airport operator, air traffic service provider, environmental protection agency, air transport operators, and local authorities.

The committee presents to ENAC a proposal for noise zoning which takes into account the airport master plan and land-use planning. The zone comes from the noise contours built on the basis of the optimum air traffic scene (in-flight and ground-based operational procedures, routes, runways, distribution of the traffic, etc.) identified to minimize the number of people affected by the level of noise perceived. The municipal authority has responsibility for enforcing the noise protection zone.

At Bologna International Airport, the noise protection zone was approved by the committee in 2003 (see Table 3), and it has a more extended surface with respect to the acoustic map. The local municipal authority enforced the noise protection zone in the same year. At that time, residential areas around the airport were characterized by high density; most of the land included in the noise contours was already urbanized. In order to limit the increase in the number of people affected by the noise levels, the municipal authority decided to extend land-use restrictions in Zone A, even limiting future changes in the use of existing buildings and preventing service buildings from being assigned for residential use.

In Zone B, new residential buildings are forbidden, and in the case of housing renovations, the increase of the residential surface is not allowed. Also, noise-sensitive land uses, such as hospitals, schools etc., are not allowed.

Table 3. Noise protection zones at Bologna International Airport

Acoustic zones	LVA limit dB(A)	Planning conditions
A	60–65	Residential areas allowed
B	65–75	Only agricultural and industrial activities allowed
C	> 75	Only airport activities allowed

In 2004, the Bologna Airport's east side runway was extended 350 metres, reaching a length of 2 800 metres. As a consequence, departing aircraft fly over Bologna at higher altitudes, with benefits in terms of noise and visual impact. The noise zone was not modified.

Table 4 shows the population assessment, based on census estimates, referring to the number of people exposed within each set of noise contours. In the absence of data about the number of dwellings, the municipal authority has supplied the number of street numbers (civic numbers).

Table 4. Examination of population and noise contour changes over time — Bologna International Airport

Scenarios		2002 census data (1)				2008 census data (2)			
		Base case				Population change (before)			
		Population		Civic number		Population		Civic number	
2002 contours	60–65 (Zone A)	4 395		508		4 151	–6%	527	4%
	65–75 (Zone B)	1 362		172		1 293	–5%	175	2%
	> 75 (Zone C)	0		0		0			
		Noise change (3)				Population change (after) (4)			
		Population		Civic number		Population		Civic number	
2008 contours	60–65 (Zone A)	3 363	–23%	367	–28%	3 159	–6%	378	3%
	65–75 (Zone B)	31	–98%	17	–90%	23	–26%	17	0%
	> 75 (Zone C)	0		0		0		0	
		Noise and population change (5)							
		Population		Civic number		Population		Civic number	
		60–65		3 159	–28%	378	–26%		
		65–75		23	–98%	17	–90%		
		> 75		0		0			

- Low decreases from 2002 to 2008 (1) (2) census data referring to 2002 contours and low decreases from 2002 to 2008 (3) (4) census data referring to 2008 contours indicate that over time the population has not substantially changed due to the efficient land-use management policy.

Note.— The low increase of civic numbers is registered from 2002 and 2003 (noise zoning enforcement date).

- Overall decreases in population and civic numbers from 2002 to 2008 (1) (5) referring to 2002 are indicative of receding contours due to runway extension.

Table 5 presents the population changes over time within the areas limited by the noise protection zone, which has a more extended surface with respect to the acoustic map. It is important to point out that the planning zones have not changed over the years even though the acoustic map has receded due to the runway extension.

Table 5. Population changes over time within areas limited by the noise protection zone

Acoustic zones (A+B+C)	Year	Extension (km ²)	Population	% variation in population	Street numbers	% variation in street numbers
	2003	12 186	9 683	—	1 290	—
2005	12 186	9 567	-1.20%	1 319	2.25%	
2008	12 186	9 368	-3.25%	1 346	4.34%	

NEW ZEALAND

In 1999, Auckland International Airport Limited (AIAL) conducted an airport noise study based on the construction of a new second runway parallel to the existing runway. Case studies for the years 1993, 2010, 2020 and 2030 were conducted. The purpose of this case study was to provide an example of how an airport can take predicted population changes into account when conducting airport noise studies involving future operational scenarios.

Among other analyses, the estimates of current and future impacts of airport noise included a study of the number of dwellings and residents within the calculated airport noise contours. The analysis considered the noise areas, namely within the 65-L_{dn} noise contour, between 60 and 65 L_{dn}, and between 55 and 60 L_{dn}.

The process involved two steps. The first was to estimate the number of dwellings within each area for each case and the second was to estimate the number of residents in those dwellings.

Number of dwellings

The local authority, Manukau City Council, had a geographical information system that was able to compute the number of properties zoned residential, rural 1 or rural 2. In the rural zones the total areas could also be calculated.

Two different dwelling development scenarios were considered as follows:

No growth. This scenario calculated the number of dwellings in each of the noise areas for each of the four cases, based on the zoning of each property. Each separate property zoned either residential or rural (R1 or R2) was taken as having just one dwelling.

Predicted growth. This growth scenario was calculated only for the 2030 case and used two sources of data for the projections. The first was a change in population study published by the national government body, Statistics New Zealand, which estimated that the population of the region would grow between 20 and 52 per cent in the period 1996 to 2031. The second was that the rural 2 zoned land would be permitted to be subdivided for residential purposes at an average rate of 650 m² per dwelling (including amenities such as roads).

The results are tabulated in Table 6. (Note that these are slightly abridged from the original report for the purposes of brevity and simplicity).

Table 6. Two different dwelling scenarios

Case	Noise area (L _{dn} dBA)	No growth scenario			Number of dwellings	Predicted growth scenario		
		Number of properties of each zone type				Statistics New Zealand population growth (residential only)	Rural 2 subdivision	Number of dwellings in 2030
		Residential	R1	R2				
1993	55-60	1 884		6	1 890			
	60-65	225			225			
	>65							
2010	55-60	2 693	8	87	2 788			
	60-65	950			950			
	>65	43			43			
2020	55-60	2 609	20	97	2 726			
	60-65	1 040			1 040			
	>65	131			131			
2030	55-60	4 019	46	106	4 171	30%	8 400	13 625
	60-65	1 578		17	1 595	20%	1 739	3 632
	>65	183			183	20%		220

The tabulated results show that the future subdivision of rural 2 land shows a substantial potential for new dwellings in the noise areas between 55 and 65 L_{dn}. Over 10 000 new dwellings could result in a three-fold increase in the number of dwellings compared with the “no growth” scenario.

Number of residents

The second step in the process was to estimate the number of residents. According to Statistics New Zealand, the average number of people living in each dwelling at the time of the study was 3.1. By 2030, that figure is expected to drop to 2.9.

Using these figures and those in Table 6, it was a simple step to determine the number of residents in each of the noise areas for each of the study years and growth scenarios.

UNITED STATES

Research was conducted on population and land-use patterns around 92 U.S. commercial airports between 1990 and 2000. The research examined how these patterns have responded to federal planning efforts to curtail residential development on land inside the 65-L_{dn} noise contours and the role land-use planning had in reducing total noise exposure during the phase-out of older, louder Stage 2 aircraft. The purpose of the research was to determine the extent to which residential populations are aggregating near airports.

The results showed that land-use planning has mixed results deterring residential development on land inside the existing 65-L_{dn} noise contours. Also, it found that land-use planning has done little to address the increasing population aggregation on lands near the existing noise footprint. The conclusions of the study indicated that the population within the 65-L_{dn} noise contour appeared to be controlled, whereas the population outside the 65-L_{dn} noise contour was increasing and showing evidence of encroachment. The findings are explained in more detail in a report entitled "Airports and Their Cities: The Effectiveness of Mitigating Noise Exposure through Land Use Planning, 1990-2000," by Wyle Laboratories prepared for the Federal Aviation Administration.

In follow-up research, an analysis into the underlying factors that influence residential land use near 71 commercial airports was conducted. In particular, it examined the relationship between changing residential housing densities near commercial airports and factors commonly attributed to suburbanization and sprawl. The research used a principle components analysis and a series of multiple linear regression models to analyse factors commonly attributed as the source of shifting residential development. The main conclusion of the study indicated that there was a strong relationship between employment opportunities and residential housing near commercial airports. It found that efforts to mitigate noise exposure by promoting large economic zones around airports have created an unintended result of people relocating to be near their employment centres.

Appendix 2 to Part I

ANALYTICAL METHODOLOGIES/TOOLS TO USE IN THE EVALUATION OF LIKELY COSTS AND BENEFITS OF STUDY OPTIONS

1. INTRODUCTION

1.1 The purpose of this Appendix is to provide guidance on the analytical methodologies/tools that might be used to evaluate “the likely costs and benefits of the various measures available under the Balanced Approach and, based on that evaluation, selection of measures with the goal to achieve maximum environmental benefit most cost-effectively.” In practice, this would include identification of the various measures available to achieve a stated environmental objective, establishment of a ranking criterion, the ranking of the measures accordingly and the selection of the most cost-beneficial or cost-effective measure. Since an environmental objective is typically stated in terms of benefits, the measures available would have the same benefits and the associated costs could be used as the ranking criterion.

1.2 This guidance describes evaluation techniques and analytical methods that can be used to evaluate the likely costs and benefits associated with the various noise- related measures under consideration. This guidance is not intended to be prescriptive; rather, it is intended to illustrate good practices in the conduct of economic analysis that can be used by States or airport authorities to achieve the goals of Assembly Resolution A37-18.

1.3 The text that follows describes how to identify, estimate and aggregate the incremental costs and benefits. By doing so, an objective comparison of various alternatives to achieve the stated environmental objective can be made. This document also provides guidelines (presents examples) on how to use this information to draw conclusions about the expected economic impact and resulting benefits to stakeholders from alternative options or scenarios. Guidance is also provided to assist in the identification of the most cost-effective, environmentally beneficial measure. It will become clear that there is a large element of uncertainty in such comparisons because of the difficulty quantifying the impact of a number of relevant factors that will affect the actual economic outcome. Planning decisions will therefore require the exercise of careful judgement as well as economic analysis based on the techniques described in this document.

1.4 This Appendix is split into two major parts. The first part (sections 2 through 4) discusses various approaches to economic analysis as well as evaluation methods. The major commonly used analysis tools that will be discussed are cost-benefit analysis and cost-effectiveness analysis. The evaluation procedures that will be described are the discounted cash flow analysis technique, person-years method and the snapshot approach.

1.5 The last part of this Appendix (section 5) discusses the application of these economic methodologies to the Balanced Approach framework. In this section, the types of costs and benefits that could be considered for each element under this framework are identified. As adopted by ICAO, the Balanced Approach contains four elements: reduction of noise at source, land-use planning, noise abatement operational procedures and operating restrictions on aircraft. However, in implementing the Balanced Approach on an airport-by-airport basis, unique situations are surely to arise. Therefore, the types of costs or benefits that are considered in the evaluation do not necessarily have to be limited to or constrained by the examples identified in this guidance material.

1.6 The likely costs and benefits resulting from the implementation of the Balanced Approach at a particular airport would depend largely upon the choice of options from the elements under the Balanced Approach (as defined in Assembly Resolution A37-18) that might offer a potential solution to meet the stated environmental objective. However, of

the possible options, the most cost-effective option would be the one having the best benefit-to-cost ratio, or the least cost for equivalent environmental benefit, that would meet the project's objective.

1.7 Examples of stakeholders that would be affected by the implementation of policy options at airports are: air carriers, airport authorities, States, nearby residential and business communities, and private and commercial entities that rely upon air transport. In conducting an economic analysis, it is important to ensure that all affected parties are identified and the relevant costs and benefits to each and every affected stakeholder are identified and assessed.

2. REASONS FOR AN ECONOMIC EVALUATION

In order to satisfy the provision in Assembly Resolution A37-18 calling for "selection of measures with the goal to achieve maximum environmental benefit most cost effectively," an economic evaluation is required. An economic evaluation allows one to quantify the uncertainty associated with particular study options through sensitivity analysis, which will aid in the decision-making process. The analysis allows assessment, a priori, of the potential impact on stakeholders (costs and benefits) of the different options under consideration. Analysis of the costs, benefits and uncertainty associated with a project or policy action must be guided by the principle of full disclosure within current laws and practices. Data, models, inferences and assumptions should be identified and evaluated explicitly, along with adequate justification for the choices made, and assessments of the effects of these choices on the analysis.

3. CHOICE OF ANALYSIS METHOD

3.1 General

3.1.1 Two economic analysis methods will be discussed in this section: cost-benefit analysis and cost-effectiveness analysis.

3.1.2 Cost-benefit analysis requires that both the costs and the benefits can be described in monetary terms. The analyst collects all of the costs, compares them to the collection of all of the benefits and produces a ratio. If the cost-to-benefit ratio is greater than one, the costs exceed the benefits and, alternatively, if the ratio is less than one, the benefits exceed the costs. Cost-effectiveness analysis is a technique that evaluates the variable costs or the variable benefits against a prescribed objective. For example, a noise objective (the environmental benefit) may be specified by an authority; the analyst then compares various schemes to achieve that objective on the basis of the cost of each of the schemes. In this case the scheme that costs the least is the most cost-effective.

3.1.3 Alternatively, the authority may establish a budget or cost cap. The analyst then compares the various schemes to reduce noise, within the specified budget, on the basis of the benefits derived. In this case the scheme that produces the most benefits is the most cost-effective.

3.2 Cost-benefit analysis

3.2.1 A cost-benefit analysis (CBA) provides a logical and consistent framework for assessing a particular option. A CBA gives an indication of the total economic welfare effects of a project by comparing all costs and benefits. An important feature is that a CBA has significant informational requirements and provides a framework such that it forces the decision maker to be explicit about the assumptions used in an economic assessment and the trade-offs between

conflicting objectives. This allows alternative options to be compared and ranked in relation to scarce economic resources being considered. In some cost-benefit analysis, the costs and benefits can be directly compared because they are in the same monetary units and the resulting ratio of benefits to costs can be easily understood. Often not all effects can be explained in monetary terms.

3.2.2 A cost-benefit analysis can still be conducted where benefits cannot be quantified in monetary units. A ratio (cost/ unit benefit) can be derived to aid in the ranking of the options. Because costs cannot be compared with benefits on a common metric, this approach will not indicate in clear quantitative terms whether the main objective of a project warrants the costs involved. Rather, it can be used to assist the decision maker in choosing from among several alternative ways of achieving a stated objective in a way that seems to minimize costs and/or maximize benefits.

3.2.3 For economic analysis conducted to evaluate environmental policy scenarios, the valuation in monetary terms can be very difficult and may not be considered practical. In the context of quantifying the benefit of reduction of airport community noise in monetary values, many difficult questions would have to be answered. For example, what are the monetary benefits from less noise disturbances for people living near airports? Assuming that a better night's sleep leads to improved productivity, how would one place a monetary value on improved productivity? Each person living near an airport may not be annoyed to the same degree. Lower community noise could contribute to a better quality of life. How would this benefit be valued in monetary units? These questions are very difficult to answer. Thus, it would be extremely difficult for someone conducting an analysis to make valuation assumptions of the benefits in monetary terms. However, as an example of benefits in physical units, it is possible to count or project the number of people that would be exposed to lower levels of noise resulting from a given policy action designed to reduce community airport noise. It may also be possible to estimate the time frame when a reduction in the number of people exposed to noise occurs. By adding this temporal element, the benefit of reducing noise exposure sooner rather than later can be valued in the analysis.

3.2.4 Ratios for each project can then be computed by dividing the value of the benefits (in physical units) by the value of the costs associated with the option or scenario. The various options can then be compared to determine which option minimizes the costs and maximizes the benefits better than other options, taking into account the assumptions embodied in determining the benefits and costs (e.g. the decrease in the number of people exposed to airport noise at the stated objective noise level per economic unit such as millions of dollars).

3.2.5 A cost-benefit analysis is a conceptual framework for the evaluation of investment projects. Within the cost-benefit analysis framework, the costs and benefits of alternative actions to the status quo (business-as-usual case) are evaluated for achieving the most efficient course of action. In short, within the cost-benefit analysis framework, costs and benefits are different for each alternative being evaluated relative to the status quo.

3.3 Cost-effectiveness analysis

3.3.1 A cost-effectiveness analysis should be used when the objective of a measure is a given. It differs from a CBA in that it asks a different question, namely, given a particular objective, which is the least costly way of achieving it? Stated another way, a cost-effectiveness analysis is applicable only when either of the following conditions exists (but not both):

- a) the benefits of alternative investment projects relative to the status quo are identical and hence only costs need be compared. Thus, for this type of analysis the objective is to determine which of the competing alternatives could achieve the same goal with the least costs; and
- b) the cost of alternative investment projects are identical and hence only benefits need be compared. Another way of stating this is to ask the question: "how to best maximize the benefits from a choice of alternative options within a fixed budget?" Technically, this type of analysis would be a benefit- effectiveness analysis. However, it is rarely, if ever, used since emphasis is usually placed on costs as the most important decision-making parameter.

3.3.2 When monetary values cannot be easily estimated for potential benefits, there should be a concerted effort to think creatively and come up with ways of at least ranking the benefits of the various alternatives. In microeconomic literature, it is well-documented that items being examined without monetary values can be ranked ordinally (relative values), rather than cardinally (absolute values). This is a process using reasoned qualitative values based upon the informed judgement of expert personnel.

3.3.3 Although difficulties exist, arising from uncertainty, imperfect information and in the application of monetary valuations, economists consider that a cost-effectiveness analysis satisfies the requirements of economic analysis and is an appropriate economic appraisal methodology to apply to aviation environmental issues.

3.3.4 However, when the benefits are in physical units (e.g. such as the number of people exposed to a lower level of noise) then the metric becomes some number of benefits per unit of cost. The ratio of costs to benefits (or inversely, benefits to costs) cannot indicate in clear quantitative terms whether the main objective of a project warrants the costs involved. Rather, it can be used to assist the decision maker in choosing from among several alternative ways to achieve a stated objective in a way that seems to minimize costs and maximize benefits.

4. EVALUATION METHODS/TOOLS

4.1 Net present value analysis — discounted cash flow method

4.1.1 Net present value (NPV) or life cycle methodology is a rigorous approach to developing a measure of the expected economic performance of a project. An NPV analysis focuses on the annual cash flows (monetary values) of costs and benefits related to the project. The NPV of a project is equal to the present value of its benefits net of (or minus) the present value of its costs. The present value of benefits (or costs) is the sum of the discounted cash flows of benefits (or costs) to the present (base year) at a given discount rate. An equivalent approach to determine the NPV of a project is to discount the yearly net benefit stream (benefit minus cost) to the present at the same discount rate. The costs and benefits in cash flow terms are unlikely to be distributed evenly over time. Often, there will be large capital expenditures in the early years of a new project followed by many years of benefits and possibly some additional costs associated with administration or operations.

4.1.2 Because many projects to reduce exposure to airport noise will occur over several years, comparisons are made on the basis of “present values”. The present values (i.e. current year capitalized values) of each stream of cash flows associated with each cost or benefit item over the project lifetime can be determined by a process of discounting the future cash flows. Costs that occur in the future will not have the same value as those accruing today. This is because society is not indifferent to having a dollar today and a dollar at a future date. It displays a “time preference”. Discounting future cash flows takes into account the time value of money. Discounting will be discussed in further detail in the next section. The present values of all these future costs and benefits can then be aggregated to form the project’s net present value.

4.1.3 Sometimes benefits cannot be expressed in monetary terms. The costs (measured in monetary units) can be capitalized and brought back to one base year, but discounting physical units is not so obvious and has to be substantiated. In the context of this guidance material, discounting physical units is justified by recognizing that removing a person from a noise exposure above a stated noise contour value today is much more valuable than removing that person from that noise exposure level at some later time, because in the interim that person will experience exposure to noise above the stated noise contour value for which protection is sought. Discounting is particularly needed when the measures to be compared have different implementation time profiles. The example in 4.1.4 illustrates this point.

4.1.4 Suppose that the stated environmental objective is to remove 100 people from a specified noise contour (for example, DNL 65 or above) over a period of four years. Two measures having the same cost are available to achieve the

stated environmental objective. The first measure removes all 100 people at once during the first year, while the second measure removes 25 people per year over the four-year period. On the face of it, the two measures are equivalent in terms of equal costs and equal effect in achieving the stated environmental objective. With the use of discounting, the first measure would be identified as preferable to the second measure because the benefit of removing the people exposed to noise more quickly would be recognized in the analysis. The choice of discount rate affects the analysis. Other methods can be used (see paragraph 4.2).

4.1.5 When employing the NPV method, future streams of costs and benefits are discounted to the present time. A major point of discussion is the discount rate to be selected which would be appropriate from society's perspective. When one performs economic analyses involving environmental policy issues, the question of the appropriate discount rate should be addressed openly, taking into account considerations determined to be relevant to the particular policy or project at issue. One such consideration could be the view that the appropriate discount rate could reflect society's willingness to postpone private consumption now in order to consume later (as measured by the social rate of time preference or SRTP). Another consideration is the marginal earning rate for private business investment (as measured by the social opportunity cost of capital or SOC). Another issue to consider is whose preferences the discount rate should be reflecting. Market rates reflect the subjective preferences of the present generation and may overlook the preferences of future generations. Some economists advocate low discount rates, even 0 per cent, to represent environmental impacts on future generations. Public and private entities often have different discount rates reflecting the different costs of capital (risk) and profit expectations.

4.1.6 If the future cash flows have all been expressed in real terms (i.e. in constant base-year monetary units), the discount rate should be a real rate. The real rate is applied when there is no inflation for the period under evaluation. If the future cash flows have been expressed in "then-year" monetary units, meaning the effects of inflation have been included, then the nominal rate of the discount rate should be used in the analysis. The term "nominal rate" is defined as the real rate plus an additional component to account for the expected annual rate of inflation.

4.1.7 In cases where the various measures have comparable implementation profiles and equivalent environmental benefits, discounting of the benefits is not needed.

4.1.8 One possible difficulty with discounting benefits expressed in physical units is the choice of the discount rate. This rate can be related to the number of people that need to be removed from the stated noise contour in the next year if no people are removed from that noise contour in the current year in order to achieve the stated environmental objective. This correlation is, however, not easy to determine.

4.1.9 For example, if removing 100 people from a noise contour this year is equivalent (from society's or the community's point of view) to removing 110 people next year from the same noise contour, then the discount rate for the benefits (expressed in physical units) should be 10 per cent.

4.1.10 Another problem with discounting is that if the analytical result is to be evaluated in absolute terms, the benefits that lie farther in the future are substantially less valued than those in the present, when discounted. But this fact does not necessarily bias the analysis since the objective is not to come up with an absolute NPV or benefit/cost ratio, but to compare different measures and rank them. The objective of discounting in this application is to reflect the benefit of achieving a noise improvement. SRTP is defined as the rate at which society is willing to trade consumption between different time periods. An indicator of SRTP is the earning rate on personal savings. The after-tax real rate of return on fixed-rate government bonds (T-bills) is often taken as an approximation of SRTP. SRTP typically ranges between 0 and 4 per cent and provides a low-bound for the discount rate. SOC can be approximated by the variable, before tax, real rate of return for business investments. SOC provides a high-bound for the discount rate sooner rather than later. Therefore, the principal consideration is to use identical terms when describing benefits in physical units and to be consistent in the application of the discounting methodology using the identical discount rate, over the same time horizon, and comparing it to the same base year to achieve the same environmental objective.

4.2 Person-years method

4.2.1 The person-years method can be employed as a way to acknowledge the value of implementing noise schemes that provide early benefits, without the necessity of discounting. The analyst expresses the benefit, not in persons removed from a given contour, but in terms of person-years of noise abatement achieved.

4.2.2 In this case, the analyst can express the cumulative benefit obtained over a number of years without having to find an appropriate discount rate for the benefit of reducing populations exposed to noise. The cumulative benefit can be determined by taking account of each person removed in each year (a person-year) and then summing the total number of person-years.

4.2.3 For example, assume a noise scheme that removes ten people exposed to noise from a specified noise contour over a period of four years. A person removed in year one would be counted four times, once in each of the four years; a person removed in year two would be counted three times; a person removed in year three would be counted twice, and a person removed in year four only once. If three people were removed in year one, three additional people were removed in year two, two additional people were removed in year three and the final two people were removed in year four, the total person-years would be 27 ($3 \times 4 + 3 \times 3 + 2 \times 2 + 2 \times 1$). If on the other hand one person was removed in year one, one additional person was removed in year two, one additional person was removed in year three, and seven additional people were removed in year four, the total person-years would be 16 ($1 \times 4 + 1 \times 3 + 1 \times 2 + 7 \times 1$). By comparing the two values of summed person-years, the analyst may find a basis to recommend one option as more beneficial than another. In this example, all things being equal, the option, which produces 27 person-years of benefits, is the more beneficial of the two options.

4.2.4 The person-years method can be thought of as an alternative method of quantifying benefits, described in non-monetary terms, and accounting for the value of time without discounting to NPV. By consistently accounting for the benefits in this way, the analyst can then compare the results of alternative options using either a cost-effectiveness or a cost-benefit analysis (however not in its purest form when costs and benefits are in monetary values). (See section 3.)

4.3 Snapshot approach

Other approaches are available for determining the measure of economic viability. One such approach, called the "snapshot" approach, is based on accrual accounting concepts. It involves choosing a future year, for example the year by which the stated environmental objective would be achieved, and then comparing benefits to the costs exclusively in that year. The choice of the future year is critical and has to be made carefully. In a way, the snapshot approach is the reverse of the NPV method. Instead of capitalizing (as present values) the projected cash flows, the upstream investment costs are transformed into a time stream of equal yearly costs (annualized). These costs together with the yearly variable costs are compared with the benefits, usually for the designated future year. The annualized investment cost is the annual payment on the loan. Several alternative option cases can be compared for the same designated future year, which allows the analyst to carry out comparative evaluations of the options on a completely consistent basis. The snapshot approach can be repeated for different future years for each of the options being studied, which would in effect provide the analyst with a time-series of results.

4.4 Comparison of NPV and snapshot methodologies

4.4.1 The advantages of the snapshot approach is that the analyst only needs to project the future for the designated future year or a small number of future years if the analyst is assembling a simplified time-series. The decision about the discount rate to be used for the investments still has to be made in order to determine the annualized investment cost, but the issue of capitalization of physical benefits, as in the case of the net present value approach, is avoided. The costs and benefits do not have to be related to corresponding values in a chosen base year but are compared in the year they take place. For this reason, no assumptions have to be made for the translation to monetary units.

4.4.2 The use of the snapshot approach is particularly useful when there is not enough information covering the project lifetime to perform a complete analysis or when the key assumptions are highly uncertain. The main limitation of this approach, however, is that it focuses on a specific year in the future only and ignores what happens in between.

4.4.3 The advantage of the NPV approach is that it is more rigorous and more detailed. It includes the time-value of money effect, allowing the analyst to account for uneven cash flows and benefits from year to year throughout the period of study. It shows how the measures available would affect the various stakeholders from year to year over the forecast period. The NPV approach, however, has more significant data requirements and key assumptions that require careful consideration. Time-series forecasts for the base case and the alternative measures have to be developed.

Note.— The biggest distinction between the NPV and snapshot approaches is the future value of money versus the present value of money. The snapshot approach shows the effects of going from today to some point in the future, while NPV shows the effects of going from some point in the future to today.

4.5 Benefit-cost ratio

4.5.1 The benefit-cost ratio is defined as the value of the benefits divided by the value of the costs. Under the snapshot approach, the benefit-cost ratio is simply the annual benefits divided by the annual costs for the designated future year. Under the NPV approach, the benefit-cost ratio is the present value of the benefits divided by the present value of the costs, where both the benefits and the costs have been discounted by the same discount rate for the entire period. The policy options or projects that have a benefit-cost ratio of one or more, assuming that the costs and benefits can be expressed in equivalent units, will return at least as much in benefits as it will cost to undertake the project, indicating that it may be worthwhile.

4.5.2 Regardless of which evaluation approach is taken, it is important that at the end of the analysis all of the options under study have been evaluated on a completely consistent basis. The results of all the study options must be directly comparable with each other in order to aid decision makers in determining which option is the most effective.

4.6 Risk and uncertainty — the use of sensitivity analysis

4.6.1 The outcome of an economic analysis (CBA or CEA) depends heavily upon the numerous assumptions, estimates and forecasts chosen in attempting to model and project the future under a base case and several policy option scenarios. Each choice of values for the assumptions and forecasts can introduce uncertainty into the economic analysis results depending upon the level of confidence in the choice of assumptions. Uncertainty should be made as transparent as possible. Data, models and their implications for risk assessment should be identified. Assumptions should be well-documented with adequate justification for the choices made. Analysts performing the economic analysis should determine the impact on the results from changes in value of some of the key assumptions by testing a range of reasonably expected values that might occur due to the uncertainty of future events. The sensitivity (the impact changes in the value of key assumptions have on the results) needs to be made known to the decision makers to instil confidence in the decisions taken.

4.6.2 Sensitivity analysis is a useful tool for evaluating the impact of uncertainty on an economic analysis. The basic method is to vary key assumptions systematically over appropriate ranges and observe the impact on the results. For some assumptions, the impact on the results from the choice of value may be insignificant, while for others it may be quite large. The sensitivity information is useful in assessing the results of the economic analysis. If varying the key assumption significantly affects the results, that key assumption must be rigorously investigated to ensure accuracy and build confidence. If comprehensive information about that key assumption cannot be developed, then the analysis should be viewed with caution.

4.6.3 If the variations of an assumption can be described by a known probability distribution, then this approach to a sensitivity analysis is known as a risk analysis. Probability statements can then be made about the value of the key assumption and the resulting outcome of the economic analysis.

5. EVALUATION PROCESS

5.1 General

An economic evaluation of policy measures or projects such as noise measures may involve several steps. The typical steps are described below as they may apply under a Balanced Approach analysis. In summary, they include:

- choosing an evaluation procedure, evaluation methods and tools;
- expressing the noise objective that has been identified in clear, quantifiable terms;
- identifying the “base case”;
- identifying the noise measures that will be considered;
- determining key assumptions;
- identifying and quantifying the costs and benefits of noise measures; and
- comparing the results of the different measures.

5.2 Choosing an evaluation procedure, evaluation methods and tools

Before an economic analysis can begin, the evaluation procedure, evaluation methods and tools to be employed in the analysis should be identified. Section 3 of this guidance provides information on the two most commonly used evaluation procedures, cost-benefit analysis (CBA) and cost-effectiveness analysis (CEA). Section 4 of this guidance describes the various evaluation methods and tools that an analyst might employ. To ensure comparability, the same procedure, methods and tools should be employed for all of the noise measures considered under the Balanced Approach.

5.3 Expressing the noise objective in clear, quantifiable terms

5.3.1 Under the Balanced Approach, an economic analysis would be performed with respect to the measures identified as being options for addressing a noise problem after it has been determined that such a problem exists through assessment of the noise situation at a particular airport. To facilitate economic analysis of a noise problem and potential measures to address that problem, the noise objective that has been identified for a particular airport should be expressed in clear, quantifiable terms. Because identification of the noise objective is also the first step in assessing the noise situation at a particular airport under the Balanced Approach, the objective should be identified before the question of an economic analysis even arises. In any event, the noise objective used in the economic analysis should be the same one used in assessing whether there is a problem.

5.3.2 As noted in Chapter 3, for noise assessment purposes, a common, quantifiable method of identifying a noise objective is to define the objective as the change in the number of people at or above a specified noise level. That guidance also identifies the use of noise contours as a common means of tracking and comparing the number of people exposed to particular levels of noise and provides further guidance on how one might quantify exposures.

5.4 Identifying the base-case

5.4.1 A starting point for the analysis must be defined in order to measure or assess the change in noise exposure that may be expected to occur should a particular noise reduction measure be chosen and implemented. This starting point, which reflects the noise situation around the airport as it currently exists, taking into account existing noise controls and current operating and land-use regulations, typically is referred to as the “baseline” or “base-case.” The baseline/base-case noise situation may also be referred to as the “no further action scenario” because it is the noise scenario that is expected to occur based on existing plans with no additional action.

5.4.2 While the base-case noise situation is supposed to reflect aircraft-related noise under existing conditions, considering the noise situation at a single point in time usually would not be deemed sufficient to truly assess the situation. Rather, the noise situation should be assessed over a projected time period, taking into account what is known about the fleet mix over that time period, traffic, operational procedures, existing management plans, agreed future noise controls, and noise mitigation actions. In such a case, the base-case noise situation is that which currently exists and that which is expected to exist at given points in the future taking into account all noise mitigation actions that are already planned. Any additional noise mitigation measure that is not agreed would be outside the base-case.

5.4.3 The length of time over which the noise situation is projected should be sufficiently long to take into account changes in the fleet mix, the longer term nature of airport planning and other factors. As noted in Chapter 3, a common approach is to establish a baseline noise assessment that examines noise in the present and into the future over a period of time established by authorities (e.g. five-year and ten-year intervals).

5.4.4 Once the base-case noise situation over a specified time period has been identified, it can be compared with the noise situation that would be expected should a particular noise reduction measure be adopted.

5.5 Identifying available noise measures (“action scenarios”) to be considered

5.5.1 As discussed in Chapter 3, if the baseline noise situation does not meet the noise objective that has been identified, then noise reduction measures may need to be taken. According to Assembly Resolution A37-18, the “various measures available” that might achieve the stated objectives should be identified and evaluated. To determine whether any such measures should be adopted, Assembly Resolution A37-18 calls for “evaluation of the likely costs and benefits of the various measures available and, based on that evaluation, selection of measures with the goal to achieve maximum environmental benefit most cost-effectively.”

5.5.2 The first step in this process is the identification of possible noise reduction measures for meeting the stated objective. Identifying as many measures as may be available (e.g. technical, buildings, organization, operations) is very important because only those alternatives which are identified will be subject to consideration. It should be recognized, however, that not all measures may be available in all States or at all airports because of national laws, geography or other local constraints. Nevertheless, it may not be possible to determine an optimal course of action if the full range of alternatives that are available at the airport in question is not identified at the outset. This does not mean that all identified measures will be subject to a full economic analysis. Some of the options could possibly be eliminated through a screening analysis based on objective criteria before beginning a detailed analysis of quantifying the likely costs and benefits.

5.5.3 This manual provides guidance on the types of noise reduction measures that might be available. These and any other possible measures should be reviewed to assess whether they are available for potential use at a particular airport. These measures can be considered independently and/or in combination. The measures that are determined to be available (and that are not eliminated by preliminary screening) are the ones that are to be analysed through economic analysis as “action scenarios” to be compared with the baseline or base-case scenario.

5.6 Determining and using key assumptions

5.6.1 A number of assumptions need to be made throughout the economic analysis process because the analysis will be made over a certain number of years in the future. In undertaking economic analysis, it is important to define clear and realistic assumptions. In addition, the assumptions that are used should be well-documented with supporting data.

5.6.2 With the exception of any assumptions which are specific to a particular noise reduction option and which should be explicitly noted in the analysis, the assumptions for the analysis undertaken for each noise reduction option should be the same.

5.6.3 Below are some examples of the types of assumptions that may be relevant in performing an economic analysis of noise reduction options. It should be noted that these are only examples and that the determination of assumptions will vary in practice.

- What assumptions are to be made regarding traffic growth?
- Should plans for a new airport in the region be taken into account?
- Are capacity constraints to be assumed?
- Is population to be held constant or some growth assumption adopted?
- How will aircraft types serving the particular airport change with time, taking into account aircraft retirements, technology advances and other considerations?
- How should continued progress in already existing noise reduction programmes (e.g. an ongoing noise insulation programme for nearby residences) be reflected?
- To what degree will macro effects on airlines or other stakeholders be analysed in addition to micro ones? (e.g. If a particular noise reduction option were an operating restriction, it would be expected to affect airlines' fleet plans. Will the analysts look only at the effects at that airport or in the larger aviation system?)

5.7 Identifying, quantifying and evaluating the costs and benefits of alternative scenarios relative to the base-case

5.7.1 In performing an economic analysis, it is critical that the costs and benefits of each of the noise reduction options under study be compared. On the benefit side, the same approach used for assessing the noise problem at an airport should be used for assessing the change in noise exposure, i.e. the "benefits" should a particular noise reduction option be chosen. On the cost side, for costs to be assessed and then compared, the cost sources must first be identified and the resulting costs estimated.

Identifying the "benefits" or effectiveness of noise reduction options

5.7.2 The environmental "benefit" associated with the implementation of a noise reduction measure or a combination of measures under the Balanced Approach can be defined as a relief in the noise climate around an airport. This can be represented by the reduction in the number of people exposed to a certain level of noise. The number of people exposed at a designated noise level under one noise reduction option as compared with those similarly exposed under another noise reduction option would form the basis for the benefit analysis within the economic analysis because it would show the relative "effectiveness" of the noise reduction measures.

5.7.3 As noted previously in this document, for a cost-benefit analysis, as opposed to a CEA, the benefits usually would be expressed in monetary terms, compared directly to the costs, discounted to the net present value and reported as a ratio of costs to benefits.

Costs related to the implementation of noise reduction measures under the “Balanced Approach”

5.7.4 For costs of various noise reduction options to be assessed and then compared, the sources of costs must first be identified and the resulting costs estimated based on actual cost data. Because actual costs vary by location, this guidance does not address actual costs. However, guidance on the types of cost sources one might expect with respect to particular noise reduction measures available under the Balanced Approach is provided below.

5.7.5 **Costs associated with reduction of noise at source.** According to Assembly Resolution A37-18, reduction of “noise at source” is considered to be noise reduction gained from integration of certification standards into the fleet and is not a measure under the control of individual airports. Accordingly, this option would not be subject to an airport-specific economic analysis for a particular airport. Should an analyst or other stakeholder be interested in the economic analysis used to support a new ICAO noise certification standard, that information can be found in the report of the Committee on Aviation Environmental Protection (CAEP) at the time CAEP recommends the standard to ICAO.

5.7.6 **Costs associated with land-use planning and management measures.** The guidance on land-use planning and management measures in Chapter 5 identifies three categories of land-use planning and management measures, including the following:

- **Planning instruments:** comprehensive planning, noise zoning, subdivision regulations, transfer of development rights, and easement acquisition.
- **Mitigating instruments:** building codes, noise insulation programmes, land acquisition and relocation, transaction assistance, real estate disclosure and noise barriers.
- **Financial instruments:** capital improvements, tax incentives, and noise-related airport charges for revenue generation to fund land-use initiatives.

Examples of cost sources for each of these types of measures are identified below.

Cost sources associated with planning instruments

5.7.7 The identification of costs associated with any land-use planning and management measure is based on the initial definition of zones of different noise exposure and on the evaluation of both the number of people living in those zones and the type of activities. This exercise must be done over the evaluation period, taking into account the planned evolution of the airport (traffic increase, change in fleet mix, new runways) as well as the planned measures in terms of land-use planning (new buildings, purchase of land, housing value evolution, change of land usage (e.g. agriculture to industry)).

5.7.8 Planning instruments are instruments that might alter the size and shape of the different zones, compared to the baseline scenario (change of noise index, updating the noise level defining the zones). This might lead to moving some geographical areas from one zone to another, thus modifying the value of land and houses as well as the type of development allowed in those zones. In such a case, some associated costs will have to be taken into account, either to compensate for any loss of value or to transfer the development rights (from one zone to another area remote from the airport) or to purchase land and sell it for a less noise-sensitive activity.

5.7.9 Some airport infrastructure modifications (extension of a runway, building of a new runway) can be considered as planning instruments that can benefit the existing noise climate over the analysis period. Nevertheless, such possibilities might create some noise disturbance in areas where no noise problem has been identified in the baseline scenario. The same kinds of costs (compensation, transfer of development rights, land acquisition) have to be considered.

5.7.10 Examples of cost sources that may be tied to specific types of planning instruments are identified below:

- **Comprehensive planning:** fees for expert planners, administrative costs, legal costs, costs associated with information dissemination and public review.
- **Noise zoning:** fees for expert planners, administrative costs, legal costs, costs associated with information dissemination and public review, the cost of land devaluation (taken into account with any enhanced valuation) resulting from re-zoning.
- **Subdivision regulation:** fees for expert planners, administrative costs, legal costs, costs associated with dissemination of information and public review, the cost of expanded development requirements and impact fees.
- **Transfer of development rights:** fees for expert planners, administrative costs, legal costs, costs associated with dissemination of information and public review, the cost of land devaluation (taken into account with any enhanced valuation), impact fees.
- **Easement acquisition:** price of the easement, fees for expert planners, administrative costs, legal costs, costs associated with dissemination of information and public review.

Cost sources associated with mitigating instruments

5.7.11 Measures that mitigate noise typically include sound insulation or noise barriers. Costs typically associated with such measures include planning and design costs and material, land and labour costs.

5.7.12 Examples of cost sources that may be tied to specific types of mitigation measures are identified below.

- **Building codes.** These codes are defined to ensure that any new building or house being constructed in a particular zone will have a minimum soundproofing standard to guarantee that the noise inside the building or house is lower than a defined level. This implies the use of materials and techniques that represent an increased cost compared to traditional buildings. It may also necessitate particular design layouts (for instance the location of a bedroom on the ground floor furthest from the flight path). The associated costs can be determined through experience with existing buildings that incorporate such codes or through consultation with the real estate community. Because building codes are a legal means of requiring adequate sound insulation, audit or monitoring check costs may need to be considered. With respect to building costs, only the additional costs posed by the proposed noise reduction measure should be considered.
- **Noise insulation programmes.** For existing buildings, the associated costs will depend on a considerable number of factors (targeted level of noise after insulation; current level of noise attenuation; the cost of materials and labour in the area; building structural modifications due to the noise insulation systems; the necessity, in some areas, to include air conditioning; building usage, i.e. housing, schools, hotels). Accurate cost estimates can be determined through consultation with local suppliers and property owners. Other costs to consider are those associated with administering the noise insulation programme, design fees and legal fees.

- **Land acquisition and relocation.** Land acquisition may be compulsory or voluntary. In both cases, it is normal to meet the full market value plus a reasonable premium (to reflect the inconvenience related to relocation). In addition, the cost of relocation will often be met. In general a proportion of the initial outlay will be recovered by resale of the land. Resale might be through easement or change of land use. In relatively few cases, the land may be “frozen” and not generate any resale value. Therefore, the costs associated with this scenario vary significantly depending on noise levels and local factors. The number of uptakes for a voluntary scheme will clearly dictate the cost. Other costs to consider are administrative costs and legal fees. In addition, environmental testing may be required and the cost of such testing and any clean-up that may be necessary should also be considered as potential cost sources.
- **Transaction assistance.** Some financial assistance can be provided by the competent authority (at least the payment of realtor’s fees) to help a homeowner who is trying to sell a noise-impacted property. In certain conditions to be defined (particular period of time during which the selling process at a defined price was unsuccessful) the competent authority might buy the property and then resell it with an easement or for another less noise-sensitive activity.
- **Real estate disclosure.** The cost sources that might be expected with a real estate disclosure include administrative costs and potential diminution of property values based on the resulting perception from would-be future purchasers.
- **Noise barriers.** They consist of earthen berms, vegetation or man-made barriers on the ground that are located between sources of ground-level noise on the airport and very close-in noise-sensitive receptors. The associated costs will vary according to the materials used, land costs for the property on which the barriers will be erected and the size of the installation. Social concerns and aesthetic considerations may also affect costs.

Cost sources associated with financial instruments

5.7.13 Costs associated with financial instruments designed to reduce noise usually will depend on the value placed on the instrument. For example, the cost of a tax incentive or noise charge will be the cost of such a measure based on the value of the incentive or charge coupled with assumptions of how many people might avail themselves of such an incentive or how many aircraft operations might be subject to the charge. There also may be administrative and legal costs associated with such instruments. If the charge is structured in such a way as to motivate air carriers to replace aircraft, the cost of such replacement should be captured.

5.7.14 Examples of cost sources that may be tied to specific types of financial instruments are identified below:

- **Capital improvements planning:** expert fees for planning services, administrative costs, costs associated with expanded development requirements, financing costs (e.g. fees, insurance, interest).
- **Economic incentives:** lost revenue (or cost of the expenditure constituting the incentive), legal fees, administrative fees.
- **Tax incentives:** lost revenue to government authorities due to tax breaks, and legal and administrative fees.
- **Noise-related airport charges:** cost of the charge to airlines, and downstream administrative and legal costs.

Costs associated with noise abatement operational procedures

5.7.15 Chapter 6 provides guidance on the types of noise abatement operational procedures that may be available and identifies issues to consider with respect to their possible adoption.

5.7.16 As described in Chapter 6, noise abatement operational procedures are designed to change the operations of the aircraft in the air or during taxi to reduce noise impacts. Sometimes these procedures result in increased flight time or taxi time. The costs associated with this increased time should be taken into account in an economic analysis regarding particular proposed procedures. Increased flight or taxi time could be expected to increase fuel burn, thereby increasing fuel costs, and labour costs associated with engaging flight and ground crews for longer periods. Also, noise abatement operational procedures might impose airspace redesign costs; additional flight planning costs; training costs for ATC, airline and airport personnel; and increased maintenance costs associated with increased equipment wear. These changes could impose a capacity constraint on the airport and such costs must be included in the analysis. In addition, certain flight procedures could require additional certification or modification to existing aircraft avionics and/or air traffic control equipment or may need new tools or equipment to be developed, thereby posing increased costs.

Costs associated with operating restrictions

5.7.17 Under the Balanced Approach, an operating restriction is defined as any action that limits or reduces an aircraft's access to an airport for the purpose of noise management. Accordingly, operating restriction costs will largely be those resulting from the reduced access of aircraft to the airport as a result of the restriction.

5.7.18 The cost of a particular operating restriction will vary based on the severity of the restriction and the ability of airlines to adjust.

5.7.19 Chapter 7 provides guidance on the types of operating restrictions that may be available and identifies issues to consider with respect to their possible adoption. Examples of cost sources associated with particular types of operating restrictions are included below:

- **Operations limited to a maximum number of movements.** The operator might be inclined to use a larger aircraft to absorb growth in demand. The larger aircraft may not necessarily be optimized to the mission (otherwise, it would have been used from the beginning), which will induce increased operating costs that can be evaluated by the airline concerned. In the worst case, an airline may need to adapt its fleet planning or composition, possibly with a fleet renewal in the most extreme case.
- **Operations limited to maximum noise energy.** Depending on the noise energy budget attributed to an operator, the operator may change the type of aircraft used (better noise performance) or re-schedule some of its flights (if slots are available) to periods when contribution to the overall noise budget will be lower. This will induce a reorganization cost for the operators as well as higher operating costs of less optimized aircraft.
- **Quotas.** The same comments apply as for maximum noise energy. In addition, quotas may limit the use of specific aircraft and may induce some manufacturing costs for certifying or re-certifying aircraft to levels compatible with those quotas.
- **Progressive reduction rules and non-addition rules.** These operating restrictions (total or partial nature) will induce a reorganization of the fleet operated by the airline at the airport(s) concerned. This can be done by using aircraft that have a better noise performance but are less optimized in terms of operational or economic performance and, in the longer term, by renewing part of the fleet, which is very costly.
- **Curfews.** Some curfews may prevent the operation of specific aircraft at particular times (night for instance). This might have an impact on long-haul flights that need to be scheduled during night for connections and passenger requirements. This may entail a complete reschedule of all long-haul international flights and potentially the connecting ones. Night curfews may affect specific activities (charter flights, freight and post flights) but must not create a competition distortion with other carriers.

Since night flights are counted with a higher coefficient in the overall noise budget, removing some night flights may give some relief to operators by allowing them to increase their daily activity, provided that daily slots remain available.

- **Restrictions on the use of aircraft based on their flight performance.** Slats/flaps and maximum take-off weight (MTOW) restrictions may lead to payload limitations for some operators, inducing associated costs. For long-haul flights, the operations might even be changed because an MTOW restriction may imply a fuel stop on the way (this extreme case would dramatically increase the operating costs of an operator since a crew change would most probably be necessary at the stopover airport). Some restrictions based on performance requirements, for instance to pass over a microphone at a certain height, may imply that the aircraft has to pass the microphone with full thrust, thus increasing the maintenance and fuel costs but also making more noise on the ground. The only alternative would be to reduce the MTOW (thus the payload) to be able to initiate the thrust cutback before passing the microphone or to use an aircraft with a different performance.

5.8 Choosing the most cost-effective measure or combination of measures

5.8.1 Once an economic evaluation has been performed of each individual measure available at a specific airport, then a measure or a combination of measures must be chosen by the competent authority. Before making a decision, it is essential to clearly identify the resulting benefit and the resulting cost of each individual measure and each combination of measures under consideration.

5.8.2 When a combination of different measures is analysed, a separate analysis of the combined measures may be necessary because some measures might be interdependent and may give a result that is not the simple arithmetic sum of each measure. Sometimes a measure designed to reduce noise exposure (e.g. a noise abatement operational procedure) will be combined with a measure designed to preserve noise reduction (e.g. a zoning change that is intended to prevent encroachment into an area where noise has been abated). In such a case, the cost and benefits of the measure to reduce noise as well as the measure to preserve the reduction should be assessed.

5.8.3 Each measure, when considered individually or in combination with other measures, that does not meet the targeted noise objective typically would be eliminated from the analysis unless the decision maker has other non-economic criteria to consider.

5.8.4 Once the measures or combinations of measures that do not meet the noise objective have been eliminated from consideration, the costs and benefits of the remaining measures should be compared.

6. CONCLUDING REMARKS

6.1 This Appendix recognizes that there is a large element of uncertainty in such comparisons because of the difficulty of quantifying the impact of a number of relevant factors that will affect the actual economic outcome. Planning decisions will therefore require the exercise of careful judgement. Economic analysis based (for example) on the techniques described in this document will aid in decision making.

6.2 The choice of the analytical method is dependent upon the availability of data and can have a significant effect on the outcome. The analysts should carefully select the most appropriate method.

6.3 Another important aspect of conducting an economic analysis is the transparency and objectivity of the underlying assumptions used by the analyst. These assumptions should be explicitly described.

PART II

AIRPORT CASE STUDIES

Editorial Note.— The case studies have been reproduced with minimum editorial review in order to retain their original structure.

OVERVIEW

This part provides airport case studies related to elements of the Balanced Approach. It should be understood that these case studies are not direct examples of the use of the Balanced Approach. Although the individual elements of the Balanced Approach are not new and are being employed successfully by airports today, integration of these elements and various measures under each element within the methodology of the Balanced Approach are new, as is the focus of the guidance material.

The following case studies provide examples of best practices on how different elements of the Balanced Approach have been applied to address noise issues in various situations. For example, many airports have employed land-use planning and aircraft operating measures successfully to address noise concerns. Many have active community outreach programmes, and so on. These case studies are not prescriptive and are not intended to suggest that airports must follow the procedures described herein. The intent in providing this information is to give the reader a better understanding of the elements that make up the Balanced Approach, and how others have used these elements in specific situations.

Finally, one of the principal benefits of following a Balanced Approach is the ability to address each airport's unique situation. The Balanced Approach allows a tailored solution at each airport recognizing its unique characteristics, for example, operations, infrastructure, and fleet mix. Readers should use the case studies as starting points as they develop their own Balanced Approach programmes.

AMSTERDAM AIRPORT SCHIPHOL (NETHERLANDS)

Noise assessment/management plan

In the Netherlands, land-use planning and management is a mutual responsibility of the national, regional and local authorities. On the national level, so called Structural Outline Plans are made by the Government and approved by the Parliament which give general information on the use of land for a certain purpose. On the regional level, regional plans are made including more detailed information on the use of land. The local authority develops its own detailed plan taking into account the national and regional conditions. In February 2003, the new fifth runway was opened.

Land-use planning

Based on the Structural Outline Plan for Civil Aviation, a policy agreement was reached in 1991 between the national government, regional and local authorities, together with the airport manager, the national airline (KLM) and the national railways on the future development of the airport. In this document more than 100 actions were listed against noise and pollution to improve living conditions in the region and to improve access to the airport and the region by new road and rail infrastructure.

The noise around Amsterdam Schiphol Airport affects the territories of three provinces and more than 30 municipalities. A committee is established in which all of the local authorities are represented together with the aviation sector (airport, airlines and air traffic control) to discuss the various noise measures and development of the noise situation periodically.

Land-use management

- **Development restriction.** No new noise-sensitive developments are allowed within the legal 35 Ke contour ($\sim L_{den}$ 58 dBA). No noise-sensitive buildings are allowed within the 65 Ke contour ($\sim L_{den}$ 70 dBA).
- **Sound insulation on existing development.** Phases 1 and 2 of the sound insulation programme for all existing noise-sensitive buildings (houses, schools, hospitals, etc.) with the 40 Ke contour ($\sim L_{den}$ 60 dBA) encompassing over 11 000 homes and other noise-sensitive buildings have been completed. With the opening of the new runway, Phase 3 has started with the assessment of the required extent of the insulation programme and is expected to cost approximately 99 million Euros.
- **Consideration of noise in development plans.** Outside the legal noise zones, there is a cautionary 20 Ke contour ($\sim L_{den}$ 50 dBA) where local authorities are requested to take into account noise in their development plans.
- **Noise monitoring and enforcement.** The total noise budget and the distribution of aircraft noise in the airport environs are strictly enforced by an independent government agency. The noise exposure is permanently measured in more than 30 measurement points in the built-up areas around the airport. Exceeding a level at one or more measurement points has to be compensated by means of mitigation measures that prevent further infringement of the noise level (such as change in runway use and/or routes, closure of runways or reduction in traffic).

Reduction of noise at source

Under the Balanced Approach, reduction of noise at source is limited to noise reduction through the adoption and implementation of noise certification Standards set by ICAO and is not within the control of individual airports.

- **ACI participation at CAEP.** Schiphol, through Airports Council International (ACI), the worldwide airport industry association, supports efforts for increased stringency beyond Chapter 4, in the ICAO Standards for aircraft noise, including the need for new Standards to require noise reduction at each of the three measuring points.
- **CAEP working groups.** Schiphol actively participates in the ICAO CAEP working groups on noise and operations.
- **Ban on Chapter 2 aircraft.** According to the European Directive 92/14, aircraft certified in accordance with the noise Standards of ICAO Annex 16, Chapter 2 have been banned since 1 April 2002.

Noise abatement operational procedures

Noise abatement operational procedures implemented at Amsterdam Airport Schiphol include:

- **Preferential runway-use policy.** A noise preferential runway-use policy and matching SIDs and STARs are in force to prevent flying over densely populated areas as much as possible, wind and weather conditions permitting. Some runway directions are not available for either take-off or landing. During evening hours, more runway directions are closed and there are special night SIDs to prevent sleep disturbance.
- **Engine run-up area.** A designated engine run-up area is located in a specially constructed fence area, located between the thresholds of Runways 27 and 22.
- **Use of auxiliary power units (APUs).** In order to reduce the environmental and noise burden, aircraft are urgently requested not to use APUs. External power sources (i.e. ground power units or 400 Hz) are available for use instead.
- **Taxiing procedure.** Aircraft are requested to use the least possible engine power when taxiing. Aircraft equipped with three or four engines are instructed to taxi from the landing runway to the gate with one engine switched off, except when it is considered unsafe or a hindrance to normal operation of the aircraft.
- **Curfew on training.** Training and all test flights within the Schiphol control zone are allowed to be performed only Mondays through Fridays between 0600 and 2100 hours. Military aircraft training flights are prohibited.

Operating restrictions

- **Restrictions of Chapter 3 aircraft.** Aircraft certified in accordance with the noise Standards of ICAO Annex 16, Chapter 3, for which the margin of the sum of the three certification noise levels, relative to the sum of the three applicable ICAO Annex 16, Chapter 3 certification noise limits, is less than 5 EPNdB:
 - For aircraft equipped with engines with a bypass ratio ≤ 3 , new operations are not allowed.

- For aircraft equipped with engines with a bypass ratio ≤ 3 , take-off and landing is not allowed between 1700 and 0500 hours.
- For aircraft equipped with engines with a bypass ratio ≥ 3 , take-offs may not be planned between 2200 and 0500 hours.
- **Reverse thrust.** Between 2200 and 0600 hours, reverse thrust above idle shall not be used after landing on all runways, safety permitting.
- **Noise budget restrictions.** Amsterdam Airport Schiphol is subject to a total annual noise load. A system of Slots is used to provide a neutral, transparent and non-discriminatory system for allocating the available noise capacity within the legal noise limits. The initially declared capacity for Winter Season 2006/2006 is 180 000 movements and for the Summer Season 2006, 270 000 movements.

**EFFECTS OF NOISE EXPOSURE FROM AIRCRAFT OPERATIONS
AMSTERDAM AIRPORT SCHIPHOL**

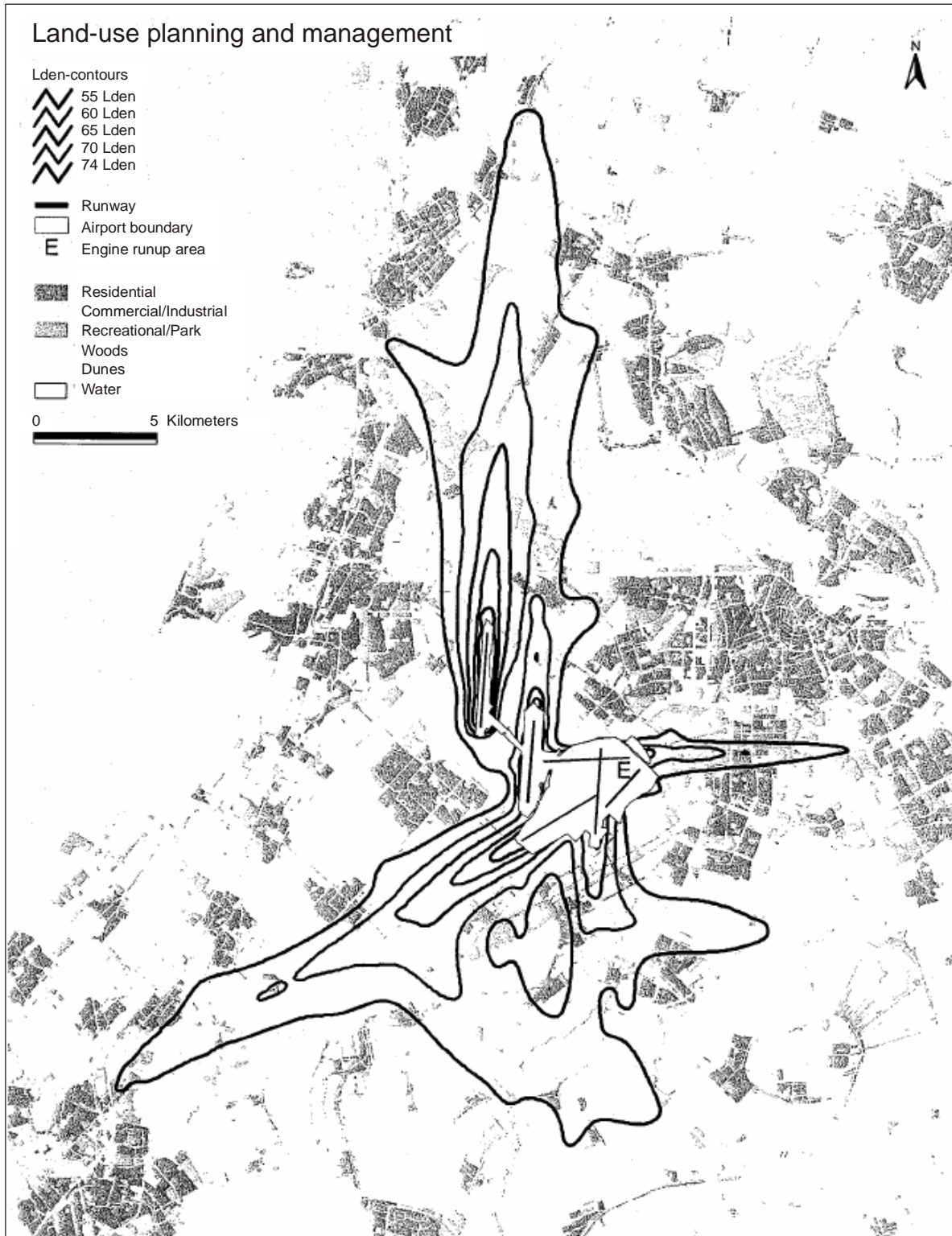
Year	Actual noise exposure area in km ²		Number of houses	
	35 Ke 24 hrs-contour	LAeq 26 dB Night-time contour	35 Ke	LAeq 26 dB
1970	270	—	—	—
1975	220	—	—	—
1980	210	—	42 000	—
1985	158	—	17 700	—
1990	125	—	13 900	—
1995	123	—	17 100	—

Since 1996, legal noise zones are established of 35 Ke for the space of 24 hours and 26 dB LAeq for the night-time period between 2300 and 0700 hours.

1996	117	142	12 250	9 100
1997	113	134	12 700	8 300
1998	102	82	10 200	4 000
1999	102	85	10 400	4 450
2000	101	87	9 650	4 300
2001	100	77	9 670	3 800
2002	95	68	9 300	3 200

Since February 2003, the new 5th runway has been taken into operation. The noise exposure area will be enlarged because of this, but the maximum number of houses exposed to aircraft noise over 35 Ke is limited to a maximum of 10 000.

Amsterdam Airport Schiphol



AUCKLAND INTERNATIONAL AIRPORT (NEW ZEALAND)

Reduction of noise at source

Under the Balanced Approach, reduction of noise at source is limited to noise reduction through the adoption and implementation of noise certification Standards set by ICAO and is not within the control of individual airports.

- **ACI participation at CAEP.** Auckland International Airport Limited (AIAL), through Airports Council International (ACI) the worldwide airport industry association, supports efforts for increased stringency beyond Chapter 4, in the ICAO Standards for aircraft noise, including the need for new Standards to require noise reduction at each of the three measuring points.

Land-use planning and management

Rules relating to noise management for Auckland International Airport (AIA) are outlined in the Manukau City Council District Plan. This plan creates aircraft noise areas in community with varying maximum levels of noise allowed in each area due to aircraft flight operations. These areas are the high aircraft noise area, moderate aircraft noise area and aircraft noise notification area.

Properties in these areas have information on the Land Information Memorandum advising that they are in an area affected by aircraft noise. Within the aircraft noise areas, developers of new dwellings are required to incorporate acoustic treatment measures in their designs. The airport company is also required to provide acoustic treatment to existing houses in these areas once noise reaches certain levels.

Methods used to manage aircraft noise in the community are outlined below.

- **Noise monitoring.** AIAL must monitor noise to ensure that the maximum level of noise allowed in each aircraft noise area is not exceeded. AIA monitors noise from aircraft operations using the ANOMS noise monitoring system. There are three fixed noise monitors and one portable monitor in the community close to the boundary of the high aircraft noise area. Restrictions on noise levels mean that outside the high aircraft noise area, noise must not exceed L_{dn} 65 dBA on a 365-day rolling average and outside the moderate aircraft noise area must not exceed L_{dn} 60 dBA on a 365-day rolling average.

AIA also monitors noise from engine testing. This must not exceed a 7-day rolling average of L_{dn} 55 dBA and a L_{Amax} 75 dBA between 2200 to 0700 hours at any dwelling which is in the main residential zone or which is outside the airport designated area and outside the aircraft noise areas.

- **Noise management plan.** AIAL has a Noise Management Plan which outlines how noise will be managed to comply with the Manukau District Plan.
- **Aircraft Noise Community Consultative Group (ANCCG).** Auckland International Airport has an ANCCG which was formed in 1997. It includes representatives from Manukau City Council, the Board of Airline Representatives New Zealand, Airways Corporation New Zealand, AIAL, industry, and Community Boards. It has an independent chairperson. The group makes recommendations to AIAL on noise issues.
- **Auckland Airport Community Trust (AACT).** AIAL is required to provide NZ \$250 000 per annum to the Auckland Airport Community Trust to be distributed to benefit local community affected by aircraft noise and located or residing within the airport noise areas.

- **Noise mitigation.** The Manukau District Plan requires AIAL to offer acoustic treatment packages to owners of houses and educational facilities in noise affected areas. This applies to buildings completed before 10 December 2001. These packages reduce the amount of aircraft noise heard inside the buildings. Acoustic treatment packages can include the installation of ventilation systems, insulation and kitchen extractor fans.
 - **Existing buildings subject to noise from aircraft operations:** AIAL is required to offer acoustic treatment based on annual aircraft noise contours once existing buildings are within the L_{dn} 60 dBA contour and L_{dn} 65 dBA contour. This includes educational facilities, registered pre-schools, household units, child centres, hospitals and rest homes, etc. Offers in the L_{dn} 60 dBA contour are 75 per cent funded by AIAL and offers in the L_{dn} 65 dBA contour are 100 per cent funded by AIAL.
 - **Existing buildings subject to engine testing noise:** AIAL is required to offer acoustic treatment to homeowners inside a specified L_{dn} 57 dBA area affected by engine run noise.
 - **New buildings at educational facilities:** AIAL is required to fund 75 per cent of the cost of acoustic treatment for new buildings at educational facilities.
- **Noise complaints.** AIAL has standard protocols for recording, responding to and reporting on noise complaints it receives relating to aircraft operations, engine testing activities and any other activities generating noise at the airport.

The general public can call the airport at any time if they have a noise complaint by contacting the 24-hour noise enquiry number. Details of the complaint are then recorded and any information associated with the complaint such as runway use and weather and information from flight controllers. The complaint is then passed to the relevant AIAL employee for investigation to identify the cause of the noise. A written response outlining the results of the investigation is sent to the complainant.

Noise abatement operational procedures

Noise abatement operational procedures are based on the Civil Aviation Authority Noise Rules as follows:

Noise Minimisation Procedures applying to Auckland International Airport include the noise abatement procedures under Civil Aviation Rule Part 93. A summary of the CAR Part 93 noise abatement procedures is as follows:

1. Departure to the East — Climb on the extended runway centreline to:
 - At least 3 000 ft before turning left;
 - At least 2 000 ft before turning right; or
 - At least 500 ft and turn right adjacent to McLaughlin's Mountain.
2. Departure to the West (i.e. over the Manukau Harbour) — Climb on the extended runway centreline to:
 - At least 500 ft before turning left; or
 - At least 3 000 ft before turning right.
3. Arrival from the North to land in a westerly direction:
 - Intercept the extended runway centreline above 2 000 ft; and

- Between 2300 hours and 0600 hours intercept the extended runway centreline more than 14 NM from the runway and above 4 000 ft.
4. Between 2300 hours and 0600 hours take-off to the west and land from the west (i.e. both over the Manukau Harbour) when there is a tailwind of less than 5 knots and air traffic conditions allow.

Operating restrictions

Chapter 2 aircraft are banned from operating in New Zealand under Civil Aviation Rule Part 91.

Further information on noise management is available on the AIAL website: www.auckland-airport.co.nz.

JOHN WAYNE AIRPORT (UNITED STATES)

Operational restrictions

John Wayne Airport (JWA) in Orange County, California, operates under judgements of the United States District Court "Settlement Agreement" of 1985 and the 2003 amendments. The Settlement Agreement fully describes the operational restrictions under which John Wayne Airport is to operate until 31 December 2015.

- **Noise.** There are two noise-based "classes" for commercial aircraft: Class A and E, with Class E departures being the most restrictive. An aircraft may not operate at John Wayne Airport if such an aircraft generates SENEL levels at the noise monitoring stations which are greater than the SENEL values defined for Class A aircraft.
- **Curfew (mandatory).** Under county ordinance, commercial aircraft may not depart from John Wayne Airport between 2200 and 0700 hours (0800 hours Sundays) or arrive at JWA between the hours of 2300 and 0700 hours (0800 hours Sundays). General aviation aircraft are subject to more restrictive noise levels during curfew hours.
- **Operational limits.** The number of regulated departures for commercial aircraft is subject to a maximum of 85 Class A average daily departures (ADDs) for passenger service, and a maximum of 4 Class A ADDs for all-cargo service. The total number of annual passengers is limited to 10.3 MAP (through 12/31/10) and 10.8 MAP (through 12/31/15).
- **Monitoring/enforcement.** Aircraft operations are monitored 24/7 and operating restrictions are strictly enforced. Violating these restrictions results in monetary penalties and, ultimately, denial of use of John Wayne Airport.

Land-use planning and management

- **Sound insulation on existing development.** Houses within the 65 db-CNEL contour of the noise impact area have been offered acoustical insulation. The programme is nearing completion and the airport is not accepting new applications.

LONDON AIRPORTS (UNITED KINGDOM)

Heathrow

Heathrow airport has two main runways plus a cross-wind runway, four passenger terminals and two cargo terminals. A fifth terminal under construction is due to open in March 2008. The airport is located approximately 13 miles (21 km) west of London City Centre and is surrounded by suburban housing, business premises and mixed use open land to the north and south, suburban housing and business premises to the east and three large reservoirs, mixed use open land, housing and business premises to the west. It currently handles around 67 million passengers a year.

Gatwick

The airport has two runways, only one of which can be operated at any given time, and two terminals. It is situated in mostly lightly-populated countryside (though between the towns of Crawley and Horley) about 28 miles (45 km) to the south of London and about 2 miles (3 km) north of Crawley. It currently handles around 33 million passengers a year.

Stansted

The airport has one runway and one terminal. It is situated 35 miles (56 km) north-east of London and is surrounded by countryside and small villages to the north, south and east and the town of Bishop's Stortford to the west. It currently handles around 22 million passengers a year.

The United Kingdom Government's Secretary of State for Transport is responsible for aircraft noise control at Heathrow, Gatwick and Stansted Airports.

Land-use planning and management

Average noise contours (Leq) are used to describe aircraft noise in the vicinity of the airports. Contours are also used to proscribe area (km²) based limits on the total aircraft noise that the airports may emit over a given time interval for daytime or nighttime operations. Limits on the total number of air transport movements per year may also be applied.

The United Kingdom Government has set out planning policy guidance on how to assess proposals for residential development exposed to sources of transportation noise. For aircraft noise, this is based on both daytime and nighttime average noise levels (Leq). Local planning authorities must take the guidelines into account in preparing their development plans and assessing planning applications for residential development.

There is a legal requirement that Heathrow and Gatwick Airports establish and operate committees to consult local representatives, elected members and officials on matters of local interest. This includes aircraft noise.

Gatwick and Stansted Airports have established Community Trusts with grant funding to support projects that benefit the area around the airport, including environmental or conservation schemes and projects that benefit community life or improve community facilities. Part of the funding is provided by surcharges for infringements of airport departure noise limits. Heathrow similarly provides funding to support local community projects.

In addition, the airports offer the following noise mitigation schemes:

- Assistance with the costs for relocation for eligible owners of dwellings in the 69 dBA daytime Leq contour.
- Acoustic insulation for community buildings in the 63 to 69 dBA daytime Leq contour.
- Acoustic insulation for dwellings in the 90 dBA SEL footprint of the noisiest night flying aircraft.

Noise abatement operational procedures

Full details are set out in statutory notices and published in the United Kingdom Aeronautical Information Package (AIP) and elsewhere. Summary details are set out below:

- ***Departure procedures***

Aircraft departing Heathrow, Gatwick and Stansted are required to follow specific paths (noise preferential routes (NPR)) up to an altitude of 4 000 ft (3 000 ft on some routes at Gatwick and Stansted due to airspace restrictions), unless directed otherwise by air traffic control (ATC). NPRs were designed to avoid overflight of built-up areas where possible. They lead from the take-off runway to the main United Kingdom air traffic routes, and form the first part of the Standard Instrument Departure routes (SIDs). Associated with each NPR is a swathe extending approximately 1.5 km each side of the nominal NPR centreline, within which aircraft are considered to be flying on track.

After take-off, the aircraft shall be operated in such a way that it is at a height of not less than 1 000 ft above aerodrome level at 6.5 km from the start of roll as measured along the departure track of that aircraft.

- ***Arrival procedures***

Gatwick and Stansted: Between 2330 and 0600 hours (local time), inbound aircraft shall not join the centreline below 3 000 ft closer than 10 NM (nautical miles) from touchdown. In addition, aircraft are requested to avoid over-flying local centres of population.

Heathrow: Between 0600 and 2330 hours (local time) where the aircraft is approaching runway 27L or 27R (0700 and 2300 hours when approaching runway 09L or 09R) and is using the ILS, the aircraft shall not descend on the glide path below an altitude of 2 500 ft before being established on the localizer, nor thereafter fly below the glide path. Between 2330 and 0600 hours (local time) where the aircraft is approaching runway 27L or 27R (0700 and 2300 hours when approaching runway 09L or 09R) and is using the ILS, it shall not descend below an altitude of 3 000 ft before being established on the localizer, nor thereafter fly below the glide path.

- ***Continuous descent approach***

A voluntary code of practice is in place which encourages air traffic controllers and pilots to seek to facilitate a continuous descent approach in the descent from 6 000 ft. The United Kingdom AIP instructs pilots to use CDA wherever possible. Where this is not practicable, aircraft are required to maintain as high an altitude as possible.

- ***Use of reverse thrust at night***

To minimize disturbance in areas adjacent to the aerodrome, aircraft are requested to avoid the use of reverse thrust after landing, consistent with the safe operation of the aircraft, between 2330 and 0600 hours (local time).

- ***Heathrow runway alternation and directional preference***

A system of runway alternation was introduced in 1972 to 1973 for aircraft landing at Heathrow during westerly operations to provide predictable periods of relief from the noise of landing aircraft for communities under the final approach tracks to the east of the airport.

The pattern of alternation was extended to the night period in 1999. This pattern provides for one runway to be used by landing aircraft from 0600 hours until 1500 hours and the other runway to be used from 1500 hours until midnight, after which landing aircraft use the first runway again until 0600 hours. However, on Sunday each week the runway used before midnight continues to be used for landings until 0600 hours. This means early morning arrivals before 0600 hours use a different runway on successive weeks and that the runways used by landing aircraft before and after 1500 hours also alternate on a weekly basis. Aircraft taking off during westerly operations can use either runway, but most use the runway that is not in use for arrivals.

Night-time runway alternation was also extended to easterly operations in 1999. Runway alternation does not operate in the daytime during easterly operations due to the Cranford Agreement.

The Cranford Agreement is an undertaking dating from the 1950s to avoid use of Heathrow's northern runway for take-offs in an easterly direction over Cranford. As a result, departures during easterly operations normally use the southern runway so most landings use the northern runway. However, some easterly arrivals land on the southern runway between departures.

The pattern of runway alternation may be suspended by Air Traffic Control if there are serious arrival holding delays, adverse local weather conditions or requirements for essential maintenance.

A westerly preference is operated at Heathrow. This means that during periods of light easterly winds, aircraft will often continue to land in a westerly direction making their final approach over London. The westerly preference was introduced in the 1960s to reduce numbers of aircraft taking off in an easterly direction over London. In 2000 following consultation, the westerly preference was replaced at night by a weekly rotation between westerly and easterly operations. However, the rotation is not operated in all weather conditions and the airport maintains the westerly preference when there are delayed departures.

- **General**

At Gatwick and Stansted, the runways are operated normally, according to wind direction.

BAA applies noise-related landing charges at its United Kingdom airports to help incentivise the use of quieter aircraft.

The United Kingdom Government has set aircraft departure noise limits for the airports. Surcharges are applied to airlines for infringements of the noise limits.

A flight track and noise monitoring system is in place to monitor compliance with operational controls.

Operating restrictions

A noise quota-based night flight control regime was introduced by the United Kingdom Government in the 1990s. The regime includes seasonal movement and noise quota limits, and restrictions on the noise Quota Count of aircraft that are allowed to operate in the night period. The restrictions are set out in a statutory notice, published each season in the supplement to the United Kingdom AIP.

The "night period" is 2300 to 0700 hours (local time) during which period the noisiest types of aircraft classified QC/8 and QC/16 may not be scheduled to land or take-off. From 2330 to 0600, the "night quota period", aircraft movements are restricted by movements limits with noise quotas as a supplementary measure. These are set for each season.

- **Chapter 2 phase-out.** The phase-out of aircraft certificated under the ICAO Annex 16, Chapter 2 noise Standards was completed in Europe from 2002.

Reduction of noise at source

Under the Balanced Approach, reduction of noise at source is limited to noise reduction through the adoption and implementation of noise certification Standards set by ICAO and is not within the control of individual airports.

ACI participation at CAEP: Through Airports Council International (ACI), the worldwide airport industry association, supports efforts for increased stringency beyond Chapter 4, in the ICAO Standards for aircraft noise, including the need for new Standards to require noise reduction at each of the three measuring points.

NARITA INTERNATIONAL AIRPORT (JAPAN)

Noise assessment / management plan

A Community Integration Programme has been developed at Narita International Airport that recommends a variety of noise abatement and mitigation measures and outlines a process for implementing those recommendations. The recommended measures of the programme include noise reduction at source, land-use planning and management, noise abatement operational procedures and operating restrictions.

Reduction of noise at source

Under the Balanced Approach, reduction of noise at source is limited to noise reduction through the adoption and implementation of noise certification Standards set by ICAO and is not within the control of individual airports.

- **ACI participation at CAEP.** NAA, through Airports Council International, supports efforts for increased stringency beyond Chapter 4, in the ICAO Standards for aircraft noise, including the need for new Standards to require noise reduction at each of the three measuring points.
- **Ban on Chapter 2 aircraft.** According to the European Directive 92/14, aircraft certified in accordance with the noise Standards of ICAO Annex 16, Chapter 2 have been completely banned since 1 April 2002.
- **Noise-related landing fee.** To encourage the use of the best technology aircraft, landing fees at Narita include a component related to the certificated noise levels of individual aircraft.

Land-use planning and management

- **Noise monitoring**
 - **Year-round monitoring.** Aircraft noise is reported 365 days a year with 17 permanent stations positioned around Runway A and 16 stations around Runway B.
 - **Short-term monitoring.** Short-term monitoring is carried out continuously at 58 locations in the noise impact zones around the airport for one week both in winter and summer. These noise impact zones were defined in accordance with the specifications of the national Noise Prevention Law. In locations where more stringent monitoring is required, additional monitoring is carried out.
- **Planning instrument.** The Special Noise Prevention Law was introduced on 20 April 1978 as a proactive step in preventing aircraft noise disturbance and also to bring development to the community through rational land use. The main points of the Special Noise Prevention Law are as follows:
 - **Specified airports.** Airports affected shall be identified as “specified airports” by Cabinet Order (at present only Narita International Airport carries this designation), where there is a recognized need to prevent disturbance from aircraft noise by using land rationally and appropriately.
 - **General policy.** The developer of a specified airport must submit a request to the Prefectural Governor to formulate a general policy on noise mitigation, designating the areas that will be affected by excessive noise and the noise levels expected. The developer must also provide a summary of the airport facilities planned for approximately ten years after the airport has been

designated. On receipt of this request, the Prefectural Governor consults with municipal leaders and residents of the area concerned and formulates policies to be submitted for approval to the Minister of Land, Infrastructure and Transport.

- **Impact zones / special impact zones.** Impact zones, with a minimum WECPNL rating of 75, and special aircraft noise impact zones, with a minimum WECPNL rating of 80, were incorporated into city planning documents after public discussion and deliberation by a city planning council. The zones specify land use around the airport and the development of aircraft noise prevention facilities, civic facilities, production bases and other facilities.
- **Sound insulation on new construction.** Any home, school or hospital constructed in an impact zone must be effectively sound insulated. No home, school or hospital may be constructed in a special impact zone without the permission from the Governor.
- **Compensation for loss.** Losses arising under normal conditions from bans on the construction of any home, school or hospital must be compensated for by the developer of the specified airport. In the event that land use is excessively impeded by a ban on construction, that land shall be purchased at its value at that time.
- **Resettlement.** When land is designed as a special impact zone, the developer of the airport may provide compensation for resettlement and purchase of the land occupied by any home, school or hospital in that zone, should the owners express a desire to relocate. The vacated property is used for promoting agriculture, greening programmes and other regional, cultural and environmental programmes.
- **Sound insulation of existing development.** Under the Noise Prevention Law (1967) and the Special Noise Prevention Law (1978) Narita International Airport provides subsidies for sound insulation of homes, schools, nurseries, hospitals, nursing homes and other similar facilities.
- **Barriers and buffer zones.** Narita International Airport continues to develop noise mitigation embankments and wooded buffer zones in accordance with the “Greening Master Plan for Narita Airport and Environs”. The embankments are 10 metres high and extend 100 metres from the airport boundary.

Noise Abatement Operational Procedures

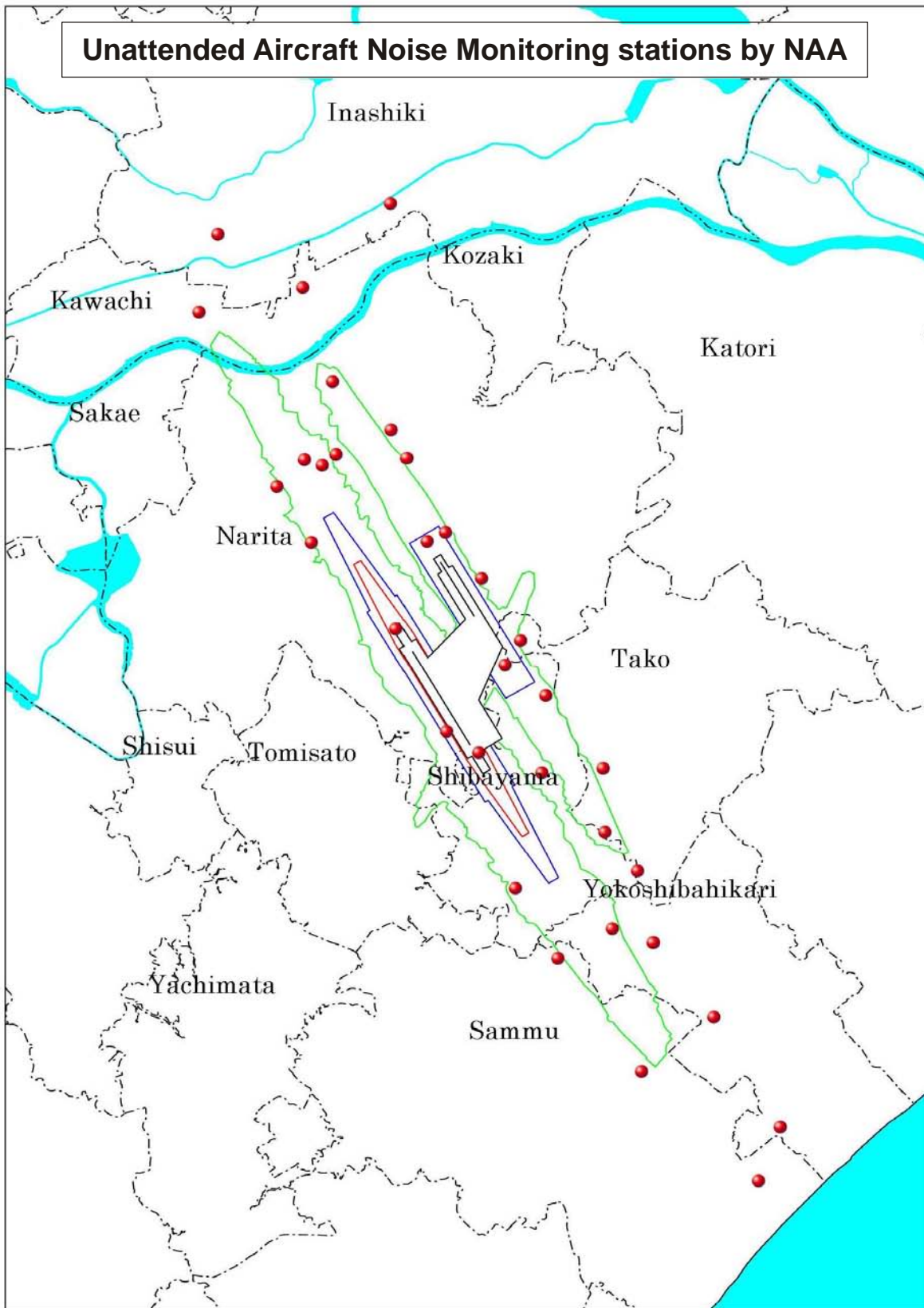
Noise abatement operational procedures implemented at Narita International Airport include:

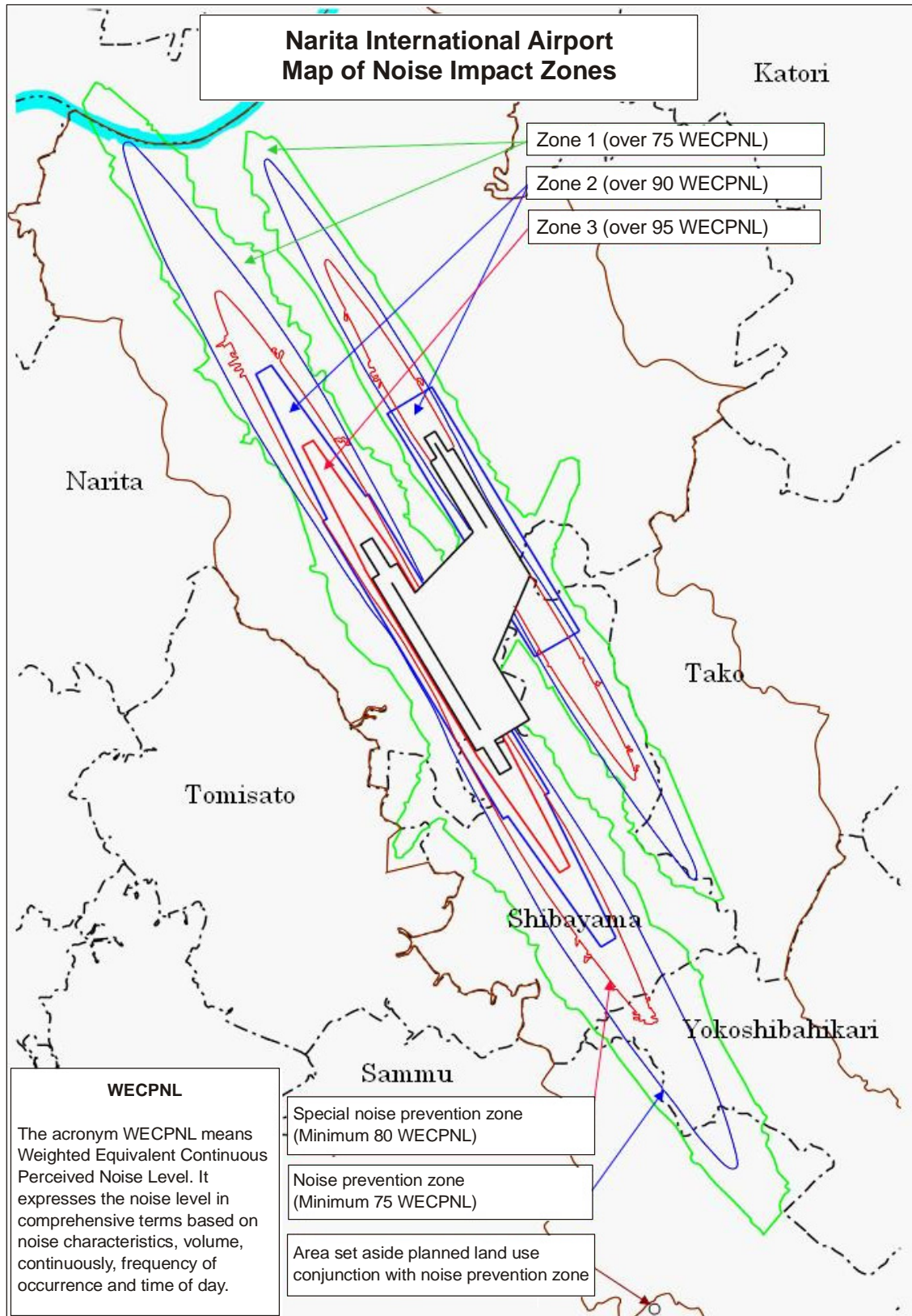
- **Arrival and departure flight procedures.** Aircraft approaching and departing NAA are strongly encouraged to follow established procedures to minimize public annoyance. Violations are reported publicly and can be subject to special directives issued by the Ministry of Land, Infrastructure and Transport. In addition, information on flight paths and noise levels for all flights is made available to residents on the local community.
- **Restrictions on the use of auxiliary power units (APUs).** On stands equipped with ground power units (GPUs), APU use is limited to 30 minutes prior to departure, the minimum time required for switching over the fixed power facilities after arrival at the parking stand or for the minimum time needed for aircraft maintenance.
- **Reverse thrust.** In cooperation with NAA, IATA has distributed circulars to airline operators recommending avoiding the use of reverse thrust providing the operator deems that safety will not be affected.

- **Ground run-up restrictions.** NAA constructed a noise reduction hangar in cooperation with Japanese carriers to reduce noise during engine testing. This facility must be used for run-ups conducted between 2200 and 0600 hours.
- **Taxiing procedure.** Aircraft are requested to use the least possible engine power when taxiing. Aircraft equipped with three or four engines are instructed to taxi from the landing runway to the gate with one engine switched off, except when it is considered unsafe or a hindrance to normal operation of the aircraft.

Operating restrictions

- **Movement caps.** Under an agreement between NAA and communities surrounding the airport, aircraft movements, arriving and departing, are limited to 200 000 per year. A daily cap of 370 aircraft movements is established on Runway A. Evening hourly slot availability has been reduced to cut noise at night.
- **Curfew** – All aircraft operations, except emergency landings are prohibited between 2300 and 0600 hours.





SEATTLE-TACOMA INTERNATIONAL AIRPORT (UNITED STATES)

Noise assessment / management plan

A Noise Compatibility Programme has been developed at Seattle-Tacoma International Airport (Sea-Tac) through the FAR Part 150 Programme that recommends a variety of noise abatement and mitigation measures and outlines a process for implementing those recommendations.

The plan begins with an assessment of the noise situation. Maps depicting existing “baseline” noise levels as well as forecast noise levels are developed. Noise levels, expressed in the form of contours lines, are depicted on land-use maps in order to determine the effects of noise on existing and planned noise-sensitive land uses and the extent of the population affected.

The plan then identifies combined measures for lessening noise impacts, evaluates the costs and benefits of the measures and proposes a phased programme of implementation. The recommended measures of the programme include land-use planning and management and noise abatement operational procedures.

Reduction of noise at source

Under the Balanced Approach, reduction of noise at source is limited to noise reduction through the adoption and implementation of noise certification Standards set by ICAO and is not within the control of individual airports.

- **ACI participation at CAEP.** Sea-Tac, through ACI, supports efforts for increased stringency beyond Chapter 4, in the ICAO Standards for aircraft noise, including the need for new Standards to require noise reduction at each of the three measuring points.
- **Phase-out of Stage 2 aircraft.** The Federal Aviation Administration (FAA) required a phase-out of all Stage 2 noise level jet aircraft over 75 000 pounds by the end of the calendar year 1999 through the Airport Noise and Capacity Act of 1990 (ANCA) and its implementing regulation 14CFR Part 91.

Land-use planning and management

The following land-use planning and management measures are being implemented at Sea-Tac as a result of the Noise Compatibility Programme:

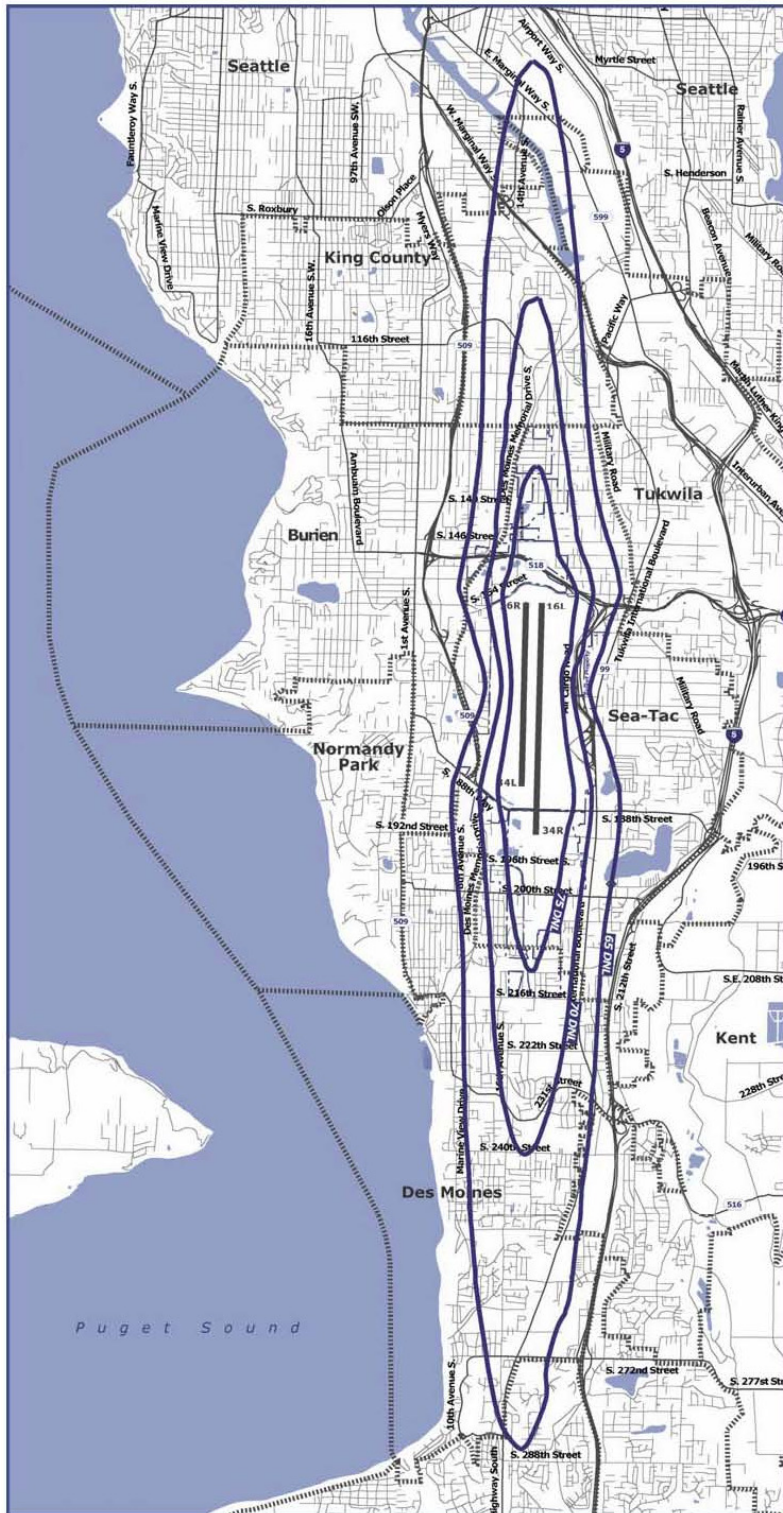
- **Residential sound insulation.** Residential buildings are provided with acoustic windows and doors to reduce interior noise levels. The improvements are made at no cost to the homeowners.
- **Mobile home park relocation.** Mobile home parks within the 70 DNL noise contour are being purchased and residents relocated to quieter neighbourhoods.
- **Approach transition zone acquisitions.** Properties within the approach transition zone (ATZ) for Sea-Tac’s new third runway are being acquired and residents relocated.
- **School insulation.** Noise insulation is provided for public and private schools within the 65 DNL noise contour.
- **Zone regulation.** Sea-Tac is working with local jurisdictions on changing zoning, building codes and comprehensive plans for communities close to the airport to encourage compatible land use and to preclude new residential growth in non-compatible areas.

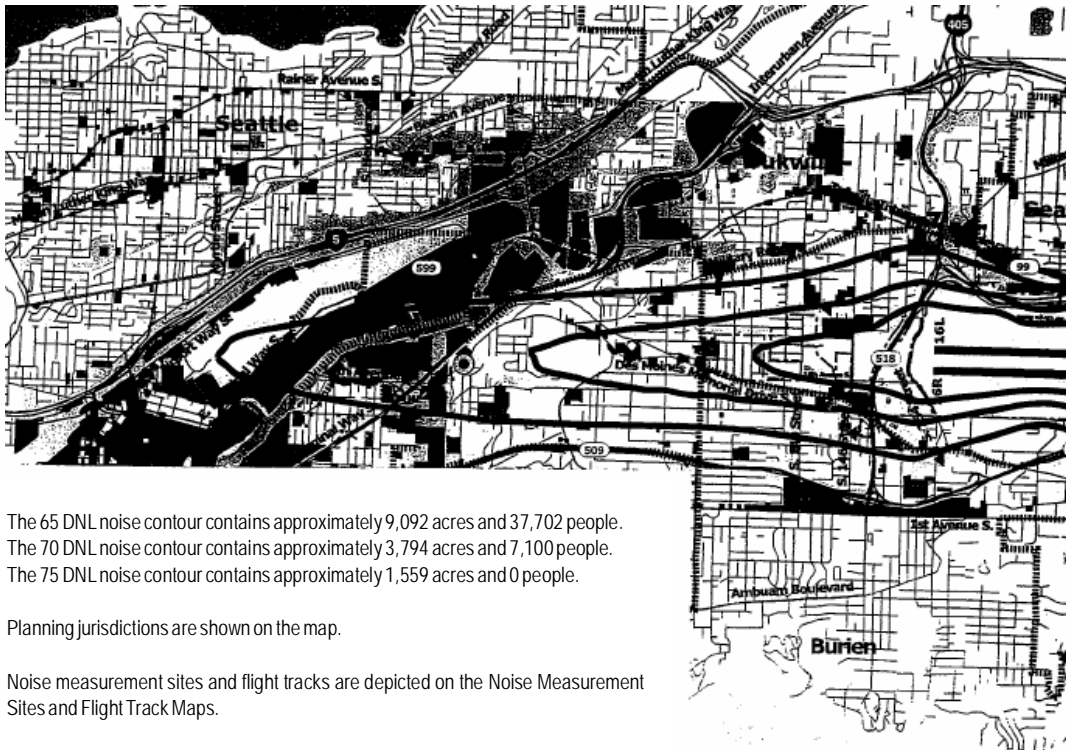
Noise abatement operational procedures

Noise abatement operational procedures recommended at Sea-Tac include:

- **Procedures compliance.** Specific headings and altitudes are established for aircraft to fly in order to minimize noise impacts.
- **Ground noise programme.** Powerbacks from gates and engine run-ups in the late night hours are prohibited.
- **Night-time preferential runway.** Between 2200 and 0600 hours, the Air Traffic Control Tower at Sea-Tac follows a preferential runway use policy that directs pilots to operate in the north flow so that departures can depart through Elliot Bay whenever wind and weather conditions permit.
- **Fly Quiet Programme** – This programme is being developed to encourage operators to reduce aircraft noise impacts through positive competition. The programme will consist of competition in the following areas:
 - Procedures compliance
 - Compliance with ground noise programme
 - Average sound exposure level (SEL) over two close-in noise monitors.

1998 Existing Noise Exposure Map — Sea-Tac Airport





The 65 DNL noise contour contains approximately 9,092 acres and 37,702 people.
 The 70 DNL noise contour contains approximately 3,794 acres and 7,100 people.
 The 75 DNL noise contour contains approximately 1,559 acres and 0 people.

Planning jurisdictions are shown on the map.

Noise measurement sites and flight tracks are depicted on the Noise Measurement Sites and Flight Track Maps.

Residential land use is defined as incompatible within the 65 DNL noise contour or greater by the FAR Part 150. However, approximately 10,000 housing units have been sound attenuated to achieve compatibility.

The Noise Exposure Map and accompanying documentation for the Noise Exposure Map for Seattle-Tacoma International Airport, submitted in accordance with the FAR Part 150 with the best available information, are hereby certified as true and complete to the best of my knowledge and belief. In addition, it is hereby certified that the public was afforded the opportunity to review and comment on the document and its contents.

Signed _____

Dated _____



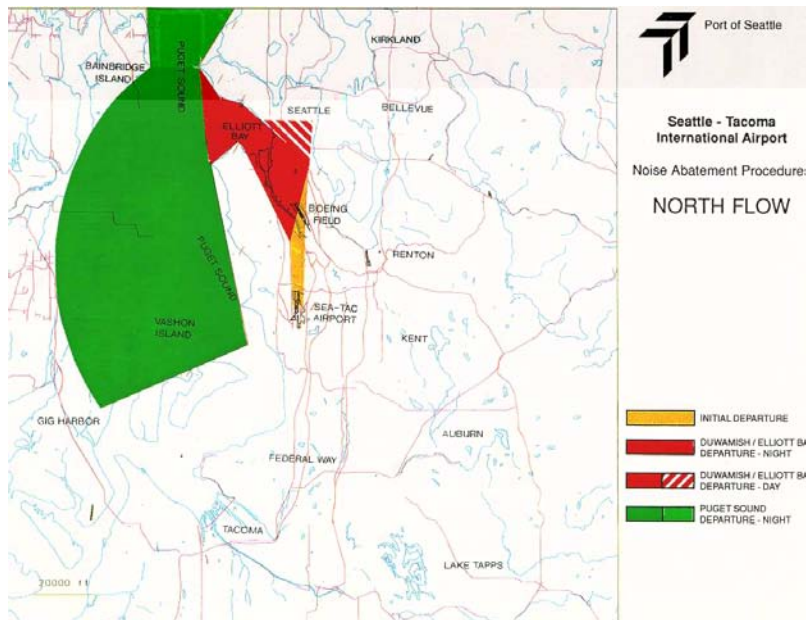
Noise Abatement Procedures Programme

Seattle-Tacoma
International Airport

What are noise abatement procedures?

Noise Abatement Procedures are specific headings and altitudes for aeroplanes to fly in order to minimize noise impacts. Over the years, Noise Abatement Procedures were established by the Federal Aviation Administration (FAA) in cooperation with the Port and local communities. These procedures were designed to minimize jet overflights of residential neighborhoods by taking advantage of existing geographical and compatible land use conditions where possible. The Duwamish Industrial Area, Elliott Bay and Puget Sound provide some opportunities for aircraft to over-fly non-residential areas to the north of Sea-Tac Airport. The attached maps depict the Noise Abatement Procedures that are used to the maximum extent possible, air traffic conditions permitting. These maps are not intended to show actual flight tracks, only the corridors that are monitored for arrival and departure noise abatement procedures. These are not all the flight corridors, only those specifically related to noise.

North Flow



The North Flow map shows the corridors used when jet aircraft depart Sea-Tac to the north. The Initial Departure Corridor, shown in yellow, is intended to confine departing aircraft to the narrowest flight path possible. During the busier daytime hours, currently 0600 hours to 2200 hours, aircraft will proceed from the Initial Departure Corridor into the Duwamish/Elliott Bay Corridor. This is the solid and hashed red coloured area, from which aircraft may turn east or west. If traffic conditions allow when turning west, the aeroplanes are directed over Elliott Bay. Before starting their turn to the east, jets first fly eight nautical miles (NM) north and reach an altitude of 4 000 feet.

During the less busy night-time hours, currently 2200 hours to 0600 hours, jet aircraft are directed over the solid red coloured area* of the *Duwamish/Elliott Bay Corridor* and proceed west. Once out of Elliott Bay, the aircraft are turned north or south in the green coloured areas*, which are designated as the *Puget Sound Departure*. Jets remain over Puget Sound until reaching a specific altitude or distance from the Airport before turning east or west over the shoreline.

When flying north over the Sound, the aircraft must reach an altitude of 10 000 feet **or** a point 20 NM from the Airport before turning east. When turning west, aircraft must reach the 20 NM point **at or above** 10 000 feet before starting their turn.

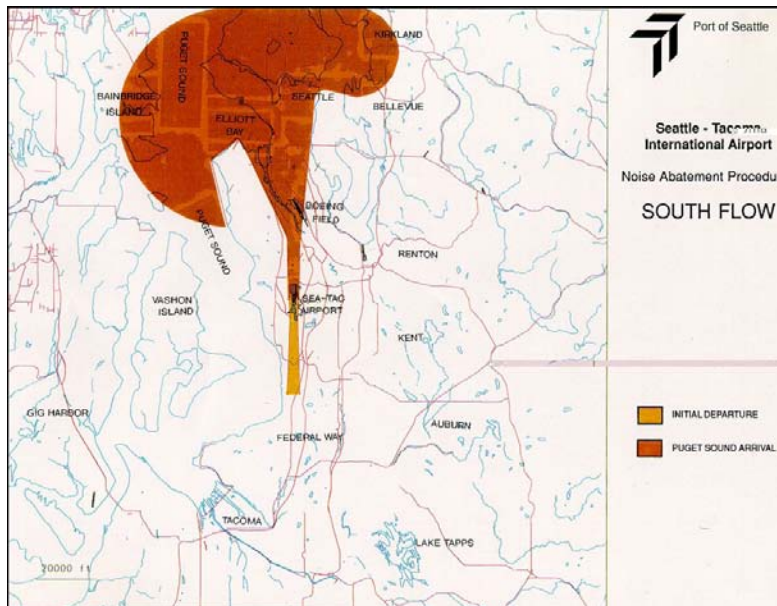
* The graphs in this document have intentionally been reproduced in black and white.



Seattle-Tacoma International Airport

When heading south, the aircraft must remain west of the shoreline until crossing the SEA 220-degree radial before starting a turn to the east. (This area is depicted by the straight edge portions of the dark green section on the map.)

South Flow



The South Flow map shows corridors used by aircraft arriving from the north over the city of Seattle and departing to the south. The large orange coloured area is the *Puget Sound Arrival*. The objective of this procedure is to have jet aircraft fly over or to the north of Elliott Bay. The yellow coloured area south of the Airport is the *Initial Departure Corridor*, which is intended to confine departing jets to the narrowest flight path possible. Aircraft remain in this corridor until they are 5 NM from the Airport at an altitude of 3 000 feet. Once out of the initial departure corridor they can either continue south or start a turn to the east or west.

Why do aeroplanes fly out of the corridors?

There are many reasons, sometimes beyond the airline's control, why a jet may fly out of the noise abatement corridors. These include traffic conflicts, weather, air traffic control directives, safety considerations, aircraft performance and pilot technique.

How are procedures monitored?

Although the Federal Aviation Administration has sole authority over aircraft in flight, the Port of Seattle, as operator of Sea-Tac Airport, has taken the lead responsibility for monitoring and reporting jet air traffic activities in terms of noise abatement. Data from the FAA's Automated Radar Terminal System (ARTS) is used to monitor aircraft performance while operating within established noise abatement corridors. A monthly summary is created and flight events are evaluated for each noise abatement procedure. The results pinpoint how successful air traffic controllers and pilots are at keeping flights within the noise abatement corridors.

The results are published in the form of a quarterly report. This programme's success is dependent on cooperative efforts between the FAA and the airlines.

If you would like to be added to our mailing list, or need further information on Sea-Tac's noise abatement programmes, please call (206) 433-5393 or Toll Free (800) 826-1147.

SYDNEY INTERNATIONAL AIRPORT (AUSTRALIA)

Reduction of noise at source

- **Chapter 2 phase-out.** The phase-out of aircraft certificated under the ICAO Annex 16, Chapter 2 noise Standards was completed in 2002.

Land-use planning and management policies

- **Land-use planning**

While details of the arrangements vary between council areas, all (local government) councils around Sydney Airport have arrangements in place to ensure that new buildings are located and constructed in accordance with Australian Standard AS 2021. This standard provides guidance on the compatibility of various building types, and the need for acoustical treatment, based on Australian Noise Exposure Forecast (ANEF) values.

- **Noise amelioration programme**

The Sydney Airport Noise Amelioration Programme (SANAP) was introduced in November 1994 in conjunction with the opening of the third runway at Sydney Airport. The sole eligibility determinant for assistance under the SANAP is aircraft noise exposure as calculated using the Australian Noise Exposure Forecast (ANEF) system.

Assistance under the SANAP comprises the voluntary acquisition of residential properties and a church within the 40 Australian Noise Exposure Forecast (ANEF) contour, assistance for the insulation of residences within the 30 Australian Noise Exposure Index (ANEI) contour, and insulation of public buildings (i.e. schools, colleges, child care centres, hospitals, health care centres, nursing homes and churches) within the 25 ANEI contour.

All eligible residential properties in Sydney, where the offer was accepted, have now been insulated. The public buildings component of the programme is close to completion, with work underway on the last remaining eligible buildings.

To recover the costs of the SANAP an aircraft noise levy was introduced at Sydney Airport on 1 October 1995. It applied to all jet aircraft landing at Sydney Airport. The aircraft noise levy was payable by the aircraft operator on a per aircraft basis and the amount payable per landing reflects the noise characteristics of the aircraft involved. The levy has now recovered the costs of the SANAP and was ceased effective 1 July 2006.

Noise abatement operational procedures

- **Long-term operating plan (LTOP)**

The Sydney LTOP is a comprehensive noise-sharing plan designed to more evenly distribute the aircraft noise generated by operations at the airport. The plan was drawn up through a major consultative process that took place during 1996 and 1997. The plan is designed to ensure that aircraft movements are maximized over water and non-residential land. Where overflight of residential areas cannot be avoided the noise is shared between communities.

A key feature of the plan is the runway rotation system. This system involves different combinations of runways (runway modes) being used at different times of the day to provide, as far as possible, individual areas with periods of respite from aircraft noise: The LTOP runway modes are shown on page II-29.

Another key feature of the plan is the detailed reporting of outcomes to the public. This is designed to maximize transparency and provide the community with factual information on the success of the plan in reaching its goals. Monthly reports are prepared by Airservices Australia and provide, among other things, information on daily runway mode usage, the number and percentage of aircraft using different flight paths and the amount of respite (periods without overflights) for residents living under the flight paths. Examples of these reports are shown on page II-30.

- **Design of flight tracks**

Individual flight tracks have been designed to avoid the overflight of residential areas or to provide a spread of tracks to reduce the concentration of noise over a small number of populated areas. For example, departures to the south from Runways 16L and 16R deviate to the left or right to the pass either through the Botany Bay Heads or over the Kurnell Sandhills and thus avoid overflying residential areas.

Operating restrictions

- **Curfew**

The airport has a legislated curfew which bans most operations by large jet aircraft between the hours of 2300 hours and 0600 hours. The rules for the curfew at Sydney Airport are laid down in the Sydney Airport Curfew Act 1995.

During the curfew, take-offs and landings at the airport are restricted to specific types of aircraft and operations. The principal categories of permitted operations are:

- Small (less than 34 000 kg) noise-certificated propeller-driven aircraft and “low noise” jets (mostly business and “small” freight jets) are allowed to operate without a quota on the number of their movements
- A limited number of freight movements by low noise, medium-sized freight aircraft (BAe 146)
- A limited number of landings by international passenger aircraft between 0500 hours and 0600 hours (no more than 24 per week with no more than 5 per day).

During the curfew aircraft must operate over Botany Bay – take-offs to the south and landings to the north. On Saturdays and Sundays aircraft must also operate over Botany Bay in the hour before and after the curfew, provided the weather and traffic conditions allow this to take place safely. Aircraft are not permitted to take off over the suburbs after 2245 hours.

The Act provides for fines of up to \$550 000 for curfew breaches.

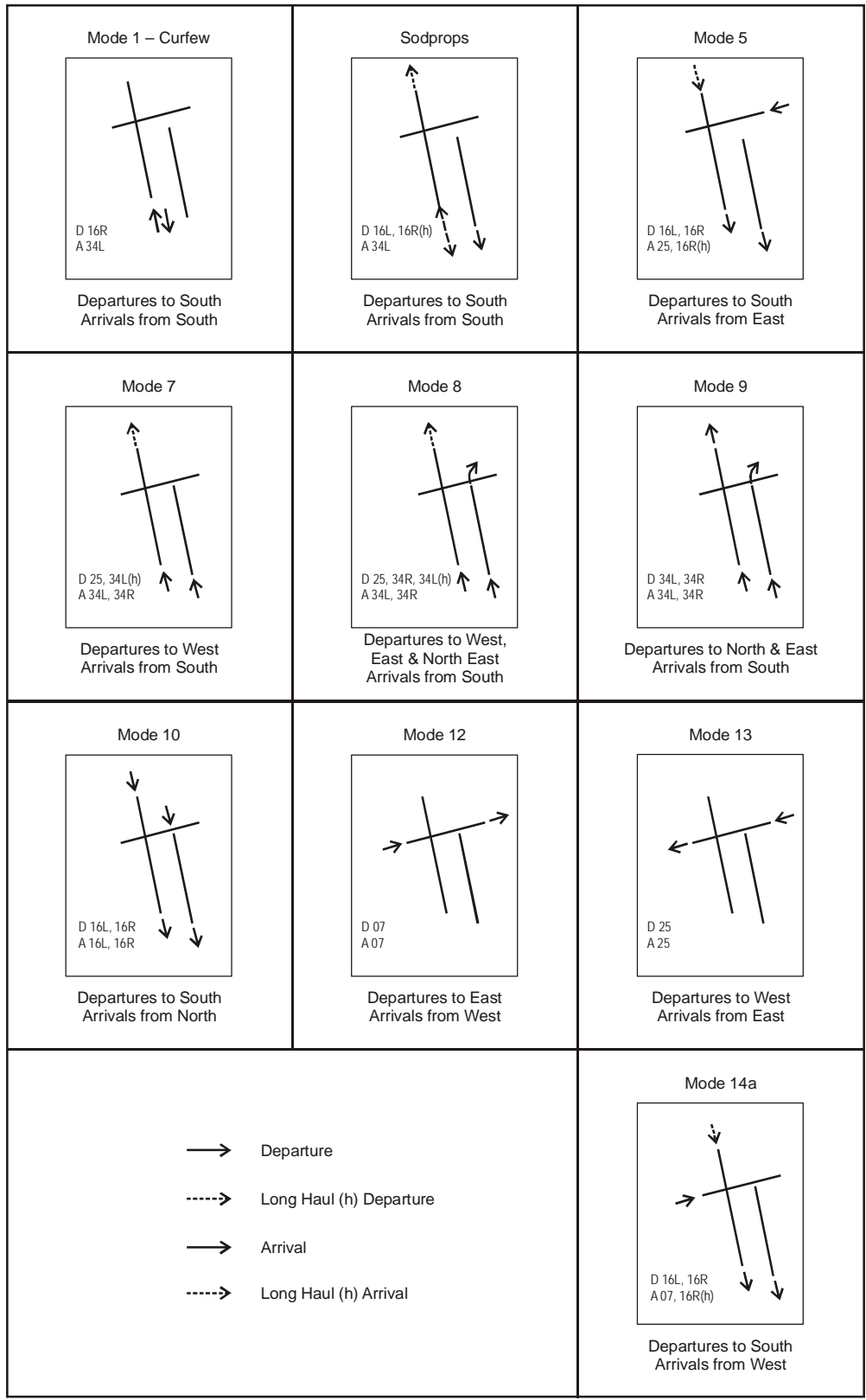
- **Movement cap and slot management scheme**

The Sydney Airport Demand Management Act 1997 was enacted on 17 November 1997. The Act enshrines a cap of 80 hourly movements and establishes a framework for a slot management scheme.

The Slot Management Scheme came into effect for the scheduling season beginning 29 March 1998 with the Compliance Scheme coming into effect on 25 October 1998.

A slot allocated under the scheme permits a specified aircraft movement at a specified time on a specified day. All commercial and private aircraft require a 'Slot' to land or take-off at Sydney Airport. Slots are allocated under the rules of the schemes and are not tradable. Airport Co-ordination Australia (ACA) undertakes day to day administration of the Slot Scheme.

Runway Modes of Operation



TUCSON INTERNATIONAL AIRPORT (UNITED STATES)

Noise assessment / management plan

A Noise Compatibility Programme has been developed at Tucson International Airport (TIA) through the FAR Part 150 Programme that recommends a variety of noise abatement and mitigation measures and outlines a process for implementing those recommended measures.

The plan begins with an assessment of the noise situation. Maps depicting existing “baseline” noise levels as well as forecast noise levels are developed. Noise levels, expressed in the form of contour lines, are depicted on land-use maps in order to determine the effects of noise on existing and planned noise-sensitive land uses and the extent of the population affected.

The plan then identifies combined measures for lessening noise impacts, evaluates the costs and benefits of the measures and proposes a phased programme of implementation. Development of the plan is a transparent process that includes consultation with a Technical Advisory Committee, composed of representatives of local government, school districts, citizens’ groups, airlines and pilot organizations; a Policy Advisory Council composed of elected government officials; and the general public through public information sessions and hearings. The recommended measures of the programme include land-use planning and management, noise abatement operational procedures and operating restrictions.

Reduction of noise at source

Under the Balanced Approach, reduction of noise at source is limited to noise reduction through the adoption and implementation of noise certification Standards set by ICAO and is not within the control of individual airports.

- **ACI participation at CAEP.** TIA, through Airports Council International (ACI), the worldwide airport industry association, supports efforts for increased stringency beyond Chapter 4, in the ICAO Standards for aircraft noise, including the need for new Standards to require noise reduction at each of the three measuring points.
- **Phase-out of Stage 2 aircraft.** The Federal Aviation Administration required a phase-out of all Stage 2 noise level jet aircraft over 75 000 pounds by the end of the calendar year 1999 through the Airport Noise and Capacity Act of 1990 (ANCA) and its implementing regulation 14CFR Part 91.

Land-use planning and management

Tucson International Airport is located at the edge of an urbanized area. As a result, very different land-use patterns exist at opposite ends of the airport. To the southeast, land is primarily undeveloped, with some noise compatible industrial use. To the northwest, land use is dominated by older, established residential neighbourhoods. These different land-use patterns necessitate multiple approaches for noise mitigation.

The following land-use planning and management measures are being implemented at TIA as a result of the Noise Compatibility Programme.

- **Developed land**

Residential sound insulation. Residential buildings constructed prior to the establishment of sound insulation requirements are provided with acoustic windows and doors, and modified ventilation systems to reduce interior noise levels. The improvements are made at no cost to the homeowners. Participating homeowners sign an Aviation Easement acknowledging the right of aircraft overflight.

- **Undeveloped land**

- **Airport environs plans / Zoning controls.** Jurisdictions affected by the operation of TIA (Pima County and the City of Tucson) have adopted “Airport Environs Plans” that serve as policy guides for local land-use decisions in the vicinity of TIA. As a result of these plans, overlay zoning ordinances have been enacted (see page II-36). These ordinances require acoustical insulation on noise-sensitive uses within noise impacted areas and prohibit certain uses (day care, elementary and secondary schools) in the areas exposed to the highest noise levels.
- **Land acquisition.** All property within the 75 DNL noise contour is owned by the airport operator. 3600 acres of undeveloped land between the 65 and 70 DNL noise contours have been purchased to prevent further development of incompatible land uses (see page II-39). Approximately 550 acres of undeveloped land remain to be acquired.
- **Participation in planning efforts and review of development proposals.** Airport staff participate in the development of land-use plans in the vicinity of TIA. The airport and local jurisdictions have a corporative partnership in the review of development proposals near TIA. Proposals are submitted to the airport by surrounding jurisdictions as a part of the standard review process (see page II-40). Airport comments are strongly considered by the jurisdictions when deciding whether to approve or deny a development proposal. As a part of the review process, airport staff request disclosure statements and aviation easements be enacted for residential development projects located near TIA, informing new residents of airport activities.

Noise abatement operational procedures

Noise abatement operational procedures recommended at TIA include:

- **Runway relocation.** The main runway at TIA was moved ½ mile to the southeast away from populated areas. This shift increases the altitude of arriving and departing aircraft as they pass over populated areas to the northwest and keeps the highest noise exposure on airport property.
- **Preferential runway use policy.** The Air Traffic Control Tower at TIA follows a preferential runway use policy that directs pilots to conduct landings, which are quieter than take-offs, to the northwest, over the residential areas, and noisier take-offs to the southeast, over less populated areas, whenever wind and weather conditions permit.
- **Engine run-ups.** Engine run-ups are conducted on a specially constructed apron at the southeast end of the airport, located as far from populated areas as possible (see page II-43). The run-up apron, which is available for use 24 hours per day, was constructed so airlines and operators would have the opportunity to perform engine run-ups without restrictions and without impacting populated areas. The apron is shielded by an earthen bund.
- **Military engine run-ups.** Because of the noise impacts of military F-16 engines, all F-16 run-ups occur within F-16 “hush houses” to prevent noise impacts on neighbours.

Operating restrictions

Operating restrictions at TIA have been minimized to the extent possible with restrictions imposed on military aircraft only. TIA’s airfield is jointly used by the Arizona Air National Guard, which operates 80 high performance F-16 military aircraft for training purposes. Due to the high noise levels of these aircraft, a Letter of Agreement was put in place to limit the degree of impact on the community.

- **Limit on total operations.** Air National Guard F-16 aircraft are limited to 40 000 operations per year.
- **Limit on afterburner usage.** Air National Guard operations involving high noise afterburners are limited to 10 per cent of annual operations.
- **Curfew on flight training and engine run-ups.** Air National Guard training operations and engine run-ups are not allowed between the hours of 2200 and 0700 hours.

Land uses generally considered incompatible in areas exposed to aircraft noise levels of Ldn 65 or higher

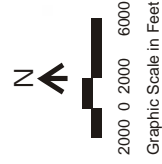
- Single-family residential
- Multifamily residential
- Mobile home park
- Public or semipublic
- Elementary school
- Church

Land uses generally considered compatible in areas exposed to aircraft noise levels of less than Ldn 65

- Single-family residential
- Multifamily residential
- Mobile home park
- Commercial/office
- Industrial
- Resource extraction
- Park/open space
- Agricultural/rural residential
- San Xavier Indian Reservation
- Vacant or rural
- Public or semipublic
- Elementary school
- Junior high school
- Senior high school
- Hospital
- Church
- Cemetery

- City/County boundary
- Airport boundary
- San Xavier Indian Reservation boundary
- Davis-Monthan Air Force Base boundary
- Tucson Mountain Park boundary
- Airport environs boundary
- Ldn contour

Note: Ldn = Day-night average sound level. For assumptions and limitations of Ldn values represented on this exhibit, see Volume I, "Noise Exposure Maps, FAR Part 150 Noise Compatibility Program Update, Tucson International Airport, prepared by KPMG Peat Marwick, January 1990.



NOISE EXPOSURE MAP, 1988

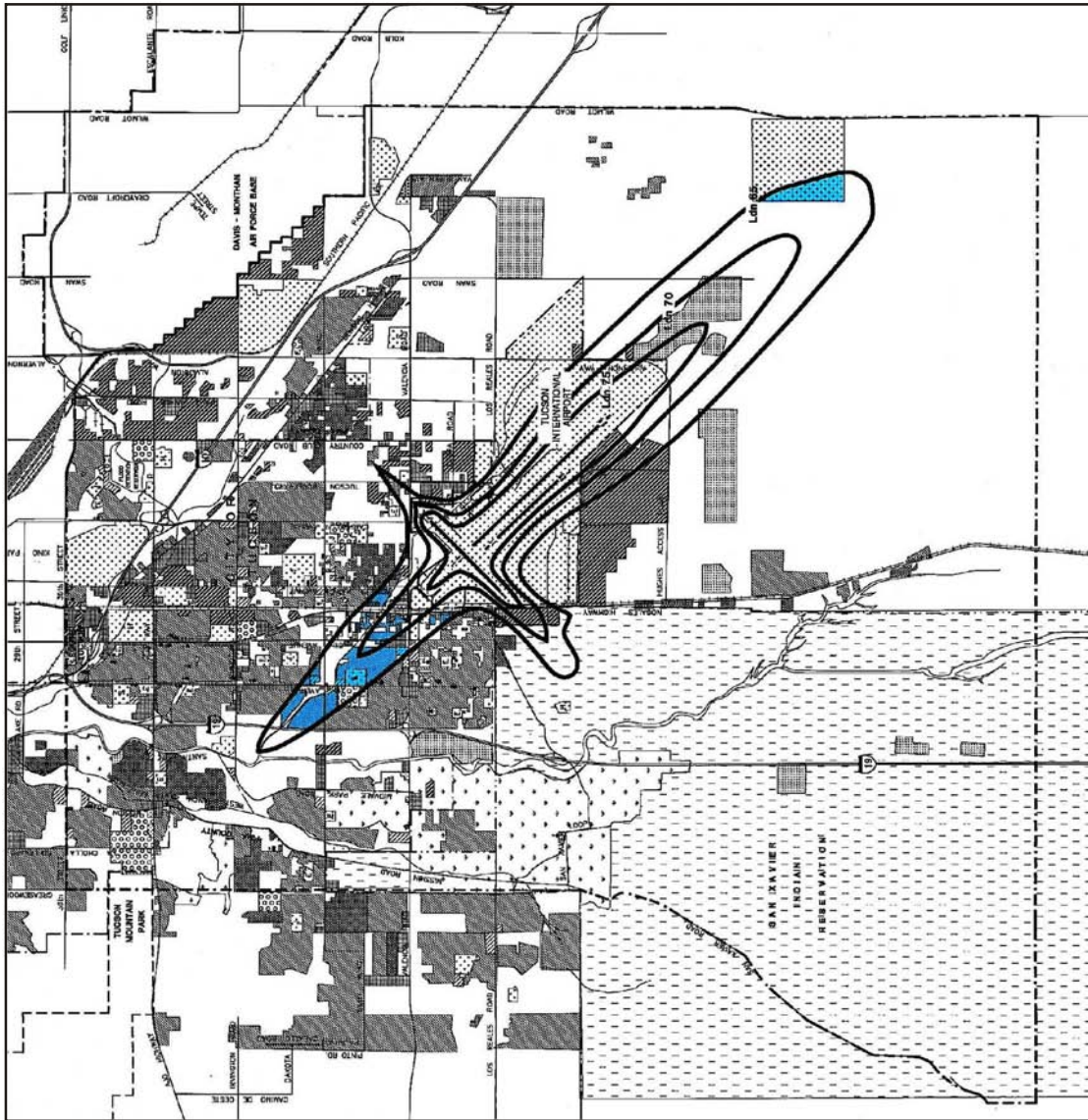


Table 1

**ESTIMATED EFFECTS OF NOISE EXPOSURE FROM AIRCRAFT OPERATIONS
ON EXISTING NOISE-SENSITIVE LAND USES — 1988 AND 1994
FAR Part 150 Noise Compatibility Programme Update
Tucson International Airport**

Noise exposure range (L _{dn}) ^b	Land-area						Number of residential units affected				Estimated population affected	Educational facilities affected
	On-Airport ^a		Off-Airport ^a		Total		Single family	Multi- family	Mobile home	Total dwelling units		
	Acres	Square miles	Acres	Square miles	Acres	Square miles						
1988												
L _{dn} 75+	1 130	1.8	270	0.4	1 400	2.2	0	0	0	0	0	0
L _{dn} 70-75	620	1.0	1 320	2.0	1 940	3.0	160	10	90	260	860	0
L _{dn} 65-70	<u>610</u>	<u>1.0</u>	<u>3 260</u>	<u>5.1</u>	<u>3 870</u>	<u>6.1</u>	<u>1 260</u>	<u>80</u>	<u>230</u>	<u>1 570</u>	<u>5 910</u>	<u>1</u>
Total L _{dn} 65+	2 360	3.8	4 850	7.5	7 210	11.3	1 420	90	320	1 830	6 770	1
1994												
L _{dn} 75+	1 030	1.6	160	0.3	1 190	1.9	0	0	0	0	0	0
L _{dn} 70-75	600	0.9	1 090	1.7	1 690	2.6	80	10	60	150	500	0
L _{dn} 65-70	<u>640</u>	<u>1.0</u>	<u>2 890</u>	<u>4.5</u>	<u>3 530</u>	<u>5.5</u>	<u>1 040</u>	<u>60</u>	<u>190</u>	<u>1 290</u>	<u>4 770</u>	<u>1</u>
Total L _{dn} 65+	2 270	3.5	4 140	6.5	6 410	10.0	1 120	70	250	1 440	5 270	1

a. The Airport Master Plan Update includes a recommendation that the TAA acquire about 2 200 acres of land for airport expansion and land-use compatibility. The actual extent of and schedule for acquisition is not known at this time. However, it is likely that TAA will have completed some of the recommended acquisitions by 1994. For the purposes of this study, on- and off-airport land areas were calculated assuming the existing airport boundary.

b. L_{dn} = Day-night average sound level.

Source: KPMG Peat Marwick, January 1990, based on population and housing data from the U.S. Census Bureau and Donnelley Marketing Information Services, July 1989.

CITY OF TUCSON *LAND USE CODE*
 ARTICLE II. ZONES
 DIVISION 8. OVERLAY ZONES
 AIRPORT ENVIRONS ZONE (AEZ)

- j. Medical Service - Major.
- k. Membership Organization.
- l. Medical Service - Outpatient.
- m. Recreation (indoor and outdoor).
- n. Religious Use.
- o. Swap Meet or Auction.
- p. Travelers' Accommodation.

2.8.5.6 Noise Control Districts.

A. *NCD-65.*

1. Within Noise Control District-65, the following uses must be provided with sound attenuation, to reduce the interior noise level to an Ldn of 45 or less, as specified by Development Standard 9-05.0.

(Ord No. 10073, §1, 10/25/04)

- a. All site-built residential uses.
 - b. All places of public accommodation.
 - c. All Administrative and Professional Offices.
2. A manufactured housing unit will not be considered equivalent to a single-family dwelling within the boundaries of NCD-65, unless located on a property zoned MH-1 or MH-2 or unless it can be demonstrated that the unit provides adequate sound attenuation to reduce the interior noise level to Ldn 45. (Ord. No. 9374, §1, 4/10/00)
 3. Prohibited Uses: Within NCD-65, the following uses are prohibited.
 - a. Day Care.

B. *NCD-70.*

1. Within Noise Control District-70, the following uses must be provided with sound attenuation to reduce the interior noise level to an Ldn of 45 or less, as specified by Development Standard 9-05.0. (Ord No. 10073, §1, 10/25/04)

- a. All site-built residential uses.
 - b. All places of public accommodation.
 - c. All Administrative and Professional Offices.
2. Single-family and multifamily dwellings are permitted, provided the property is residentially zoned as of May 16, 1990, and provided the interior noise level is reduced to an Ldn of 45 or less as specified in Sec. 2.8.5.6.B.1.

3. A manufactured housing unit will not be considered equivalent to a single-family dwelling within the boundaries of NCD-70, unless located on a property zoned MH-1 or MH-2 or unless it can be demonstrated that the unit provides adequate sound attenuation to reduce the interior noise level to Ldn 45. (Ord. No. 9374, §1, 4/10/00)
4. Special Exception Land Uses. The following uses are generally considered to be inappropriate within the high noise area, NCD-70. They may be approved as Special Exception Land Uses upon application, review, and approval in accordance with Sec. 23A-50, 23A-53, Full Notice Procedure, Zoning Examiner Special Exceptions. In addition to the standard notice required for Special Exception Land Use applications, the Tucson Airport Authority and Davis-Monthan Air Force Base will be notified of all such applications within the boundaries of the Airport Environs Zone (AEZ). (Ord. No. 9781, §1, 10/28/02; Ord. No. 9967, §2, 7/1/04; Ord No. 10073, §1, 10/25/04)
 - a. Civic Assembly.
 - b. Cultural Use.
 - c. Educational Use: Postsecondary Institution.
 - d. Entertainment.
 - e. Medical Service - Major.
 - f. Swap Meet or Auction.

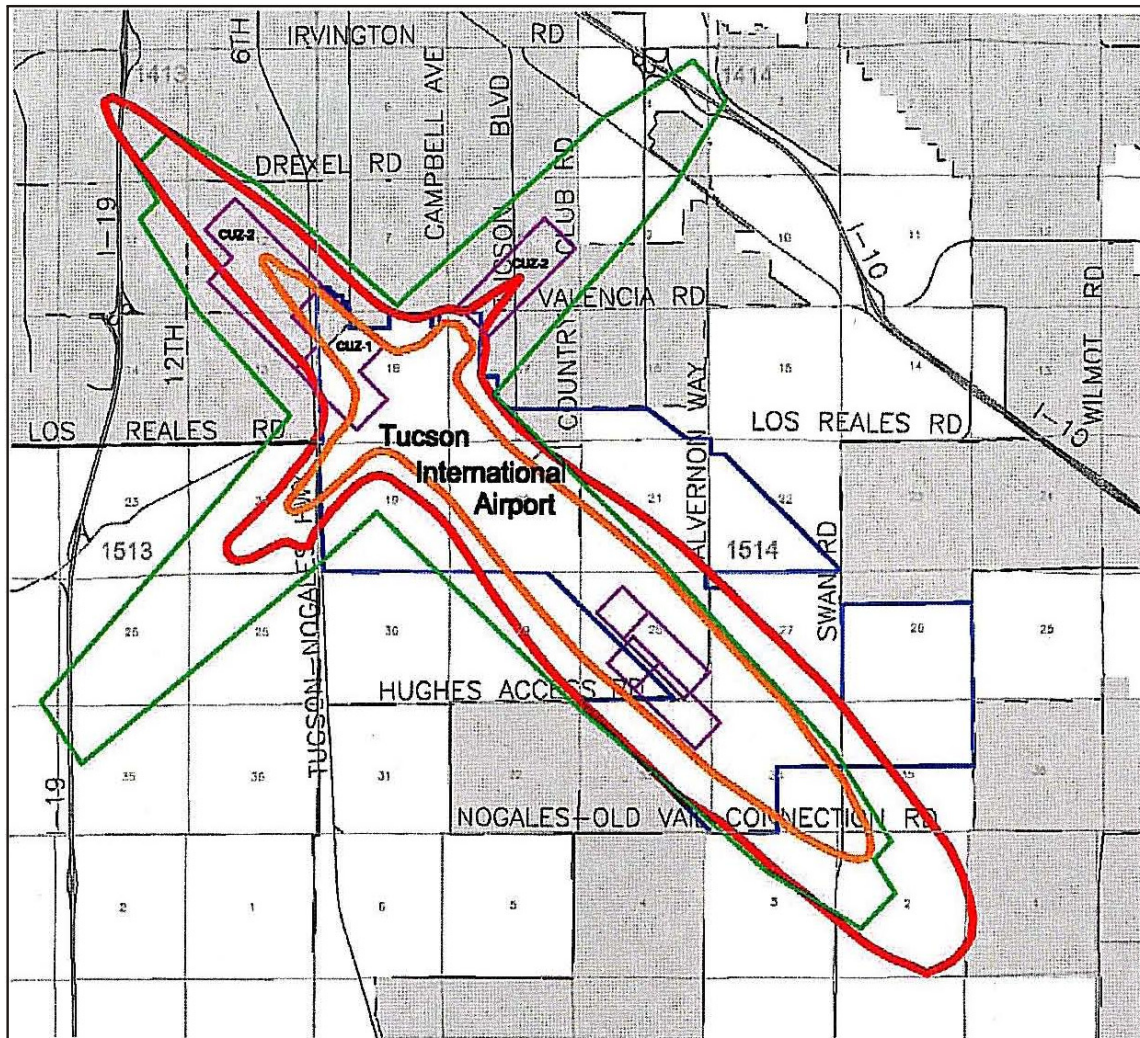
In addition to the required findings and conditions specified in Section 23A-50, 23A-53, Full Notice Procedure, Zoning Examiner Special Exceptions, these uses must be shown to be consistent with the intent of the Airport Environs Zone (AEZ) and the Airport Environs Plan or the Air Installation Compatible Use Zone (AICUZ) Report and must be capable of sound attenuation to mitigate the effects of high noise. In addition, all activity associated with the use must be shown to take place within an enclosed building. An acoustical engineer must demonstrate that the proposed use is noise insulated to an interior noise level of an Ldn of 45 or less. (Ord. No. 9781, §1, 10/28/02; Ord. No. 9967, §2, 7/1/04; Ord No. 10073, §1, 10/25/04)

5. Prohibited Uses. Within NCD-70, the following uses are prohibited.
 - a. Day Care.
 - b. Educational Use: Elementary and Secondary Schools.







2.8.5.7 Applicability. Sections 2.8.5.7, 2.8.5.8, 2.8.5.9 and 2.8.5.10 apply to the DMAFB Environs. Where more than one (1) district or zone is applicable to a property, the requirements of all applicable districts or zones apply. Where requirements conflict, the most restrictive applies. The provisions of the Airport Environs Zone (AEZ) apply to the following on all property located within the DMAFB Environs boundaries established by Sec. 2.8.5.2. B. For property partially within the AEZ, the provisions apply to only those portions within the boundaries of the AEZ. For areas outside the city limits, which have not been annexed by the City, the AEZ overlay provisions apply upon annexation.

A. New Development.

1. For property located within the zones and districts ADC-1, ADC-2, ADC-3, NCD-A and NCD-B, the provisions established by Section 2.8.5.8, Approach-Departure Corridors for DMAFB Environs and Section 2.8.5.9, Noise Control Districts for DMAFB Environs will apply on January 1, 2005.



TIA Airport Environs Zone

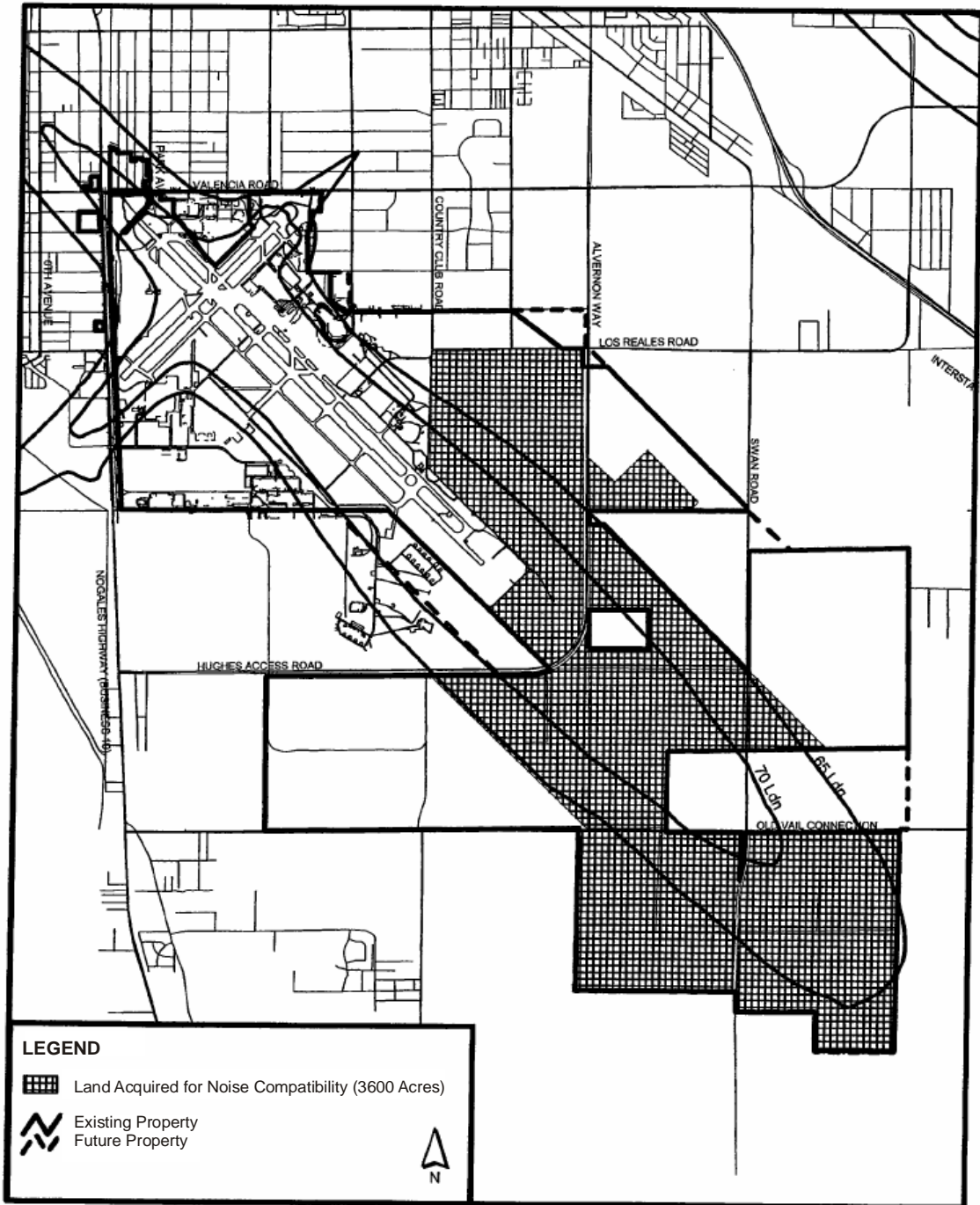
- Legend**
-  TIA Boundary
 -  Airport Hazard District (AHD)
 -  65 Noise Contour (NCD-65)
 -  70 Noise Contour (NCD-70)
 -  Compatibility Use Zones (CUZ)
 -  City of Tucson



Map 2.8.5.2-II TIA Base Camp

(Ord. No. 10073, §1, 10/25/04)

LAND ACQUISITION FOR NOISE COMPATIBILITY





CITY OF TUCSON DEVELOPMENT SERVICES DEPARTMENT

COMMUNITY DESIGN REVIEW COMMITTEE
APPLICATION

Case Number: _____

Transmittal Date: _____

Project Type:

- Tentative Plat (TP)
- Final Plat (FP)
- Development Plan (DP)
- Minor Subdivision
- Residential Cluster Project (RCP)
- Condominium

(Check all applicable)

Project Location Map

APPLICANT/CONSULTANT:

Name: _____

Company: _____

Address: _____

City/State/Zip: _____

Phone: _____ Fax: _____ E-Mail: _____

OWNER:

Name: _____

Company: _____

Address: _____

City/State/Zip: _____

Phone: _____ Fax: _____ E-Mail: _____

PROPERTY INFORMATION:

ASSESSORS PARCEL: _____ WARD: _____

Project Name: _____

Location: _____
(Address Or Nearest Cross Streets)

No. Of Lots/Residential Units: _____ Gross Lot Area: _____

Land Use: _____ Gross Floor Area: _____

Existing Zoning: _____ Proposed Zoning: _____

Section: _____ Township: _____ Range: _____

ASSOCIATED CASE NUMBERS:

CDRC: _____ REZONING: _____ BOARD OF ADJUSTMENT: _____

LOT DEVELOPMENT OPTION: _____ OTHER: _____
(Block Plat, Annexation, Specific Plan)

OVERLAY ZONES:

- AIRPORT ENVIRONS FLOODPLAIN GATEWAY ROUTE HILLSIDE DEVELOPMENT
- HISTORIC DISTRICT SCENIC ROUTE NEIGHBORHOOD/AREA PLAN _____
- WASH ENVIRONMENTAL RESOURCE ZONE _____ (PLAN NAME)

Has neighborhood contact been made? Yes _____ No _____

If yes, documentation of that contact must be attached. If no, and notification is required, application may not be acceptable. Please contact the Planning Department at 791-4505 for determination.

DSD PRESUBMITTAL CONFERENCE DATE:
(Please fill-in the date of the conference attended:)

DATE: _____

SEWER OR SEPTIC INFORMATION:
Is This Septic? YES ____ NO ____
If septic, please include an additional plan for DEQ review.

SIGNATURES:

I CERTIFY THAT ALL INFORMATION CONTAINED ON THIS APPLICATION IS COMPLETE AND TRUE TO THE BEST OF MY KNOWLEDGE:

OWNER/APPLICANT: _____ DATE: _____

This application is to be filed at the City of Tucson Development Services Department, 201 N. Stone Avenue, Tucson, Arizona. Please submit a complete, accurate, and legible application accompanied by the appropriate plans, documentation, and fees. Fees information is in the Development Standards, Section No. 1-05.0. Submittal requirements can be found in the Development Standards Sections 2-03.3.0 and 2-05.3.0. Make your check payable to the "City of Tucson."

LAND USE CATEGORIES

Please Choose from the options listed below. Complete a breakdown according to acreage, square footage (pad area) and number of units for **EACH USE**.

COMMERCIAL

- Office
- Automotive
- Golf Course
- Restaurant
- Mini Storage
- Animal Care
- Resort
- Church
- Retail
- Day Care
- Contractor Yard
- Recreational Facility
- Utilities
- Cemetery
- Financial Service
- Other _____

INDUSTRIAL

- Warehouse
- Gravel Pit
- Other _____
- Factory
- Industrial Subdivision

INSTITUTIONAL

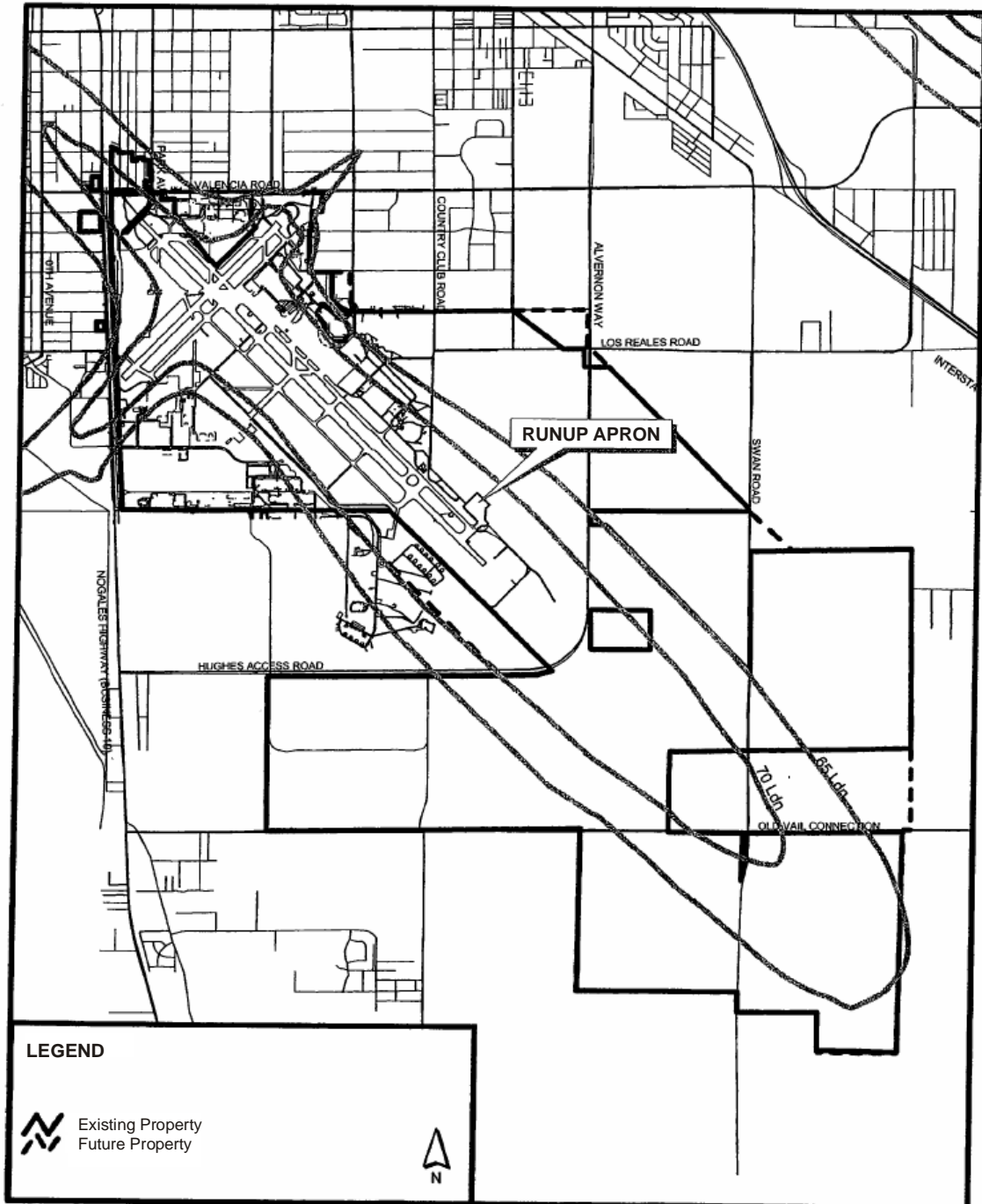
- School
- Government Agencies
- Other _____
- Hospital

RESIDENTIAL

- Apartments
- Condominiums
- Single Family Attached
- Other _____
- MH Park
- RV Park
- Single Family Detached

OTHER (EXPLAIN) _____

RUNUP APRON



VANCOUVER INTERNATIONAL AIRPORT (CANADA)

Noise assessment / noise management plan

The Vancouver International Airport Authority manages Vancouver International Airport (YVR) under a long-term ground lease with Transport Canada (a federal government department). Under this lease agreement, the Airport Authority is responsible for noise management activities and is required to have a Noise Management Plan.

The Federal Minister of Transport approved the current Noise Management Plan in June 2004. The 2004-2008 YVR Noise Management Plan is the primary mechanism used by the Airport Authority to meet its objective of minimizing the level of disturbance to those living in communities in the vicinity of YVR, while recognizing the need for continued aircraft operations. The Plan provides an overview of the YVR Aeronautical Noise Management Programme and describes 17 initiatives that will drive the direction of the airport noise management over the 5-year period. Topics addressed include night-time operations, delay reduction, engine run-ups, compatible land-use planning, international noise standards, air traffic control procedures, new noise metrics and noise monitoring.

A copy of the 2004-2008 YVR Noise Management Plan can be found on the airport's website (http://www.yvr.ca/pdf/authority/NoiseMgmt_2004-2008.pdf). Progress summaries on these initiatives can be found in annual noise reports published by the Airport Authority (http://www.yvr.ca/pdf/authority/yvr_noise_report_2005.pdf).

The Plan was developed with input from the Aeronautical Noise Management Committee. This committee has representatives from communities, airlines, industry associations, air traffic control and governments and provides input on aircraft noise management issues.

The Vancouver Airport Authority operates a comprehensive 24-hour noise monitoring and flight tracking system with 16 terminals in the community, as illustrated in the figure on page II-46.

Informing and engaging key stakeholders are undertaken through several forums including public open houses, public meetings, electronic newsletters, community update brochures and advertisements.

Reduction of noise at source

ICAO sets Standards for aircraft noise that are adopted by member States. Under the Canadian Aviation Regulations [CAR 602.150-602.162], the Federal Government legislated the phase-out of Chapter 2 jet aircraft (greater than 34 000 kg) from the Canadian fleet, beginning at the end of 1995 and concluding 1 April 2002. Airports encourage manufacturers to develop and produce and airlines to use the quietest possible aircraft.

Vancouver International Airport Authority, through Airports Council International (ACI), encourages increased stringency, beyond Chapter 4, in the ICAO Standards for aircraft noise. These new Standards should require noise reduction at each of the three measuring points. As an ACI member, the Airport Authority actively supports the work of ACI to push for increased stringency, including calling for a mechanism to ensure that noise stringency keeps pace with expected future growth of aviation.

Land-use planning and management

As a planning guide, Transport Canada has prepared land-use guidelines based on NEF contours; however these are for guidance only. They are not supported by legislation and have no associated mechanism for compliance or enforcement. Transport Canada's document, Land Use in the Vicinity of Airports (TP 1247E) refers to all types of land use and recommends the following:

- Residential housing is not suitable in areas of NEF 30 and above;
- Sound insulation is recommended for some residential housing between NEF 25 and 30.

In the Province of British Columbia, land-use planning is provincially delegated to the municipalities, and there is no legislation that regulates development in airport noise affected areas.

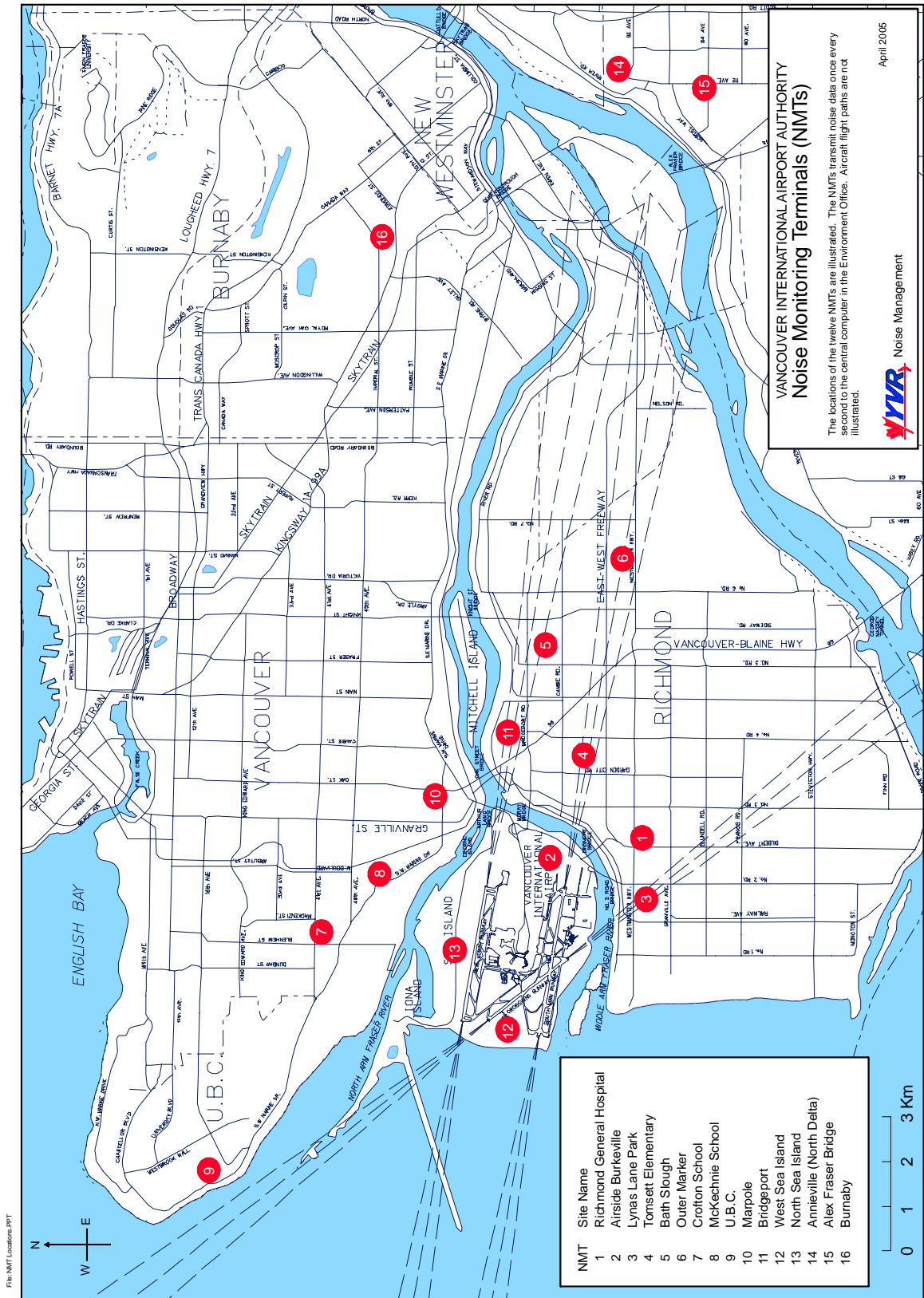
In November 2004, the City of Richmond, where YVR is located, adopted an Aircraft Noise-Sensitive Development Policy (http://www.richmond.ca/__shared/assets/54_noise10206.pdf), to provide guidance to City Planning staff with regards to development in high aircraft noise areas. While this policy includes some strong elements with respect to covenants, noise mitigation standards, and education/awareness requirements, the policy does permit residential developments in areas within the NEF 30. The Airport Authority continues to work with the City to strengthen key elements of the policy, and continues to oppose new residential development in areas exposed to high levels of aircraft noise.

Noise abatement operational procedures and operating restrictions

The noise abatement procedures (NAP) for YVR are published in the Canada Air Pilot and are primarily intended for jet aircraft. The NAP specifies departure/arrival procedures, preferential runway determination, altitude restrictions, night restrictions, and the vertical noise abatement procedure. Under the Canadian Aviation Regulations [CAR 602.105], the procedures published in the NAP are enforceable by Transport Canada Civil Aviation Enforcement.

Some of the procedures included in the NAP are:

- Specific headings and altitudes established to minimize noise.
- Preferential runway assignments to place the noisiest operations (departures) over the water during the day, and the use of two-way flow at night (weather permitting) to minimize over-flights of populated areas.
- Directives on engine run-up operations to minimize noise disturbance at night.
- Minimal use of reverse thrust consistent with safe operating procedures.
- Approval requirement for jet operations between midnight and 0700.



VIENNA INTERNATIONAL AIRPORT (AUSTRIA)

In 2005, VIA concluded a 5-year mediation process that included local and regional governments, citizen and resident groups, and aviation stakeholders. The process achieved binding contracts concerning operation procedures to minimize noise, the location and operation of a future third runway, and appropriate land-use planning. A new body, the Vienna Airport Dialogue Forum will review activities on an on-going basis, including operation with flight corridors, night flight restrictions, ultimate noise limits, restrictions on new residential development and an Environment Fund.

Land-use planning and management

- **Agreement with surrounding communities.** A combination of average noise level contours (Leq) and number of events contours (N65) were used to define noise zones. These zones and contours are used to define ultimate noise limits on airport operations and at the same time define settlement boundaries, within which noise-sensitive activities are prohibited or restricted.
- **Environmental fund.** Based on passenger numbers, the fund is designed to mitigate adverse environment effects by various measures ranging from research on noise generated stress, to community professional training, job creation, nature and landscape protection, and sports.
- **Arbitration Board.** Disputes arising under the legally binding contracts can be brought before an Arbitration Board.

Noise abatement operational procedures

Noise abatement operational procedures are regularly reviewed by the Dialogue Forum and the district conferences in order to improve the noise climate around the airport. Changes in the SID system take place nearly every year. The changes are investigated with the flight track and noise monitoring system and the results are used as the basis for further negotiations. Measures implemented at VIA include:

- **Minimum noise routes.** Apart from allowed maximum airspeed and minimum turning altitudes, all instrument departure routes are defined as minimum noise routes in order to avoid overflight of communities whenever possible.
- **Flight track and noise monitoring system.** A flight track and noise monitoring system is in place to track adherence to established procedures.
- **Improvement of flight procedures.** Based on flight track and noise monitoring and in close cooperation with ATC and airlines, improved flight procedures have been established.
- **Further investigations.** Additional investigations into increasing approach glide angles and defining departure routes by waypoints have been conducted to further improve noise conditions.

Operating Restrictions

- **Night flight restrictions** — From 2007 the number of night flights will be gradually reduced and night-time landings and take-offs in certain directions will be prohibited.
- **Night runway closures** — In order to avoid overflights of populated areas at night Runways 11 and 34 are closed between 2300 and 0600 hours, and 2100 and 0600 hours, respectively.

- **Night departure routes** — Specific night departure routes for every runway direction are defined for flights with westerly destinations.

Reduction of noise at source

Under the Balanced Approach, reduction of noise at source is limited to noise reduction through the adoption and implementation of noise certification Standards set by ICAO and is not within the control of individual airports.

- **ACI participation at CAEP.** VIA, through Airports Council International (ACI), the worldwide airport industry association, supports efforts for increased stringency beyond Chapter 4, in the ICAO Standards for aircraft noise, including the need for new Standards to require noise reduction at each of the three measuring points.
- **Chapter 2 phase-out.** The phase-out of aircraft certificated under the ICAO Annex 16, Chapter 2 noise Standards was completed in 2002.

ZURICH AIRPORT (SWITZERLAND)

Noise assessment / management plan

The noise programme for Zurich Airport is defined by the 2010 Action Programme. This programme outlines a variety of goals and measures to reduce noise impacts in the airport environs.

Reduction of noise at source

Under the Balanced Approach, reduction of noise at source is limited to noise reduction through the adoption and implementation of noise certification Standards set by ICAO and is not within the control of individual airports.

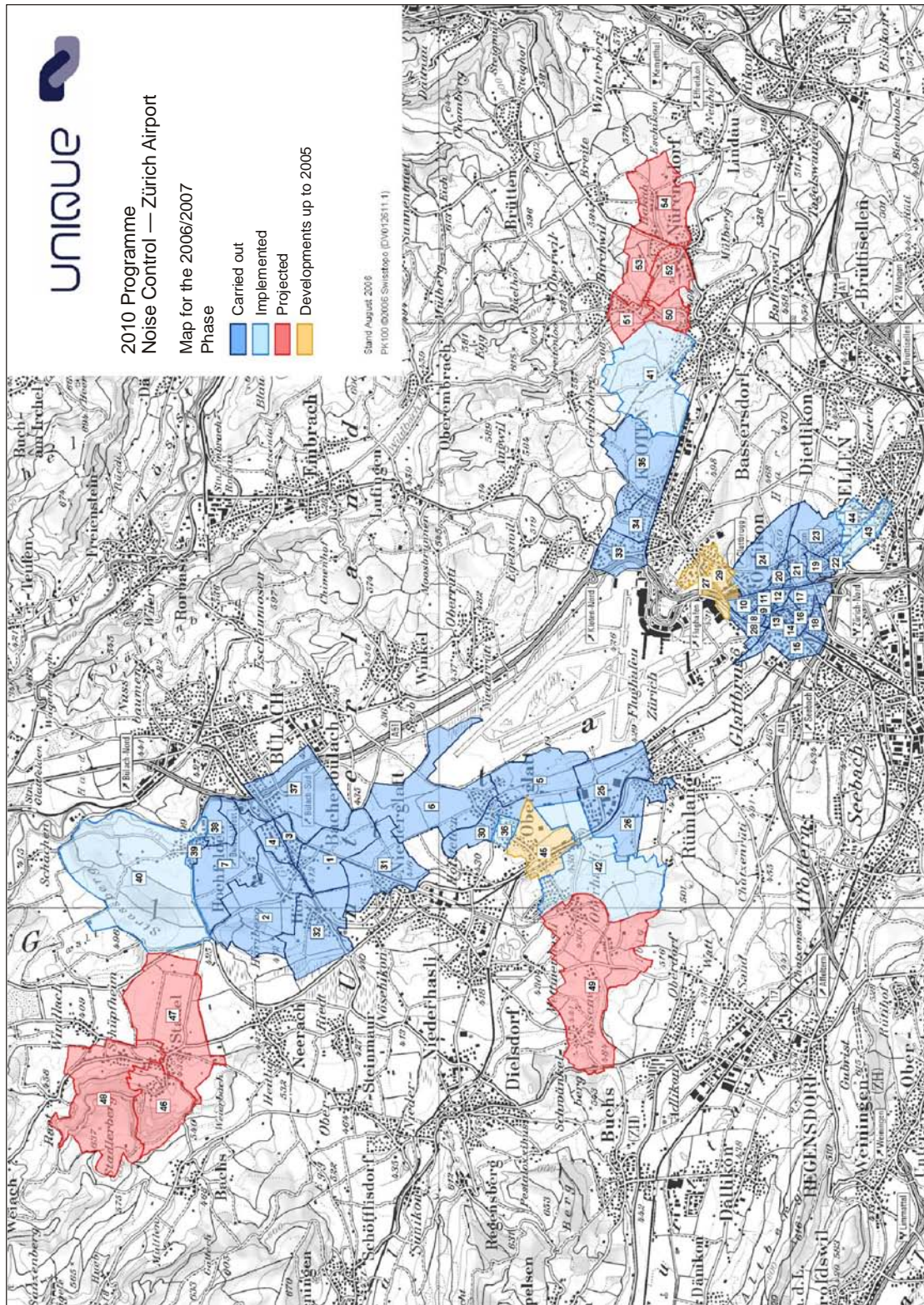
- **ACI participation at CAEP.** Schiphol, through Airports Council International (ACI), the worldwide airport industry association, supports efforts for increased stringency beyond Chapter 4, in the ICAO Standards for aircraft noise, including the need for new Standards to require noise reduction at each of the three measuring points.
- **Ban on Chapter 2 aircraft.** Chapter 2 aircraft have been prohibited at Zurich Airport, as well as at the majority of airports in the European Union since 1 April 2002.
- **Promotion of quieter aircraft.** The trend towards the use of less noisy aircraft continues mainly as the result of the collection of noise-related charges.

Land-use planning and management

- **Sound insulation of existing development.** Under the 2010 Zurich Airport Sound Proofing Programme, all homeowners whose property lies within a clearly defined zone referred to as the Noise Insulation Perimeter are entitled to this service. As of 2006, insulation work has been completed on approximately 1 700 properties.
- **Noise monitoring.** Nine permanent noise monitoring terminals are operated in the vicinity of the airport. The results are evaluated each month in a noise bulletin that is available to municipal authorities, politicians and other interested parties via the Internet.

Noise abatement operational procedures

- **Curfew on night-time operations.** Flights are discouraged after 2200 hours and flights arriving or departing after 2300 hours require a special permit.
- **Flight path deviation.** Investigations are conducted into pilots who deviate from established flight paths.



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