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Part 2

AIRPORT PLANNING MANUAL

PART 2

LAND USE AND ENVIRONMENTAL CONTROL

SECOND EDITION — 1985

Approved by the Secretary General and published under his authority

INTERNATIONAL CIVIL AVIATION ORGANIZATION

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Airport Planning Manual

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Land Use and Environmental Control

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AMENDMENTS

The issue of amendments is announced in the *ICAO Bulletin* and in the monthly supplements to the *Catalogue of ICAO Publications*, which holders of this publication should consult. These amendments are available free upon request.

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FOREWORD

The purpose of this part of the manual is to provide guidance material on land use or planning in the vicinity of airports and on environmental aspects, as no Standards or Recommended Practices on this subject exist in any Annex. It is based in part on conclusions of the Special Meeting on Aircraft Noise in the Vicinity of Aerodromes held in 1969, and on the current practices of several States and incorporates guidance material on airport environmental aspects as recommended by the Eighth Air Navigation Conference held in 1974.

It is intended that the manual be kept up to date. Future editions will be improved on the basis of the results of the work of ICAO and of comments and suggestions received from the users of this manual. Therefore, readers are invited to give their views, comments and suggestions on this edition. These should be directed to the Secretary General of ICAO.

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CHAPTER 1 - GENERAL

1.1 - The Airport and Its Environs

1.1.1 The compatibility of an airport with its environs is an ideal which can be pursued by proper planning of the airport, control of pollution-generating sources and land-use planning of the area surrounding the airport. The aim is to provide the best possible conditions for the needs of the airport, the community in the surrounding area and the ecology of the environment.

1.1.2 Airport planning must be recognized as an integral part of an area-wide comprehensive planning programme. The location, size and configuration of the airport need to be co-ordinated with patterns of residential, industrial, commercial, agricultural and other land uses of the area, taking into account the effects of the airport on people, flora, fauna, the atmosphere, water courses and other facets of the environment.

1.1.3 Within the comprehensive planning framework, airport development and operations should be co-ordinated with the planning, policies and programmes for the area in which the airport is located. The social and economic impact, together with the environmental effects of the airport can then be evaluated. This will ensure that the airport environs are compatible with the airport and, conversely, that the physical development and use of the airport is compatible with the existing and proposed patterns of land use. To the extent that technical considerations permit a choice, decisions on runway alignment and other airport development should take account of their effect for ameliorating and preventing environmental conflicts. "Land-use control" is a term which describes only a portion of the total planning process and even highly innovative controls can have little impact unless they are imposed within the context of sound policies and careful planning. "Planning for compatible land-use airport relationships" more adequately describes the process directed towards achieving an optimum relationship between an airport and its environs.

1.2 - The Need for Environmental Control

1.2.1 Needless to say, airports have generated pollution since their inception, but the problem has been highlighted with the general growth in air traffic volume and particularly since the wide-spread introduction of commercial turbo-jet aircraft operations. Furthermore, in recent years there has been increased public concern generally regarding environment protection and public opinion and protestation have emphasized the need to apply effective measures to abate airport, urban and industrial pollution. Since pollution may be generated within an airport as well as within the area surrounding it, environmental controls should be generally applicable to the airport and its environs.

1.2.2 Since pollution may be hazardous to public health and detrimental to the ecology of the environment, controls are frequently necessary to either curb pollution at its source or to reduce its effect. Controls take different forms such as aircraft engine noise limits, flight and ground operating procedures, aircraft and ground vehicle engine emissions standards and water purity standards, etc. Through the application of such measures and in conjuction with land-use planning, airports may be located and operated so that they fit harmoniously into their local community.

1.2.3 Not only may an airport be a disrupting influence through pollution but the vast size of some airports and the development associated with the airport may have negative aspects that need to be taken into account. For example, drainage patterns may be altered as a result of extensive earth works or surface water run-off as a result of paved areas.

1.3 - The Need for Land-use Planning

1.3.1 The need for some public control of land in the vicinity of an airport was recognized in the early history of civil aviation. In general, these early actions were usually concerned with height control of possible hazards or obstacles to flight into or out of airports. The need for a certain type of control for non-conforming purposes was experienced, such as:

a) uses which would cause electrical interference with radio communications and navigational aids;

b) lights which might confuse pilots in the clear interpretation of aeronautical lights; and

c) smoke which reduces visibility.

The compatibility of land use with noise exposure in the vicinity of airports did not become a major consideration until the early 1960s, a few years after the wide-spread introduction of commercial turbo-jet aircraft operations, although litigation regarding aircraft noise was not infrequent before that time. Today aircraft noise is probably the most significant influence on land-use planning in the vicinity of airports.

1.3.2 The requirement for land-use planning in the vicinity of an airport is twofold;

a) to provide for airport needs, e.g. obstacle limitation areas, future airport development, etc.; and

b) to ensure minimal interference to the environment and the public, e.g. by locating residential areas away from zones subject to excessive noise or other pollution, by preserving parklands, etc.

CHAPTER 2 - ECOLOGICAL CONSIDERATIONS

2.1 - The Atmosphere

2.1.1 Some degree of atmospheric contamination associated with an airport is unavoidable. Emissions from aircraft and ground vehicle engines, incinerators, terminal buildings and other sources contribute to air pollution in the vicinity of an airport. Pollution generated by aircraft engines is the most obvious type of atmospheric pollution associated with airports and it is probably for this reason that much public interest is shown in this aspect of airport pollution.

2.1.2 The undesirable by-products of combustion generated by aircraft engines are carbon monoxide, unburnt hydrocarbons, the oxides of nitrogen and minute solid particles. It is mainly the minute solid particles suspended in the air which create the visible evidence of air pollution in the form of a smoke plume which, while visually unpleasant and operationally undesirable, is considered less harmful to public health than the other engine emissions. The engine efflux from modern turbo-jet aircraft is generally accepted as being less harmful to health than that from reciprocating engines such as those used in ground vehicles, certain light aircraft and early commercial aircraft.

2.1.3 Studies of the air quality at certain large airports and in nearby areas have generally indicated that atmospheric pollution in these areas is primarily attributable to automobiles, airport ground vehicles and other urban pollution sources.

2.2 - Flora and Fauna

2.2.1 Utilization of land for airport purposes inevitably creates disturbances to flora and fauna. Airport development work frequently entails clearing and cutting back of trees and other vegetation, changes to the topography of the land and interference with watershed patterns. Thus airports may destroy the natural habitat and feeding grounds of wildlife and may eradicate or deplete certain flora important to the ecological balance of the area.

2.2.2 An important consideration related to airport operational safety is the prevalence and habits of birds in the area and the associated risk of aircraft bird strikes. Bird hazards at proposed new airports can be minimized by careful selection of the site to avoid established bird migration routes and areas naturally attractive to birds, and by using the land surrounding the airport for purposes which will not attract concentrations of birds to the area. The subject of bird strike reduction is covered in detail in the Airport Services Manual (Doc 9137), Part 3 - Bird Control and Reduction. In an appendix to this manual land uses compatible and incompatible with minimum bird hazards to aircraft are set out. At existing airports the bird problem may be controlled by scaring techniques and by making the airport and its environment unattractive to birds.

2.3 - Soil Erosion

2.3.1 As a consequence of vegetation clearing and interference with watershed patterns, land on an airport, or within its vicinity, may be vulnerable to soil erosion by the natural elements and, to a limited degree, by aircraft jet blast. This problem can mostly be prevented by re-planting; however, in arid areas it may be necessary to take artificial erosion protection measures such as facing of escarpments, paving of taxiway flanks and lining of drains.

2.4 - Streams, Lakes and the Sea

2.4.1 If not properly controlled, contaminants may enter streams or waterways from airport drainage systems and eventually run into lakes or the sea. These contaminants could originate from ground vehicles and aircraft washing, terminal services, aircraft servicing, pavement cleaning and airport maintenance and construction work. Typical contaminants include petroleum products, fragments of rubber and metal, soil sediments, detergents and other chemicals, human waste and food products. As discussed in 3.4, water pollution controls generally preclude indiscriminate contamination of streams and watercourses.

2.4.2 Particular consideration should be given to possible water pollution during construction phases of airports. Construction activities likely to cause stream pollution include clearing and grubbing and pest control. The clearing of vegetation generally results in an increase in the amount of soil carried into streams. Pest control, particularly the use of sprays, introduces long-life toxic chemicals into the water. Fuel spillages from equipment and chemicals employed in building and pavement construction work can also contribute to upset the hydrological balance of waterways in the area. Changes to the natural drainage patterns of an area due to the construction of an airport can overtax certain streams and give rise to flooding. In other cases, due to diversion of flow, streams may be dried up.

2.4.3 Some airports, as a consequence of their siting, interfere with the shore lines of rivers, lakes and the sea. In planning such airports, careful consideration needs to be given to possible environmental problems associated with water currents, silt deposits, marine or fresh water life and marine or stream erosion.

2.5 - Noise

2.5.1 By far the most significant factor in the generation of airport noise is the aircraft engine. The intensity and nature of aircraft engine noise is quite variable, depending on the engine type and the nature of the operation being undertaken. Noise nuisance associated with an airport is also closely related to frequency of aircraft operations and their diurnal distribution, i.e. noise at night is more a nuisance than in the daytime.

2.5.2 High levels of airport noise are most undesirable. Noise is a particular health hazard to employees who, because of their duties, are subjected to long durations of intense aircraft noise. Consequently strict precautionary measures are necessary for these people, such as the mandatory usage of acoustical protective devices. The repercussions of excessive airport noise in residential areas are primarily of a social and behavioural nature. Assessment of noise in relation to land-use planning is discussed briefly at 5.2.

2.6 - Environmental Impact Studies

2.6.1 Detailed study of the impact of airport development on the environment is an essential part of the assessment for any major project. Social and ecological impacts should be investigated fully before work is undertaken or, in the case of a new airport, when its site is being selected.

2.6.2 Environmental impact studies, depending on the nature of the project, take into account the following considerations:

a) compatibility with community including health, transport and social implications;

b) influence on ecology including effects of pollution, preservation of flora and fauna; and

c) means of overcoming any problems.

CHAPTER 3 - ENVIRONMENTAL CONTROL MEASURES

3.1 - General

3.1.1 Pollution abatement measures applicable to an airport and its environs are necessary in the interests of both airport operations and the protection of the environment around the airport. These measures are, in some instances, legislative controls and in other cases they are physical in nature. Some measures limit pollution at its source whereas others reduce the effect of it on the community and ecology. While environmental control measures should be applied generally throughout communities, discussion in this Chapter is limited to controls specifically applicable to pollution associated with airports.

3.2 - Noise Abatement

3.2.1 Before an aircraft is permitted to operate, noise certification must be granted by the State of Registry. Aircraft noise certification provisions are detailed in Annex 16 to the Convention. In addition to the noise limitations imposed by aircraft certification, States and local authorities frequently apply local restrictions applicable to specific airports, aircraft types and/or operations. Such local restrictions have been responsible for the introduction of night curfews at many airports and, at some airports, the banning altogether of certain aircraft types due to noise considerations. Such limitations are generally undesirable as they create insufficient utilization of airport facilities and impose undesirable restrictions on air transport developments.

3.2.2 To meet the demand for quieter aircraft engines, manufacturers have undertaken research which, although costly to the aviation industry, has led to a considerable lessening of aircraft engine noise output. For example, modern wide-bodied transport aircraft such as the B747, DC10, L1011 and A300B types are much quieter than earlier generation aircraft such as the B707, DC8 and VC10 types.

3.2.3 Noise restrictions have necessitated the introduction of operational procedures to reduce the noise level in nearby areas. For example, the selection of specified approach and take-off paths and the adoption of maximum engine thrust settings for certain operational phases are commonly employed aircraft noise abatement procedures. Controls may also be imposed on the noise generated by aircraft engine testing operations, ground movement of aircraft and certain airport construction works, e.g., blasting.

3.2.4 In addition to the measures mentioned above which attack noise at its source by operational means and by scheduling, it is possible to reduce the effects of noise by:

a) land-use planning (which is dealt with in Chapter 5); and

b) acoustical barriers.

3.2.5 Acoustical barriers can include such wide-ranging measures as the use of protective ear coverings for people subjected to high intensity noise to soundproofing of buildings (which is discussed at 6.7) and methods for screening sound.

3.2.6 Trees may be planted to screen certain areas from some airport noise. A study in Japan of the sound-insulating characteristics of wooded areas indicated that good protection against ground run-up noise might be expected from judiciously planted trees. Various configurations of insulating forest were considered but after study the configuration shown in Figure 3-1 was recommended. The sloped embankment makes planting easier and a considerable sound-insulating effect can be expected even during the early stage when the trees are not fully grown as the embankment itself has a significant sound-insulating effect. Figure 3-2 shows the sound absorption effect of different tree species. The sound attenuation through 100 m of evergreen trees will be 25 to 30 dB.

3.2.7 When selecting trees to be used for the development of a sound-insulating forest, consideration should be given to selecting species which:

a) are suitable to the climatic conditions of the airport site;

b) have effective sound-insulation properties (e.g. do not shed their leaves or needles in winter, grow rapidly and densely, etc.);

c) do not generate a bird hazard; and

d) are easy to care for (e.g. normally healthy and not readily affected by blight or noxious insects, etc.).

3.2.8 Buildings may be soundproofed to protect the occupants against excessive noise levels. Chapter 5 deals with soundproofing in relation to building codes.

3.3 - Air Pollution Control

3.3.1 As with aircraft noise, technology has been developed and continues to be developed to lessen the emission of pollutants by aircraft. Jet engine combustors are now available which eliminate smoke emissions and on many aircraft the venting of fuel directly to the atmosphere during normal operations is avoided. Much effort by designers is now going into the reduction of gaseous emissions. Operational procedures which reduce emissions are also possible. Chief among these are measures to reduce time spent with engines idling, such as delaying start-up of engines until it is known that a direct taxi to take-off is possible. Early shut down of one or more engines after landing is also possible, although it must be remembered that such techniques can increase noise by requiring higher power or thrust from the remaining engines.

3.3.2 In regard to engine emission from ground vehicles, the engines may be modified to burn propane gas or alternatively, pollution control devices - similar to those required to be used on automobiles in some countries - could be incorporated. Emissions generated by access traffic can be reduced by decreasing traffic congestion and by providing alternative means of transport.

3.3.3 Air pollution originating from aircraft engine testing and maintenance facilities may be controlled through the use of test cells equipped with afterburners and catalytic converters. Measures should also be taken to reduce emissions from incinerators, heating and air-conditioning plants, and certain construction or maintenance works, e.g. smoke from asphalt paving plant, refuse burning, etc.

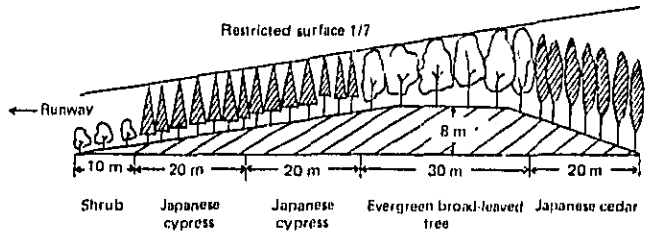

Figure 3-1. Cross-section of sound-insulating forest

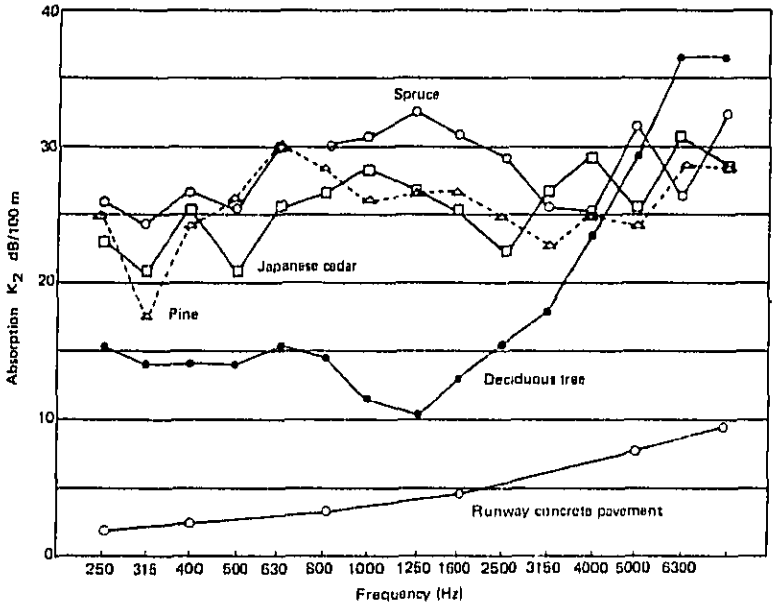

Figure 3-2. Sound absorption by tree species

3.4 - Water Pollution Control

3.4.1 Legislation exists in many States regarding water quality control. Local regulations generally cover the allowable points of discharge and the quantity of waste water which may be discharged. Waste water may be either treated on the airport or connected to a nearby municipal treatment system. Treatment of airport waste water must meet the stipulations of the legislation and if airport waste water is connected to a municipal system, pretreatment of the waste may be necessary to ensure compatibility with the treatment works.

3.4.2 Sanitary and industrial waste water, such as may originate from terminal and aircraft servicing areas, should be directed to receive sewage treatment. Impervious area run-off and other drainage may be discharged separately and may be required to pass through a separation basin or other device in order to remove sediment or other undesirable pollutants.

3.4.3 When chemicals are employed on the airport they should be selected and used in a manner to minimize water pollution. Chemicals are frequently used for runway rubber removal, runway ice removal and aircraft de-icing. At Montreal/Mirabel airport a special central aircraft de-icing facility was constructed to control run-off of the de-icing chemicals.

3.4.4 Because of the amount of aircraft fuel required, a significant amount is stored at a large airport. Storage and handling of such large quantities of aircraft fuel products may create a potential for water pollution. The following outlines the elements of a water pollution control programme which has been made part of on-going airport operations at maintenance areas, aprons and fuel farms at a large airport. Maintenance areas in hangars, as well as automotive and equipment service areas are provided with oil-water separators which are connected to sanitary sewers leading to the municipal waste treatment plant serving the airport. All existing oil-water separators are checked and upgraded when necessary by airport personnel to meet the requirements of the municipal sewerage treatment plants. All oil-water separators are inspected by airport personnel on a monthly basis and deficiencies found are promptly corrected.

3.4.5 The primary pollutant originating on aprons is oil resulting from spills and accumulations. Grease and suspended solids from various sources such as aircraft, service vehicles and minor aircraft maintenance may also occur. The airport pollution control effort has focused on:

a) strict enforcement of good housekeeping regulations to control pollution at its source and minimize accidental spills; and

b) removal of accidentally spilled oil and fuel by containment and spill recovery.

3.4.6 The following procedure has been put into practice:

a) no aircraft maintenance work, other than emergency repairs, is allowed on the apron. All regular maintenance activities are done in hangars protected by oil-water separators;

b) no washing of equipment is allowed in apron areas; and

c) all spills of fuel or oil are immediately picked up using absorbents which are subsequently removed from the airport by licensed disposers.

3.4.7 The airport personnel also respond to spill reports, check all relevant manholes, monitor the removal of any fuel or oil found therein, and analyze spill reports for common causes in order to prevent future spills. Whenever fuelling operations are done by truck fuelling, the trucks are inspected every six months and hydrant pits used for transferring fuel from the underground piping systems are checked on a routine basis for any accumulation of fuel.

3.4.8 Another problem is the presence of underground oil-saturated soils at fuel farms. There are several potential sources of oil contributing to the oil-saturated soil beneath a fuel farm:

a) leakage in underground fuel distribution lines;

b) leakage from mechanical equipment which penetrates cracks and joints in the slabs beneath the equipment; and

c) leakage through the joints in the storm water drainage pipe used to convey condensate from the fuel storage tanks to the oil-water separator system.

3.4.9 A number of steps have also been taken to solve the problem of underground oil-saturated soils. When required, wellpoints at preselected locations are installed to determine the presence of and depth of oil. Pipes are inserted into the ground to a depth that ensures a penetration below the ground water elevation. A continuous slotted pipe assures that any oil floating on the surface of the underground water is free to enter the pipe at its natural elevation and also assures that any fluctuations in the underground liquid surface are accurately reflected within the pipe.

3.4.10 A device - developed to measure the depth of water that collects beneath fuel oil in storage tanks - is utilized to measure the pressure and depth of oil. An alarm sounds when the probe makes contact with the water. The probe is then withdrawn and its dry length and total length are measured from the mark. The elevation of the oil or water surface is calculated by subtracting the measured length from the pre-established elevation at the top of the wellpoint. Upon the detection of underground oil at any wellpoint, supplementary wellpoints are installed to define the horizontal limits and thickness of the oil-saturated soils encountered. Placement of the supplementary wellpoints may be performed in stages. Upon finding oil in a wellpoint, additional wellpoints may be installed around the first to establish the limits of the oil-saturated soils. If oil is found in the supplementary wellpoint, additional wellpoints are installed. This procedure may be repeated through several stages until the outer perimeter of wellpoints indicates the absence of oil.

3.5 - Protection of Flora and Fauna

3.5.1 Legislative controls exist in many States which protect certain species of flora and fauna. Such controls must be taken into account in planning airport development and in managing the day-to-day operation of an airport. Apart from mandatory requirements, it is important that every consideration be given to the impact of airport development on flora and fauna and that measures be taken to minimize undesirable interference to this aspect of the environment.

3.5.2 The requirement to protect certain flora and fauna may eliminate airport siting proposals or make future expansion of an airport impossible. Such controls can also jeopardize the control of vegetation in approach and take-off areas and make the control of certain animals, particularly birds, on the airport extremely difficult. Where practicable, siting an airport with such limitations should be avoided.

3.5.3 When airports create interference with flora and fauna, every effort should be made to minimize this interference. It is generally the case that suitable alternative areas are available for the habitation of wildlife. If this is not the case, it may be possible to develop other areas as suitable habitat, perhaps by such measures as replanting particular types of vegetation or the provision of artificial lakes.

CHAPTER 4 - LAND USE

4.1 - Natural

4.1.1 Every airport is different, as are the areas surrounding them. Natural areas, such as forests, open land, rivers, swamps, bays - with and without wildlife - are found in varying degrees in the vicinity of airports. In many cases, the presence of natural areas influences the selection of the airport site. In other cases, the selection is based on different factors, but the existence of natural areas provides additional benefits.

4.1.2 The presence of natural features in the approach and climb-out areas has done much to mitigate the aircraft noise problem. An example is a new airport which has been situated in the bend of a river to take advantage of the close-in water approaches under both ends of the runway. Runways located on filled land on the edge of bays also afford unobstructed approaches over water.

4.1.3 Natural features have been, and can be, used to advantage not only in protecting the airport against noise complaints but in adding natural beauty and interest to the airport. Nevertheless, where rivers, lakes, bays or swamps are found in the airport area, a bird problem may exist. This has been serious at some airports to the point of causing accidents. Compatible and incompatible land uses around airports for minimizing bird problems are identified in the Appendix.

4.2 - Agricultural

4.2.1 While it may not always be possible to use land for agricultural purposes in metropolitan areas, many airports can do so, at the same time increasing revenues for the airports. Privately-owned land around airports can also be used for farming.

4.2.2 The agricultural use of land contributes several important factors to an airport programme:

a) it produces income from what might otherwise be waste or idle land;

b) it provides crop cover and prevents soil erosion; and

c) it eliminates the expense to the airport of mowing or taking care of the land.

4.2.3 Furthermore, land that has been turned over to agriculture is still available for industrial or commercial development, recreational facilities, or public utilities at a later period. Crop cultivation may, however, have an adverse effect on aircraft operations due to the presence of birds which are attracted by the seeds. The effect of crop cultivation on bird occurrence at airports is discussed in the Airport Services Manual, Part 3 - Bird Control and Reduction.

4.2.4 All agricultural uses have proven compatible with aircraft noise, with the exception of poultry and mink farms. Location of these farms within approximately 5 km of an airport is not recommended because of the adverse reaction of the mink and fowl to high levels of aircraft noise. It should also be noted that birds may be attracted to some pig farms where garbage is used as fodder.

4.3 - Highways

4.3.1 In view of the vast network of highways today and the constant building, realignment and rebuilding that will take place in the future, it is only sensible that highway planning be co-ordinated with noise abatement plans of airports. In planning a highway system near an airport, or in planning one which includes an access road to the airport, co-ordination with the airport officials can often result in placing the highway beneath the approach and climb-out paths of the aircraft. The highway construction can take the place of housing adversely affected by noise, and adjacent areas can be more easily adapted to commercial, industrial, and recreational uses and parks. Not only can residential areas be removed but they can actually be prevented from developing in critical noise areas by locating the highway there.

4.4 - Recreational

4.4.1 Every community needs recreational facilities for its population, and there are a number of outdoor recreational uses that are compatible with airport operations. When such facilities must serve large population areas, it is apparent that a considerable amount of land is involved. Many airports have sufficient undeveloped adjacent land which, through proper planning, can be developed into complete recreational complexes.

4.4.2 The survey of recreational land uses in airport areas revealed inter-relationships among activities which substantiate the idea of a community recreation complex in the vicinity of the airport. Golf courses are increasing in popularity, parks take little development and are ideal for hiking and riding trails, and outdoor living facilities, swimming pools, tennis courts, playgrounds, and athletic fields (non-spectator) may be grouped with a clubhouse-restaurant facility except under the approach areas. Botanical gardens can be included with most be these activities and ponds fit into parks and golf courses. All add interest, beauty and activity to the airport surroundings. On a more reduced scale, recreational facilities combined with industrial areas are complementary and supporting to an airport and serve the workers living near by.

4.4.3 A review of the experiences with the many types of recreational facilities indicates that, from a standpoint of noise and public hazard, playgrounds and athletic fields are considered marginal. Fairgrounds and race tracks, outdoor theatres, and amphitheatres are considered poor uses. Tennis courts and golf courses, if under approach areas to a busy airport, should be at least 3 km from the airport boundary. Other recreational uses reported as compatible within approximately 5 km of the airport include archery ranges, golf driving ranges, go-cart tracks, dog tracks, skating rinks, and bowling alleys.

4.5 - Municipal Utilities

4.5.1 The siting of municipal utilities at an airport is not only compatible but logical. The industrial, residential, and commercial growth of the airport community creates increasing demands for water, sewage disposal, and power utilities, and the concentration of these municipal requirements in the airport area has proved to be economical as well as wise. However, while all municipal utility uses are compatible in the sense that there is no noise problem, electrical plants and power lines are considered a hazard by many airport planners. Trash dumps and incinerators may create a smoke problem. Also water storage may attract birds.

4.6 - Commercial

4.6.1 Commercial activity is similar to residential activity in that people are going into and out of buildings and the area; however, the bulk of commercial operations is carried on during daylight hours, and is not affected by the problem of noise during the night or sleeping hours as residential areas are. In addition, persons pursuing the normal business activities found in commercial areas are not generally so disturbed by aircraft noise as are people in residential areas.

4.6.2 Commercial activities established on or around the airports reportedly range from shopping centres to pet cemeteries.

4.6.3 Although such operations can be situated in areas subject to higher noise levels than residential developments, they generally cannot be carried on in the same areas as industrial operations which are performed primarily inside and have a higher associated noise level. Sound conditioning and air conditioning should be incorporated in the construction of commercial structures to the extent necessary to reduce exterior noise to the acceptable level for the conduct of business inside the building.

4.7 - Industrial

4.7.1 The location of industrial sites at the airport has generally been found to be compatible with aircraft noise because of the relatively higher ambient noise level, both internal and external, associated with industrial activity. This factor, combined with the ever growing need for industrial land around airports, has contributed to the development of industrial parks on and around commercial and general aviation airports. Business has learned to take advantage of the unique benefits air transportation can offer, and many major commercial enterprises, too, are located at airports.

4.7.2 Important benefits can be gained from encouraging industrial development in airport areas. First, the normal industrial noise tends to make inhabitants more amenable to aircraft noise. Second, as a result of this location, these industries will usually become supporters of the airport and interested in airport operations. In addition, airport owners and operators can derive a substantial income by selling or leasing the undeveloped land, or by developing the land and subsequently leasing or selling it to industrial firms.

4.7.3 It must be noted, however, that prospective sites for industrial development must still satisfy the following basic requirements:

a) desirable geographical location, considering the community in question;

b) availability of land of sufficient size to accommodate the planned industrial development;

c) access to commercial transportation facilities, in addition to air transportation, if necessary;

d) present and/or future availability of needed utilities;

e) access to nearby residential areas for the industrial employees, with reasonable commuting time; and

f) compatibility of proposed industrial development with other area land uses.

4.7.4 Residential and institutional, recreational, municipal utilities, highways and railways and commercial land uses support the above requirements. It should be noted, too, that those industries that emit offensive noises, odours, and smoke, or that create electronic interference with airport operations, must be given special consideration before they are sited at the airport.

4.7.5 In constructing industrial developments, consideration should be given to reducing aircraft noise through the use of sound and air conditioning.

4.8 - Residential and Institutional

4.8.1 Residential, in this case, includes single-family dwellings, multi-family dwellings, and estates. Institutional refers to community facilities such as schools, hospitals and churches.

4.8.2 Sound conditioning and air conditioning can do a great deal towards making all types of dwellings acceptable during hours when the interior of the building is in use; this is particularly important during the night-time hours. Hence, the amount of sound reduction must be balanced against the external sound level to achieve an acceptable noise level for the occupants of the dwelling. Installation of sound conditioning can be relatively simple if incorporated initially in new construction but more complex if incorporated as a modification of old construction.

4.8.3 In single-family dwellings in temperate and warm climates families live outside during many of the daylight hours, especially in the summer months. This is also true of estates and, to a lesser extent, of multi-family dwellings, particularly where a community swimming pool exists. It is this outdoor activity that creates the real noise compatibility problem for residential property in the vicinity of the airport.

4.8.4 Institutional dwellings may require a greater degree of sound conditioning than residential structures because a lower sound level is necessary for internal use. The requirements of patients in hospitals and of the speech level in schools and churches demand special evaluation in the vicinity of the airport.

CHAPTER 5 - LAND-USE PLANNING

5.1 - General

5.1.1 The problem of noise in the vicinity of airports can be solved only by pursuing all possible means for its alleviation, and the benefits which can be derived from proper land-use planning can contribute materially to the solution. Although in many instances the benefits to be derived from land-use planning may necessarily be long range, any solution to the problem is also likely to be long range. Efforts to correct situations detrimental to proper land use around airports should not be ignored because of the time required for such measures to be effective. This is particularly appropriate to applications of land-use planning to existing airports where it is recognized that the ability to make immediate improvements is limited. On the other hand, there are substantial benefits to be gained from the correct application of land-use planning techniques to the development of new airports. The value to be derived from proper land-use planning should not be overstated but, on the other hand, it is believed more attention should be paid to this useful tool.

5.2 - Assessing Noise for Land-use Planning

5.2.1 The intrusiveness of aircraft noise into airport communities is dependent upon many factors including the following: sound pressure level; broadband frequency distribution; special irregularities; noise duration; flight path including take-off and landing profiles; number of operations; operating procedures (such as engine power settings); mix of aircraft; runway utilization; and time of day and year including meteorological conditions. All of these factors contribute to the total aircraft noise exposure of the communities.

5.2.2 The response of the communities to aircraft noise exposure is dependent upon such factors as: land use; building use; type of building construction; distance from airport; ambient noise in the absence of aircraft; diffraction, refraction, and reflection of sound due to buildings and topographical and meteorological conditions; and factors of sociological nature. All of these factors contribute to the sensitivity of the communities to the airport environment.

5.2.3 Methods of forecasting aircraft noise exposure and predicting community response have been developed:

a) for determining the relative merits of different aircraft operating procedures, and runway utilization in reducing aircraft noise exposure; and

b) to serve airport and community planners as a guide in planning land use and building construction in the vicinity of airports.

Descriptions of these methods is given in Circular 116, Noise Assessment for Land-use Planning.

5.2.4 Noise exposure forecasts are necessary to develop programmes to limit the total exposure to aircraft noise experienced by communities and to make airport operations and the community life mutually compatible. These programmes must co-ordinate various measures such as the monitoring of noise caused by aircraft movements and the planning and control of land use. Effective programmes can be established only if the basic principle is applied, namely that aircraft noise around an airport should be described, measured and, if necessary, monitored by methods that make due allowance for the effect such noise has upon people.

5.3 - Noise Zones and Associated Maximum Noise Indices

5.3.1 A review of current practices used by States shows that there are two basic approaches to the establishment of noise zones around airports. The first of these considers that only a broad approach, as typified by two or three zones, is required. This is based in part on the accuracy of the noise exposure measuring and forecasting techniques used, which are thought by some not to possess an accuracy greater than 5 dB. Also, it is felt that the use of only a few zones permits greater flexibility in application. On the other hand, States which favoured five distinct noise zones considered that the finer gradation permits the best utilization of land area around the airports and when applying the zones to existing airports enabled planners to specify the most effective remedial treatments. This approach is particularly effective for short-term planning and in planning industrial areas. Although the basic accuracy of the noise exposure indices is perhaps coarse, planning authorities find a need for such a fine distinction between zones. There is unanimous agreement that the structure of noise zones must be inherently related to the particular environment in which they are applied.

5.3.2 As a minimum, three zones should be established for the purpose of land-use planning with regard to aircraft noise in the vicinity of airports. These might broadly be described as:

Zone A: where developments and land uses need not be restricted by noise exposure considerations.

Zone B: where moderate noise exposure levels may be encountered and there may be some need to restrict land uses and developments.

Zone C: where high noise exposure levels may be encountered and as a consequence, most land uses may need to be restricted, and most developments not permitted.

5.3.3 The values of the noise exposure indices corresponding to the noise zones adopted for land-use planning should form a logical progression. Nevertheless, it is feasible at present to make a comparison between the values of the different methods used by States[1]. In fact, the material submitted by the United States (NEF method), the United Kingdom and Switzerland (NNI method), France ($\mathcal{N}$ method), and Federal Republic of Germany (Q method) indicates that the correlation between the ICAO unit and the units used by States is:

a) strictly limited to the particular situation - for example, the standard reference situation; and

b) only an approximation and affected by the accuracy of the method used to convert one unit of perceived noise level to another - for example, the dB(A) and the PNdB when considering the NNI method;

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1 For a description of these methods see Circular 116.

c) impossible to establish when the measured physical properties of sound are basically different (as in the case of the comparison between ICAO and NNI methods). Consequently Table 5-1, which is based on the standard reference situation, allows only for a rough comparison to be made and cannot be used as a conversion table.

ICAO			$\mathcal{N}^0$	
WECPNL (2)	WECPNL (3)	NEF	(day)	Q
	72	24		
72		25		
75				
	77	29		
77	77, 86	30	84	62
80	82	34		
82	82, 86	35	89	67
85				
	87	39		
87		40		
89			96	
90	90, 86			75

Notes

1. Boxed values relate to noise zone contours adopted or intended to be used for land-use planning purposes.

2. The relationship between WECPNL (2) and WECPNL (3) values, as shown in the table, results from a mathematical study submitted by the United States and is valid only for the hypothetical situation under discussion.

Table 5-1. Approximate relationship between noise indices (as related to the standard reference situation)

5.4 - Land Uses Within Noise Zones

Summary of the Special Meeting on Aircraft Noise in the Vicinity of Aerodromes

5.4.1 The types of development to be permitted in the three suggested zones is typified by Table 5-2. This table may be used as a guide to States contemplating or operating land-use planning schemes, although it is emphasized that the examples of different development and land uses given in the table as illustrations should be taken only as a broad indication of the relative sensitivity to aircraft noise exposure of the activities mentioned. Other planning considerations, such as the need to provide community services (e.g. schools or hospitals) lacking in communities already established in noise-exposed areas, may require developments to be allowed with adequate soundproofing, etc., to maintain the viability of the community. Wherever possible, however, and in particular when planning for the provision of new airports, the placement of the airport should be considered as a part of the total planning environment, so that long-term community needs and the consequences of the airport's operation in noise exposure terms are not in conflict.

Examples of compatible land uses or developments	ZONE A Unrestricted land uses and developments	ZONE B Some restrictions on land uses and developments	ZONE C Most land uses and developments not permitted
Agricultural			
- Crop farming			
Industrial			
- Machine shop			
Commercial			
- Warehouse and shipping			
- Office and banking			
Residential			
- low density housing			
Public Facilities			
- Schools			

Notes

1. The length of the bar indicates where the uses might be permitted without restriction in relation to aircraft noise exposure only and excluding other planning considerations. With respect to certain uses, e.g. housing, commercial, a development might be allowed in a zone of a higher restriction when other planning considerations indicate a need, and where suitable building techniques, sound insulation, etc., can reduce the aircraft noise exposure to an acceptable level.

2. In the special cases of activities dependent on speech communication, e.g. schools, or requiring more stringent standards, e.g. certain hospital activities, additional restrictions may be required to take account of absolute noise levels as well as total noise exposure, unless adequate noise reduction can be ensured in the building construction.

3. The zones will require to be defined against a noise exposure scale and in their application will need to take account of local and national needs.

Table 5-2. Some typical examples of compatible land uses around airports

5.4.2 The following is a condensation of compatible land-use tables being considered or used by five States. The land uses are ranked in categories according to their compatibility with level of exposure to aircraft noise. This summary is intended as information regarding the various approaches to compatible land use and to demonstrate differences that may occur because of variations in building construction techniques, climatic conditions and community attitude to aircraft noise in various states.

5.4.3 Two States relate land uses to five categories as follows:

First State

Category 1: Single family residence, 2-4 family residence, mobile homes, cultural activities, medical.

Category 2: Multi-family residence, group residence, hotels, transient residence, education, churches, outdoor entertainment.

Category 3: Manufacture of professional and scientific instruments, communication, merchandising retail, food and drink retail, finance, insurance, real estate, business services, indoor recreation, government services, playgrounds.

Category 4: Food manufacturers, merchandising wholesale, auto retail, construction, storage, cemeteries, parks (large), nature exhibits, spectator sports, golf courses, water recreation, camping, agriculture (livestock).

Category 5: Manufacture of textiles, lumber, paper, printing, chemicals, rubber, plastics, stone, clay, glass, primary metals, refining petroleum, fabricating metals, transport industries, auto parking, utilities, building materials retail, farms (not livestock), forestry, fishery, mining, undeveloped land, water areas.

Second State

Category 1: Churches, schools, hospitals, community centres, individual dwellings, town houses, camping, outdoor theatres.

Category 2: Auditoriums, banks, hotels, motels, offices, restaurants, stadiums, apartments.

Category 3: Bakery, shopping plaza, auto lot retail, mobile home lot retail, stores retail, laboratories, athletic fields, racetracks (horse).

Catetory 4: Bus and airline terminals, factories, machine shops, fairgrounds, parks, picnic areas, playgrounds, tennis.

Category 5: Crop farms, market gardens, plant nursery, tree farms, livestock pasture, enclosed poultry farms, aircraft sales, schools, repair, cemetery, automobile service stations, garbage disposal, parking lots, train and truck terminals, warehouses, coal yards, rail yards, cement plants, quarries, refineries, lumber yard, saw mill, ship yards, power lines, golf courses, marinas, beaches and swimming pools, racetracks (autos), highway and railways, electric generating plants, gas and oil storage, garbage treatment, water storage, water treatment.

5.4.4 A further two States relate land uses to four categories as follows:

Third State

Category 1: Developments not restricted on aircraft noise grounds.

Category 2: Schools with sound insulation, hospitals, churches, hotels, infilling houses.

Category 3: Offices, hotels with some sound insulation, infilling houses with insulation.

Category 4: Factories, warehouses, etc., insulated where necessary, hotels with complete insulation.

Fourth State

Category 1: Developments not restricted on aircraft noise grounds.

Category 2: Density limitations to be applied to population; soundproofing of buildings recommended; public buildings (i.e. schools, hospitals, etc.) to be soundproofed; new residential developments to be avoided.

Category 3: Density limitations to be applied to population; residential buildings to be soundproofed; development of existing communities to be restricted to areas located within the smallest possible perimeters; erection of public buildings (i.e. schools, hospitals, etc.) and multi-family residential buildings to be avoided. Should such buildings be essential, soundproofing should be studied with particular attention.

Category 4: All buildings prohibited except those which are associated with the activity of the airport and are provided with soundproofing provisions which make living conditions at least equal to what they would be if the buildings were erected in Category 2.

5.4.5 The fifth State relates land uses to three categories as follows:

Category 1: Low-density uses - hospitals, schools, etc.

Category 2: Dwellings with sound insulation.

Category 3: Airport buildings - industrial.

Detailed Guidance Submitted by States

5.4.6 A method for relating land uses to three categories in connexion with the use of the NEF method[1] is given in Table 5-3.

5.4.7 The following guidance material is related to the use of the NNI method[2].

5.4.7.1 Three noise zones for housing may be distinguished:

Zone A: This is a zone where nuisance due to the noise of aircraft is slight. From the socio-psychological viewpoint, this type of nuisance is not, or is barely perceptible, since 85-90 per cent of the persons questioned do not feel disturbed by the aircraft noise. This zone requires no special measures.

Zone B: In this area, the noise of aircraft is of medium intensity. From the socio-psychological point of view, nuisance is clearly proved, because the proportion of persons disturbed by the noise increases. For the population as a whole, disturbance may be considered to be moderate. The question of whether and where the limit of tolerance for different individuals in this zone should be set is a matter of judgement. Medium nuisances should be regarded as undesirable.

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1 Submitted by the United States of America.
2 Submitted by Switzerland.

Land-use compatibility	Noise exposure forecast (NEF) areas		
	Under 30	30 - 40	Over 40
Residential	yes	(B)	no
Commercial	yes	yes	(C)
Hotel, Motel	yes	(C)	no
Offices, Public Buildings	yes	(C)	no
Schools, Hospitals, Churches	(C)	no	no
Theatres, Auditoriums	(A) (C)	no	no
Outdoor Amphitheatres, Theatres	(A)	no	no
Outdoor Recreational (Non-Spectator)	yes	yes	yes
Industrial	yes	yes	(C)

Notes. (A) - A detailed noise analysis should be undertaken by qualified personnel for all indoor or outdoor music auditoriums and all outdoor theatres.

(B) - Case history experience indicates that individuals in private residences may complain, perhaps vigorously. Concerted group action is possible. New single-dwelling construction should generally be avoided. For apartment construction, Note (C) applies.

(C) - An analysis of building noise reduction requirements should be made, and the necessary noise control features should be included in the building design.

Table 5-3. Land-use compatibility chart for aircraft noise

Zone C: In this zone, the nuisance is considerable. From the socio-psychological point of view, the nuisance should be regarded as excessive, since, judging by the main criteria used, a distinct majority of the population is disturbed by the noise of aircraft beyond this limit.

5.4.7.2 It is quite clear from the definition of excessive noise and the above-mentioned division of nuisance zones, that the limit for housing beyond which the disturbance caused by noise is excessive is situated at the point of transition from Zone B to Zone C.

5.4.7.3 Acceptable maximum (and not desirable values) associated with other land uses, which have been found suitable are shown in Table 5-4.

5.4.7.4 In certain cases, rare but extraordinarily violent causes of noise result in relatively low NNI values. It is thus desirable that an absolute upper noise level limit be set expressed in terms of noise level and not as an NNI value. It is considered that no noise should exceed the level of 130 PNdB in normal operation (=117 dB(A)).

5.4.8 Table 5-5 material[1] shows the use of three zones associated with specified ranges of noise exposure expressed in terms of the NNI method.

5.4.9 The following material[2] is related to the use of the $\mathcal{N}$ index.

Use	Type of construction		
	Low noise protection (2)	Traditional construction (3)	Reinforced for noise protection (4)
	NNI	NNI	NNI
Hospitals	30	35	45
Schools	35	40	45 or 50
Housing	45	50	55
Commercial buildings	45	50	55
Industry and handicrafts	50	55	60
Warehouses and temporarily occupied buildings	60	60	60
Agricultural and military	60 & over		

Notes

1. Values are for 0600-2200 hours, i.e. day-time values. Night-time values are 15-20 units less.
2. Low noise protection: light condition not complying with traditional construction methods.
3. Traditional construction methods: outside walls 350 kg/m^2; heavy concrete covering 14-16 cm; normal double-paned windows with a soundproofing potential of 25 dB when closed.
4. Reinforced construction for protection against noise: outside walls 500 kg/m^2; roofing with heavy concrete slabs 30 cm; special windows with double panes (reduction of noise through closed window 35 dB).

Table 5-4. Maximum NNI value related to land use (1)

5.4.9.1 The definition of land utilization in the neighbourhood of airports is based on the determination of 3 noise areas, namely A, B and C. These areas are delineated by isopsophic curves, which are based on the PNdB, with the following indices:

$\mathcal{N}1 = 96$ $\mathcal{N}2 = 89$ $\mathcal{N}3 = 84$

The values of $\mathcal{N}1$, $\mathcal{N}2$ and $\mathcal{N}3$ were determined in agreement with the Public Health Authority.

1. Submitted by the United Kingdom.
2. Submitted by France.

Level of aircraft noise to which site is, or is expected to be exposed	60 NNI and above	50 - 59 NNI	40 - 49 NNI	35 - 39 NNI
Dwellings	Refuse	No major new developments. Infilling only with appropriate sound insulation		Permission not to be refused on noise grounds alone
Schools	Refuse	Most undesirable. When, exceptionally, it is necessary to give permission, e.g. for a replacement school, sound insulation should be required	Undesirable Sound insulation to be required	Permission not to be refused on noise grounds alone
Hospitals	Refuse	Undesirable	Each case to be considered on its merits Appropriate sound insulation to be required	Permission not to be refused on noise grounds alone
Offices	Undesirable Full insulation to be required	Permit	Permit but advise insulation of Conference Rooms depending upon position, aspect, etc.	
Factories, warehouses etc.			Permit	

Table 5-5. Recommended criteria for control of development in areas affected by aircraft noise

5.4.9.2 Land use in noise areas

Housing

In noise areas A and B, building for housing purposes is strictly prohibited.

Only housing necessary for civil and military aeronautical activities will be permitted exceptionally, providing it is soundproofed.

In noise area C, only isolated individual houses may be permitted exceptionally, provided that:

- the applicable town planning regulations are respected;
- they are situated in a residential environment;
- they are served by existing public facilities;
- they are soundproofed.

Public superstructure equipment

In noise areas A, B and C the superstructure equipment necessary for civil and military aeronautical activity and the public superstructure equipment essential to the existing populations will be permitted, provided that:

- they cannot be situated elsewhere;
- they are soundproofed.

Other buildings

Other buildings, particularly for industrial, commercial or office use, may be permitted in any noise zones in so far as they are consistent with rational use of land and infrastructure situated around the airport and do not lead to the settlement of a permanent population or the establishment of public superstructure equipment (schools, social facilities, etc.). These buildings must be soundproofed.

5.4.9.3 Land use outside noise zones

Although there are no restrictions added to the applicable town planning regulations, it is nevertheless desirable that a special study be made when there are plans to build highrise buildings so as to determine whether these buildings should be soundproofed.

5.4.10 The following material is given in connexion with the use of the Q index[1].

5.4.10.1 The bill entitled "Law for Protection against Aircraft Noise in the Vicinity of Aerodromes", specifies the noise exposure index values adopted for delineating noise protective zones as follows:

a) The noise protective zone comprises the area outside the aerodrome where the equivalent permanent noise exposure index, caused by the aircraft noise, exceeds 67 dB(A).

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1 Submitted by Federal Republic of Germany.

b) According to the respective noise stress the noise protective zone is subdivided into two protective zones. Protective zone I comprises the area where the equivalent permanent noise exposure index exceeds 75 dB(A) and protective zone II the remaining area of the noise protective zone.

5.4.10.2 The bill further specifies restrictions on buildings as follows:

a) Hospitals, old people's homes, recreation homes, schools and similar facilities with equal protective requirements shall not be created within the noise protective zones. Exceptions may be authorized by the competent state authority if this is urgently required for the provision of public facilities to the population or for other reasons of public interest.

b) Housing facilities shall not be created within protective zone I.

5.4.10.3 Buildings as exceptions in the noise protective zones and dwellings in protective zone II must meet certain sound protective requirements. The federal government is authorized to establish - by way of legal prescription, and subject to developments in the field of sound protection techniques in building construction - sound protective requirements which must be satisfied by the buildings with regard to the protection of their residents against aircraft noise.

CHAPTER 6 - LAND USE ADMINISTRATION

6.1 - General

6.1.1 The technical factors which form the basis of all methods for the evaluation of total aircraft noise exposure are not the only ones to be taken into account for the purpose of land-use control in the vicinity of airports. It is recognized that economic factors are involved when determining compatible land uses. The authorities, local or central, have an important part to play in ensuring that aircraft noise exposure is taken into account as one of the factors to be considered when planning land use in the vicinity of airports and that the plans drawn up are complied with.

6.1.2 There are many techniques for regulating development or bringing about conversion or modification of existing land uses to achieve greater compatibility between the airport and its environs. Some of these may be controls, such as zoning or building and housing codes; other methods influence development through acquisition or the taxing power. Experience has shown that attempts to control land use through easements and purchases is extremely expensive and cannot be considered as a solution to the entire aircraft noise problem. A more practical approach is through proper land-use planning and zoning. Zoning, however, is limited in its ability to effect changes around existing airports located in developed areas. Better possibilities for effective control of land use through zoning exist in its application to new airports and existing airports located in as yet undeveloped areas.

6.1.3 Decisions regarding land development involving land-use controls are characterized by the fact that they can be made at the local level and are individual in character. Local actions are often made on the basis of narrow considerations which may ignore many important area-wide or metropolitan goals. The most common local issues are the return that the owner or developer wants to obtain on his property, the local government's interest in increasing the tax base, and the interest of the residents in maintaining or improving the value of their homes. Generally, these decisions reflect the desire to maintain the community in its present physical form and to avoid radical changes and risk-taking in fostering new kinds of development. For the airport environs, as well as for the total metropolitan development pattern, the cumulative total of such local decisions can seriously degrade a sound comprehensive planning approach and development policy.

6.2 - Zoning

6.2.1 Zoning for land use serves a two-fold purpose: the protection of the airport and the protection of the residents. Land-use zoning should take into account anticipated future airport development so that when airport developments take place interference to the vicinity will be minimal. The legislation enabling land-use zoning is in some cases provided by State or Provincial law and in other cases it is provided by National or Federal law. The power to implement land-use zoning is generally endowed upon local government or regional planning authorities.

6.2.2 The noise contours extending outward from the airport delineate areas affected by different ranges of noise exposure. No use should be permitted in an area subjected to levels of noise higher than considered acceptable for that use. One "authority" should have over-all responsibility for developing land-use criteria and

guidelines for use and development of an "airport development area" around new airport sites. Local zoning and land use should be consistent with these criteria and guidelines, and the authority should be empowered to make amendments to ensure consistency.

6.2.3 Such an approach may overcome the problem of multi-jurisdictional interests in the airport environs which has sometimes prevented effective zoning. This, of course, involves the transfer of zoning powers to some higher governmental level such as an area-wide planning agency or the State, with the designated public agency exercising the authority to ensure compatibility between airports and their neighbours. Local jurisdictions with zoning power (cities, towns or larger administrative units) have rarely taken effective zoning action needed to alleviate this problem, because a given airport often affects several jurisdictions, and the co-ordination of zoning is difficult. Moreover, zoning has proven extremely vulnerable to development pressures and local politics. Another problem is that the interests of the affected communities are not always consistent with the needs and interests of the airport operator, as well as with each other. Within each community there is usually a desire for a larger tax base, population growth, and rising land values, and these goals are often in conflict with the need to preserve the airport environs for "non-sensitive" activities.

6.2.4 The need for zoning based on the noise sensitivity of various land uses and activities is frequently self-evident in close proximity to the airport, although such zoning farther away might require the development of more sophisticated guidelines on this subject than are at present available. A complication is the vast difference between activities which fall into the same zoning category and the varying noise sensitivity that would result, not from the activity itself, but from the construction characteristics of the building that houses it.

6.2.5 Zoning is not retroactive and does not affect pre-existing uses that will be adversely affected by airport operations. Through the zoning process, non-conforming uses may be removed; however, this requires a long time during which the uses are amortized, and it is unlikely that such zoning provisions would have much impact on development patterns on a large scale. For this reason zoning is most effective at airports that have not yet felt the impact of buildings. Also, uses proposed for vacant land normally have some relation to the market demand for such activities and zoning for compatible uses, such as commerce or industry, may be considered an impermissible expropriation if there is no established need for these functions: however, experience indicates that most airports create exactly that type of demand.

6.3 - Land-use Control

6.3.1 Various means are available for controlling the use of land around airports. The effectiveness of these means for both existing and new airports should be considered for each particular situation. The most common means are:

1. Planning - the creation of a planning body to study, plan and advise on land use.

2. Zoning - the legal means whereby planning objectives are enacted.

3. Easement - the purchase of partial rights to land by the airport or other public authority.

4. Purchase - the purchase of full ownership of land by the airport or other public authority.

6.3.2 Any consideration of land-use planning and control to reduce the total exposure to aircraft noise experienced by communities must take into account:

a) the need to overcome noise problems that may have arisen in existing communities; and

b) the need to prevent the development of communities in areas subject to high noise exposure.

6.3.3 On the one hand, the possibility of planning the use of land in built-up areas near existing airports differs appreciably from the possibilities in areas not yet developed. On the other hand, the planning of a new airport must necessarily involve a distinction between the planning for built-up and underdeveloped areas in the region in which the airport is to be sited. Efforts, therefore, should always be directed to developing both preventive and remedial programmes to achieve land use compatibility.

6.4 - Public Awareness

6.4.1 Local government and/or planning authorities should make available for public perusal a plan showing noise contours and land-use zoning in the vicinity of an airport. Large notice boards located within noise affected areas and/or at the airport boundary may also be employed to explain the extent to which land in the area is subjected to airport noise. For example, airport boundary notice boards in one State measure 6 m x 3 m and bear a plan of the airport and vicinity on which noise contours and zoning details are shown.

6.4.2 To ensure that persons buying land affected by airport noise are aware of the noise problem, title documents for such land may bear a statement to the effect that the land is in a noisy area and that the local government authority should be consulted regarding noise levels.

6.5 - Negotiated Acquisition, Eminent Domain, and Redevelopment

6.5.1 If zoning is not feasible for either legal, practical or political reasons, then the airport authority (or some other jurisdiction such as an area-wide planning agency or airport commission) may have to rely on the purchase of noise-affected properties to a much greater extent. As in the case of zoning, acquisition of land prior to its development is obviously preferable to postponing action until a remedial situation exists. Most airport authorities already have eminent domain powers and the practice of purchasing easements is well established.

6.5.2 The use of the eminent domain power to acquire development rights over land within noise-exposed areas around an airport would be enormously costly and would be beyond the fiscal resources of practically all airport operators, as well as most local governments. If, however, airport authorities or other designated public agencies were sufficiently funded, they could use eminent domain power to acquire development rights over land within the noise-exposed areas around the airport. The purchase of easements may often prove to be a satisfactory noise abatement strategy and would be less expensive than outright acquisition. Where extensive re-use of land is required, an extension of the urban renewal programme authority and funds for this purpose would be worth exploring. This technique raises many questions, however. Substantial additional funding would be required, and problems of relocation and neighbourhood disruption would have to be handled in terms of benefits to the whole area.

6.6 - Compensation

6.6.1 It is the practice in some States to pay compensation to owners of land which has become subjected to a certain level of airport noise. Methods of determining eligibility and the amount of payment are varied.

6.6.2 There are many problems associated with the payment of compensation particularly in regard to who pays, the basis of payment and eligibility to receive compensation. Other problem questions include:

- Is compensation refunded in the event of reduced airport noise (due to quieter aircraft, changing operating patterns or closure of the airport)?
- Should compensation be paid to a land owner if the land was purchased after adequate steps had been taken to publicize the noise problem? and
- Should only the first owner receive compensation?

6.7 - Building Codes and Soundproofing

6.7.1 It is technically possible to build near airports and provide satisfactory interior noise levels. Determining factors in deciding on such construction are whether the value of the location equals or exceeds the insulation costs, or whether other suitable building sites in the general area do not exist or are extremely scarce or expensive. Among the types of structures which may be feasible to locate near airports are commercial offices and industrial buildings and hotels. Criteria for permissible interior noise exposure need to be developed and translated into specific performance standards for the amount of acoustical insulation which will be required in different noise zones for various categories of buildings. Incorporation of such standards into building codes, and the knowledge that they will be enforced, would offer important protection to the public and give developers a basis for estimating the cost differentials of building at various distances and directions from airport operations. As with zoning, practical application of soundproofing standards in building codes would presuppose the existence of reliable noise contours and assurance that the noise will not exceed the levels assumed in establishing soundproofing requirements.

6.7.2 A summary of soundproofing recommendations submitted by France is given at Table 6-1. This tabulation gives the maximum internal acoustic levels permitted in that State for buildings located within the noise exposure zones defined in 5.4.9.1.

6.7.3 Subsequent insulation of homes adversely affected by aircraft and other forms of noise is simply not sufficient protection for the average citizen. Too many individuals and families can unknowingly buy and rent in noise-exposed areas and only later learn of the expense they must undergo to take ameliorative action. It is much more desirable to control from the outset insulation requirements for such buildings, if they must indeed be constructed in such areas. While there will 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. Dwellings in these areas are often of light construction which would be very expensive to soundproof. Research and controlled prototype soundproofing are not far enough advanced to give a basis for confident prediction but even if houses in high noise areas are of masonry construction, insulation and air conditioning may cost more than the value of the additional rents or sales prices which could be obtained.

Noise exposure zones	Housing necessary for aeronautical activity	Individual and collective accommodation	Premises for education and for medical treatment	Premises for office use and hotels	Establishments open to public; warehouses and industrial and commercial workshops
	1	2	3	4	5
A	42 dBA (failing special study)	Not permitted	Exceptionally 47 dBA permitted (failing special study)	42 dBA	Special study
B	35 dBA (failing special study)	Not permitted	Exceptionally 40 dBA permitted (failing special study)	35 dBA (1)	Special study
C	30 dBA (1)	30 dBA (individual only)	35 dBA (failing special study)	30 dBA (1)	None
Outside, adjacent to or near area C	None (1)	None (1)	Special study	None (1)	None

Note

1. A special study is nevertheless desirable for highrise buildings planned in some position in relation to the aerodrome, particularly where they will be lateral to the runways, where the ground effect taken into account in calculating the psophic index is no longer applicable in their case.

Table 6.1. Soundproofing recommendations

APPENDIX

LAND-USE TABLE*

Bird Hazard Considerations Only

The land uses tabulated below should not be considered as an exhaustive listing, but merely as examples of how various land uses may be graded in two areas, Area A and B surrounding an airport. These Areas are arrived at by describing two concentric circles (radii 3 and 8 km respectively) around an airport, centred on the Airport Reference Point (see Figure 1).

LAND-USE GUIDELINES FOR THE AVOIDANCE OF BIRD HAZARDS

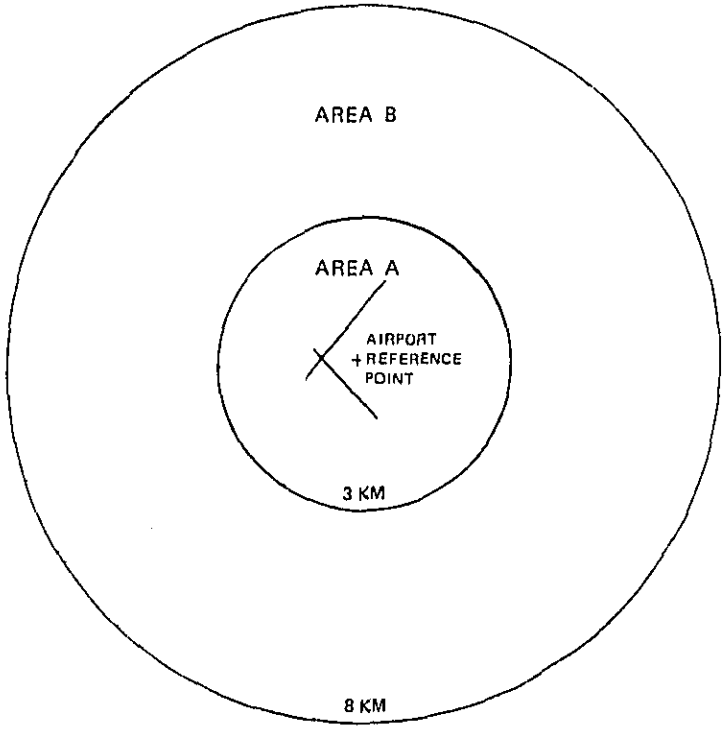
LAND USE	LAND-USE GUIDELINES Area A	Area B
Agriculture		
landscape nurseries (Note)	YES	YES
tree farming (Note)	YES	YES
stock farming (Note)	YES	YES
dairy farming (Note)	YES	YES
sod farming	NO	YES
piggeries	NO	YES
fruit tree farming	NO	YES
Wildlife Sanctuaries		
bird sanctuaries	NO	NO
game reserves	NO	NO
Recreational		
golf courses (Note)	YES	YES
parks (Note)	YES	YES
playgrounds (Note)	YES	YES
athletic fields (Note)	YES	YES
riding trails (Note)	YES	YES
tennis, lawn bowling (Note)	YES	YES
picnic and camp grounds	YES	YES
riding academies	NO	YES
racetracks	NO	YES
fair grounds	NO	YES
outdoor theatres	NO	YES

* Canadian Air Transportation Administration, Land Use in the Vicinity of Airports.

LAND-USE GUIDELINES FOR THE AVOIDANCE OF BIRD HAZARDS

LAND USE	LAND-USE GUIDELINES Area A	Area B
Commercial (Note)		
offices	YES	YES
retail sales	YES	YES
hotels and motels	YES	YES
restaurants	YES	YES
parking lots	YES	YES
indoor theatres	YES	YES
warehouses	YES	YES
shopping centres	YES	YES
service stations	YES	YES
cemeteries	YES	YES
drive-in restaurants	NO	YES
food processing plants	NO	YES
Municipal Utilities (Note)		
water treatment	YES	YES
non-food garbage landfill	YES	YES
food garbage disposal	NO	NO

Note.- These are general guidelines for planning and land-use zoning only. The avoidance of bird hazards during airport operations is another subject that can involve special controls to keep land free from food and shelter for birds.



AREA A CONSISTS OF ALL LAND INSIDE THE 3 KM CIRCLE
AREA B CONSISTS OF ALL LAND LYING BETWEEN THE 3 KM AND THE 8 KM CIRCLE

Figure 1.- Bird hazard areas

- END -

ICAO TECHNICAL PUBLICATIONS

The following summary gives the status, and also describes in general terms the contents of the various series of technical publications issued by the International Civil Aviation Organization. It does not include specialized publications that do not fall specifically within one of the series, such as the Aeronautical Chart Catalogue *or the* Meteorological Tables for International Air Navigation.

International Standards and Recommended Practices are adopted by the Council in accordance with Articles 54, 37 and 90 of the Convention on International Civil Aviation and are designated, for convenience, as Annexes to the Convention. The uniform application by Contracting States of the specifications contained in the International Standards is recognized as necessary for the safety or regularity of international air navigation while the uniform application of the specifications in the Recommended Practices is regarded as desirable in the interest of safety, regularity or efficiency of international air navigation. Knowledge of any differences between the national regulations or practices of a State and those established by an International Standard is essential to the safety or regularity of international air navigation. In the event of non-compliance with an International Standard, a State has, in fact, an obligation, under Article 38 of the Convention, to notify the Council of any differences. Knowledge of differences from Recommended Practices may also be important for the safety of air navigation and, although the Convention does not impose any obligation with regard thereto, the Council has invited Contracting States to notify such differences in addition to those relating to International Standards.

Procedures for Air Navigation Services (PANS) are approved by the Council for world-wide application. They contain, for the most part, operating procedures regarded as not yet having attained a sufficient degree of maturity for adoption as International Standards and Recommended Practices, as well as material of a more permanent character which is considered too detailed for incorporation in an Annex, or is susceptible to frequent amendment, for which the processes of the Convention would be too cumbersome.

Regional Supplementary Procedures (SUPPS) have a status similar to that of PANS in that they are approved by the Council, but only for application in the respective regions. They are prepared in consolidated form, since certain of the procedures apply to overlapping regions or are common to two or more regions.

The following publications are prepared by authority of the Secretary General in accordance with the principles and policies approved by the Council.

Technical Manuals provide guidance and information in amplification of the International Standards, Recommended Practices and PANS, the implementation of which they are designed to facilitate.

Air Navigation Plans detail requirements for facilities and services for international air navigation in the respective ICAO Air Navigation Regions. They are prepared on the authority of the Secretary General on the basis of recommendations of regional air navigation meetings and of the Council action thereon. The plans are amended periodically to reflect changes in requirements and in the status of implementation of the recommended facilities and services.

ICAO Circulars make available specialized information of interest to Contracting States. This includes studies on technical subjects.
